

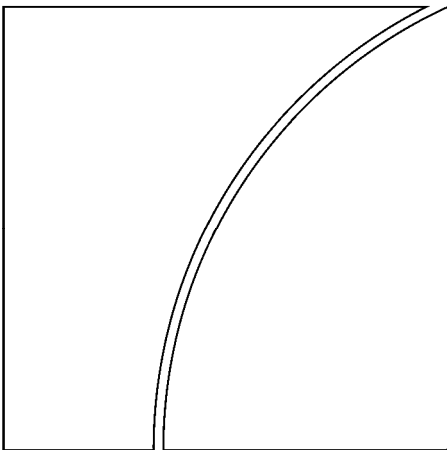


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measurement of inflation:  
prices, wages and expectations



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## Contents

<b>Participants in the meeting</b> .....	iii
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### **BIS background papers**

Monetary policy and the measurement of inflation: prices, wages and expectations Stephen G Cecchetti.....	1
Some issues in measuring and tracking prices in emerging market economies Ramon Moreno.....	13
Wages, productivity and “structural” inflation in emerging market economies Dubravko Mihaljek and Sweta Saxena.....	53
Inflation expectations, persistence and monetary policy Ramon Moreno and Agustín Villar.....	77

### **Contributed papers**

Monetary policy and measures of inflation Miguel Angel Pesce.....	93
Survey-based inflation expectations in Brazil Carlos Hamilton V Araujo and Wagner P Gaglianone.....	107
Terms of trade, commodity prices and inflation dynamics in Chile Jorge Desormeaux, Pablo García and Claudio Soto.....	115
Assesing inflationary pressures in Colombia Hernando Vargas, Andrés González, Eliana González, José Vicente Romero and Luis Eduardo Rojas.....	129
Inflation expectations under Czech inflation targeting Mojmír Hampel.....	173
Measures of trend inflation in Hong Kong Frank Leung, Kevin Chow and Simon Chan.....	177
Monetary policy under import price shocks: the case of Hungary Zoltán M Jakab and Ferenc Karvalits.....	201
Monetary policy in response to imported price shocks: the Israeli case Zvi Eckstein and Guy Segal.....	209
Measures of core inflation in Korea Jae Chun Kim, Yang Woo Kim and Seung Yong Lee.....	233
On the predictive content of the PPI on CPI inflation: the case of Mexico José Sidaoui, Carlos Capistrán, Daniel Chiquiar and Manuel Ramos-Francia.....	249
Measurement of price indices used by the central bank of Peru Adrián Armas, Lucy Vallejos and Marco Vega.....	259
Measurement of inflation and the Philippine monetary policy framework Diwa C Guinigundo.....	285
To what extent can we trust core inflation measures? The experience of CEE countries Piotr Wiesiołek and Anna Kosior.....	297

Monetary policy and the measurement of inflation: prices, wages and expectations Abdulrahman Al-Hamidy .....	325
Monetary policy and the measurement of inflation: prices, wages and expectations – a South African perspective South African Reserve Bank.....	331
Monetary policy and underlying inflation pressures: the essence of monetary policy design Atchana Waiquamdee, Pranee Sutthasri and Surach Tanboon .....	347
Difficulties in inflation measurement and monetary policy in emerging market economies Mehmet Yörükoğlu.....	369

# Monetary policy and the measurement of inflation: prices, wages and expectations

Stephen G Cecchetti<sup>1</sup>

Inflation measurement is fundamental to the conduct of monetary policy. Price indices form the foundation of central bank policy frameworks around the world. They serve as guides to decision-making, as well as providing the primary mechanism for holding independent policymakers accountable. The purpose of the annual meeting of Deputy Governors of emerging market economies, held in Basel on 5–6 February 2009, was to explore three issues: price indices used by central banks; the role of wages and productivity in inflation policy; and the measurement and assessment of inflation expectations. In this brief introductory essay, I will introduce each of these topics.

## Price indices used by central banks

Over the last quarter of the 20th century, a consensus developed that price stability should be the primary focus of monetary policy. It is now agreed that the economic well-being of the general population is best served by keeping inflation low and stable and that, in order to deliver on this objective, central banks should be independent of political authorities, but receive a clear mandate for which they are then held accountable.<sup>2</sup>

Day-to-day implementation of a price stability mandate, as well as accountability, has to be based on data. This means choosing a price index. And, as everyone knows, there are a variety of indices available. National statistical offices in most countries produce survey-based consumer price indices as well as indices used in the construction of national income and product account measures. These indices differ based on their coverage and their weighting. For example, consumer price indices generally cover out-of-pocket expenditures with fixed weights based on survey responses, while personal consumption expenditure price indices may be implicit deflators, with weights that change every period and cover both actual expenditure and services provided by governments, or imputations for other goods that are not explicitly priced.

Before going into the details of the problems facing central banks, it is worth reflecting on the broad reasons one might wish to measure prices. There are three. The first is to transform nominal quantities into real quantities. This is the role of implicit deflators and chained indices constructed in the process of computing real gross domestic product and its components. The second rationale for computing a price index is to compensate individuals for price changes in order to keep their utility invariant in the face of aggregate inflation. Consumer price indices are computed for this purpose. Third, and last, we compute price indices for the

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<sup>2</sup> How central banks implement this price stability goal and their precise relationship with the executive branch varies around the world. Many inflation-targeting central banks clearly take account of short-run behaviour of output in their decisions, while some do not. And some are much more independent of the executive than others. Depending on the circumstances this could have an impact on the nature and effectiveness of policy.

conduct of monetary policy. At the abstract level of macroeconomic modelling, it is simple to say that this is *the* aggregate price level. More concretely we could think of it as the common element of all prices in the economy. That is, every price can be decomposed into a common and an (orthogonal) idiosyncratic element. The common part is the aggregate price level, and this is the part with which monetary policy should be concerned – in theory, that is. Practice is harder, and that is where we go next.

The questionnaire responses in Table A1 of Moreno (2009, this volume)<sup>3</sup> make it clear that the primary price indicator or target for the majority of emerging market economies (EMEs) represented at the 2009 meeting is headline CPI,<sup>4</sup> often supplemented by a set of other indicators. Large structural changes in developing economies can make the accurate measurement of inflation a far from trivial exercise. Rapid productivity growth, terms-of-trade shocks and divergent price movements across sectors all create challenges for monetary policy.

Beyond the choice of an index to target – a headline measure – central bankers face two challenges in measuring inflation for the purpose of short-term policymaking. The first concerns transitory phenomena, or noise, that should not affect policymakers' actions. Sources of such noise include changing seasonal patterns, broad-based resource shocks, exchange rate changes, changes in indirect taxes, and asynchronous price adjustment. Knowledge of the extent to which noise is present in measured aggregate price indices is important since it determines the extent to which policymakers should react to monthly or quarterly changes in observed aggregate price indices.

The second potentially severe difficulty associated with measurement involves biases that are a consequence of weighting schemes, sampling techniques and quality adjustments employed in the calculation of price indices. These biases can be divided into two broad categories: those related to the way in which individual prices are weighted together to form an aggregate index (weighting bias; an example is substitution bias); and those that result from actual errors in measuring the individual prices themselves (measurement bias), such as quality or new goods bias.

### **Underlying or core measures of inflation**

There have been a number of suggested solutions to the problem of high-frequency noise in monthly or quarterly inflation measures. The most common is to measure the underlying or *core* component of inflation by excluding certain prices from the computation of the index; that is, assign a zero weight to parts of the index believed, a priori, to contain substantial amounts of noise (and then proportionally increase the weight on what remains). This is the “ex food and energy” strategy that is common in many countries. There are a variety of alternative methods of measuring core inflation. These include median and trimmed mean measures<sup>5</sup> or more involved econometric procedures.<sup>6</sup> While these alternatives are widely employed inside of central banks – most policymakers monitor a suite of indices – complexity limits their usefulness in external communication.

In addition to transparency and simplicity, core measures should exhibit a variety of other properties. First, they should be unbiased so that over relatively long periods they exhibit the same average inflation as the headline index. Second, their volatility should in fact be lower

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<sup>3</sup> This paper also provides more detail on some of the measurement issues discussed in this section.

<sup>4</sup> An exception is Thailand, which targets core CPI.

<sup>5</sup> See Bryan et al (1997).

<sup>6</sup> One such example is described in Bryan and Cecchetti (1993).



than that of the all-items measure. Third, since the core is supposed to be devoid of transitory fluctuations, the headline measure should revert to it, not the other way around. Related to all of these is that the core and headline measures should be cointegrated – that is, their difference should be mean zero with no trend (either deterministic or stochastic).

It is worth noting that some central banks (notably the Bank of Thailand and the National Bank of Poland) have put substantial energy into successful education programmes, with the result that the public in those countries are comfortable with the relatively complex concept of core inflation. However, other central banks have questioned the ability to do this. As one central bank meeting participant noted, in his country there is one price index for each person. In the end, since everyone eats and uses electricity and fuel, excluding food and energy can be quite difficult to explain. And in poor countries, where food is a large fraction of expenditure, this can present significant difficulties.<sup>7</sup> Over-reliance on core measures can damage the central bank's credibility.

Meeting participants highlighted a variety of disadvantages of core measures of inflation. First, there is the fact that the exclusion measures (ex food and energy) are built under the assumption that the items left out contain no information about the long-run inflation trend. That need not be true. For example, commodity price inflation may exhibit substantial persistence, and if it does, then core measures will diverge from headline inflation for significant periods. In recent years, both Colombia and Thailand have experienced such a problem.

Some participants observed that, in their environment, core measures of inflation were of limited usefulness in policy formulation. First, there is the problem of communication: in the Philippines, for example, the general public is more familiar with headline inflation (both headline and core inflation are available five days after the reference month). Second, on an analytical level, the amount of information contained in core measures, over and above what is in headline inflation, varies. In Brazil, for example, measures of core inflation have not been useful in forecasting the trend in headline inflation. And in the Philippines, the correlation between headline and core CPI inflation is 0.91, and tests of mean and variance show no advantage in the measure of core inflation. However, in periods of volatile commodity and energy prices, the use of core inflation would be an important indicator for decision-making, especially if central banks are concerned about the second-round effects of these volatile commodity prices on inflation.

Beyond the potential usefulness of core measures for decision-making and communication, there is the question of whether a central bank should target core or headline inflation. As headline inflation is the measure of the cost of living, and this is what affects welfare, most central banks target headline inflation, using core as a supplementary indicator primarily for internal use. But one central bank, the Bank of Thailand, has taken a different route, targeting core inflation.

There is ample theoretical justification for the Thai decision. In state-of-the-art macroeconomic models, price rigidity is why monetary policy has real effects.<sup>8</sup> It is these sticky prices that cause output and unemployment to fluctuate away from their optimal levels. Policymakers should therefore only concern themselves with the fluctuations in activity associated with these particular price (and wage) movements. Flexible prices – those of items like food and oil that are determined in markets and change every day (or minute) –

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<sup>7</sup> For example, in Bangladesh 60% of the basket consists of food, while in the United States food only accounts for 15%. This also raises distributional issues related to the fact that the price index of the rich is not the price index of the poor.

<sup>8</sup> The canonical reference for this is Woodford (2003). As discussed below, policy credibility and the anchoring of inflation expectations may have a bearing on price rigidity.

are of no consequence. In fact, in the benchmark New Keynesian model, when inflation is stable, output is equal to potential, so there is no output gap. But in the end, this is an empirical question that needs to be answered on a case by case basis: does stabilising core inflation lead to a more stable economy or not?<sup>9</sup>

### Measurement bias, administered prices and coverage

Understanding short-run fluctuations in price measures is only one of the problems policymakers face. Their lives are made even more difficult by the fact that traditional price indices are biased upward. The sense in which they are biased is somewhat difficult to describe, but quite precise: if you use standard price measures like the CPI to increase the nominal wage of the typical household in an attempt to keep their welfare invariant in the face of price changes, you will be giving them too much additional money. So long as this bias is approximately time-invariant, it affects the central bank's inflation target itself, not day-to-day stabilisation policy. Since measured zero is not zero, price stability is achieved when reported inflation is positive by the amount of the bias.

Measures of consumer price inflation that are rooted in the theory of the cost of living index may be biased measures for a variety of reasons.<sup>10</sup> Loosely speaking, bias arises because of the way the raw data that go into the index are collected, how they are weighted together and combined into a single index, or how the statistical agency gathering the data tries to deal with improvements and deteriorations in the quality of the goods being priced.

A typical consumer price index is intended to measure the inflation experience of a hypothetical average or representative consumer. To construct the index, a statistical agency must determine what it is this hypothetical consumer spends their money on – that is, what the consumer buys.<sup>11</sup>

The first bias, **substitution bias**, arises because the assumptions about what individuals buy do not reflect actual expenditure patterns as consumers tend to shift away from goods that become relatively more expensive. The ability of consumers to substitute between food and clothing, or food and entertainment, in response to relative price changes is somewhat limited. However, the scope for substitution between bread and chicken, or between movies and video rentals, is usually a lot greater.

The biases due to the various forms of substitution induced by changes in relative prices are well understood and in principle easy to deal with by using alternative weighting schemes, such as chain-weighted indices, and by increasing the frequency with which the weights are changed. However, the problems posed by changes in the quality of the goods and services included in the consumer price index and the arrival of new goods in the consumer marketplace pose the greatest challenges for statisticians in accurately measuring the cost of living. **Quality bias** arises when statisticians fail to take into account improvements in the quality of a good or service included in the consumer price index. Finally, **new goods bias** arises when statisticians fail to recognise the introduction of new goods or services on which consumers spend a significant fraction of their income.

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<sup>9</sup> It is worth noting that if the targeting horizon is long enough – greater than one or two years – it should not matter whether the central bank targets headline or core inflation.

<sup>10</sup> The following discussion on bias is based on Cecchetti and Wynne (2003).

<sup>11</sup> National statistical agencies also try to determine *where* consumers make their purchases. When, in order to escape inflation, buyers shift from higher-priced small stores to larger hypermarkets, for example, this can give rise to what is known as *outlet substitution bias*.

How big are these biases? In advanced countries, they are probably on the order of 1 to 2 percentage points, at most. But in EMEs, where data collection is more difficult, they can be large.

While computing the size of measurement bias in a particular index may pose a significant practical challenge, it is clear what to do once you have the number. The same cannot be said for administered prices. How should a central bank treat inflation arising from changes in administered prices? In Brazil, for example, there are two sorts of prices that are not set by markets: regulated prices, such as those for telephone use and electricity, which are set based on rules; and administered prices, including those for mass transportation and health insurance, which are determined by national, regional or local governments. Most of these prices relate to services, with a public or private monopoly or oligopoly. Some of these prices move in predictable ways as they are based on things like past inflation, the exchange rate, or the international oil price, so they are known in advance. But in general, changes in regulated and administered prices are difficult to integrate into a macroeconomic model designed to produce an aggregate inflation forecast. Nevertheless, policymakers are obligated to try to control inflation in the economy as a whole, so they need to react to movements – both expected and unexpected – in these prices.

## Wages, productivity and structural inflation

Original models of macroeconomic fluctuations – the first Keynesian models – were built on the premise that wages were not flexible, so labour markets did not clear. The idea was simple: employment was demand-determined. Since demand fell during a cyclical downturn, the result would be unemployment. But in the 1970s this logic fell out of favour in academic circles. Observed wages had little relationship to the marginal product of labour on a day-by-day or even month-by-month basis. Instead, wages were conceived of as instalment payments in longer-term contracts, with the vast majority of workers working harder when there was more work to do and sitting around the rest of the time. There was a spot market for marginal workers, and their wage moved to clear that market.

Starting in the late 1970s, macroeconomists began to build models based on price rigidity. There was a labour market in the background (with an implicitly flexible wage determined by the equilibrium of supply and demand) but the baseline models were composed of a set of monopolistically competitive firms that faced costs of adjusting their prices. It took a while, but over the last decade researchers have been looking at price data to see how sticky prices really are. The answer is: not very! And the prices that are fixed for extended periods tend to be the ones in service-based industries. In fact, the higher labour's share in costs, the less flexible prices tend to be.<sup>12</sup>

Maybe academics should not have given up on wages. Central bankers clearly did not. And the reason for this is their importance in the inflation process. Wage growth equals productivity growth plus inflation.<sup>13</sup> In fact, growth in real wages that is in line with labour

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<sup>12</sup> See Álvarez et al (2005).

<sup>13</sup> This relationship does have to be used very carefully. While it is an implication of equating the marginal product of labour with the wage, it is not an identity, so the measurement of the various quantities must be taken into account. Two points are worth noting here. First, there is often only one source of price data. These data are then combined and used in different ways to produce consumer price indices, which are in turn used to deflate nominal wages and national income and product account data in order to compute real quantities that go into the computation of productivity. Second, in a variety of cases output is imputed from a combination of hours and electricity usage. Not all output measures included in GDP, and used for productivity computations, are measured directly.

productivity growth (usually measured as average output per hour paid) is widely seen as a necessary precondition for macroeconomic stability. In EMEs, with their concern for exports, a close relationship between real wage growth and labour productivity growth helps preserve external competitiveness while limiting inflationary pressures and the risk of a wage-price spiral developing.

A wage-price spiral typically occurs when employees and others seek wage increases to keep pace with rising prices. The increased wages force employers' costs up. These increased costs may then be passed on to consumers in the form of higher prices. Higher consumer prices feed into future wages, and the spiral is on its way.<sup>14</sup>

During the first half of 2008 there were widespread concerns in both EMEs and many advanced economies that the run-up in food and oil prices would set up just such an adverse inflation dynamic. In China in the spring of 2008, for example, authorities in several provinces felt obligated to raise minimum wages by double digit amounts to relieve the pressure higher consumer prices were putting on real household income. This raised concerns that overall inflation could accelerate as a result and hurt China's external competitiveness.

All of this strongly suggests that measures of labour costs at the aggregate level could serve as a useful indicator of economy-wide inflation pressures. Unfortunately, until recently a lack of data has undermined attempts at such an analysis in most EMEs. As a result, few EME central banks have mentioned the labour-cost inflation linkage in the past. But the adoption of inflation targeting frameworks by many emerging market central banks has provided an incentive to compile better labour market data and has enabled central banks to use productivity and unit labour costs more widely in their inflation forecasts.<sup>15</sup> Even so, some countries employ proxy measures for wages: interestingly, the Magyar Nemzeti Bank (the Hungarian central bank) uses service price inflation to forecast wage dynamics. And in countries where productivity data do exist, interpretation can be tricky. For example, in Korea the difference between real wage growth and productivity growth has declined over time.

Attempts to use wage data in inflation analysis are always going to be challenging for several reasons. First, there are problems with timing and quality that do not appear in the case of price information. Wage data often come with a long delay – two to three months in Israel and Poland, for example. And because many series are based on national accounts information, they are also subject to revisions (as they are in the Czech Republic). In other cases, data are simply unreliable as national statisticians are unable to ensure sample consistency, so the numbers are not adjusted for changes in composition.

Nevertheless, in those countries with high levels of collective bargaining, wage agreements provide substantial information. The Reserve Bank of India pays attention to wage bargaining and contracts, particularly in the public sector. The extent to which these are forward-looking can provide policymakers with information about inflation expectations. And, in inflation targeting countries, the central bank's inflation target can become an anchor if it is built into wage agreements.

Finally, any attempt to employ official wage data in the policy process can be hampered by the existence of an informal sector. A number of Latin American EMEs report informal sectors that account for 50% or more of their economies. In such cases, movements in measured wages can be very misleading. For example, if a country raises its statutory minimum wage, this will be reported as wage inflation. But if the result is to drive more workers into the lower-wage informal sector, the result could be a net reduction in the

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<sup>14</sup> In the background of a wage-price spiral we would expect some degree of monetary accommodation.

<sup>15</sup> Due to the difficulties associated with monitoring and interpreting wage statistics, the People's Bank of China focuses on price statistics to gauge future inflation.

properly measured average wage. There are, of course, forces pushing in the opposite direction as governments push to shift the informal sector into the formal one. Unfortunately, there is very little information on the implications of employment dynamics between formal and informal sectors for overall wage setting in EMEs.<sup>16</sup>

Before moving on, I would like to note that it is often useful to supplement the analysis based on economy-wide measures of wage and productivity growth with more disaggregated measures derived from two-sector models.<sup>17</sup> One of the most widely used two-sector models is that of differential productivity growth in tradable and non-tradable industries. This kind of model has some quite interesting implications for the economies with rapid productivity growth in tradable industries, including that: (1) the rate of wage increase tends to adjust to the “room” for wage increase in the tradable sector, as defined by the sum of the (exogenous) increase in world market prices for tradables and the (exogenous) rate of productivity increase in that sector; and (2) as faster productivity growth in tradable industries is a normal part of economic development, not all inflation in such economies is necessarily undesirable or avoidable. If labour and capital markets are unencumbered, there is not much that monetary policy can do to control this source of inflation.

What this means is that as EMEs catch up to the productivity *level* of their advanced neighbours and trading partners, they can expect to have higher inflation. Such real convergence creates structural inflation differences that pose significant medium-term challenges. Does this mean that EME monetary authorities would be well served by focusing on inflation in tradable/non-tradable goods (as they do, for instance, in Colombia)?<sup>18</sup>

## **Inflation expectations and monetary policy**

The third topic discussed at the February 2009 meeting of Deputy Governors of emerging market economies was inflation expectations and their relationship to monetary policy. In considering this very general topic, a series of questions arise:

1. How do central banks measure and use inflation expectations?
2. What is the relationship between inflation expectations and the costs of disinflation?
3. Are monetary policy frameworks effective in anchoring inflation expectations?

## **Inflation expectations measurements and their use**

There are two basic sources of inflation expectations: surveys and financial markets.<sup>19</sup> Moreover, the first group encompasses surveys of households and businesses, professional forecasters and financial market participants. All of these have drawbacks. For example, household and business surveys are costly, which can influence coverage, frequency and quality. The survey population can be unrepresentative, with more informed than uninformed people in the sample. There is a clear tendency for household surveys to be biased, with inflation expectations systematically overestimating actual inflation experience. (In fact,

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<sup>16</sup> These are clearly big issues in EMEs; for example, Turkey's GDP was revised by 32% in 2008 due to better coverage of the informal sector.

<sup>17</sup> Mihaljek and Saxena (2009, this volume) provide additional perspective on this topic.

<sup>18</sup> See Table A3 in Mihaljek and Saxena (2009, this volume).

<sup>19</sup> See Moreno and Villar (2009, this volume) for further discussion on the use of these two types of data sources in EMEs.

households systematically *perceive* inflation to be higher than it is.) Obviously, policy decisions should not be based on biased expectations.<sup>20</sup>

Turning to professional forecasters and financial market participants, the data here also have shortcomings. Prime among them is concern about incentives. Two issues arise. First, there is the cost of revising expectations. However, given that these are professionals, that problem is likely to be small. Unfortunately, the second problem is significant. Professional forecasters are paid for their forecasts, and their pay depends not just on accuracy but on recognition. The only way to be recognised is to be right when everyone else is wrong; however, that is impossible if everyone's forecast is the same. This creates an incentive to try to distinguish forecasts from each other that has nothing to do with accuracy.

Finally, there are financial market expectations. In many developed financial markets the existence of inflation-linked financial securities provides a market-based measure of inflation expectation as well as attitudes toward inflation risk. The difference in the rate of return of an inflation-linked bond and a nominal rate (the "break-even rate") would offer a market-based measure of inflation expectations. An important issue is how to disentangle inflation expectations from other factors that may be embedded in the break-even rate. Break-even rates can be decomposed into at least three components: (i) expected inflation during the remaining maturity of the bonds; (ii) inflation risk premia; and (iii) liquidity premia. Technical factors specific to each market may also play a role.

Sometimes, the expected inflation component is extracted by using expectations from professional forecasts. In the case of the United States such (longer-run) expectations have been relatively stable, and it appears that most of the recent volatility in the break-even rate is attributable largely to liquidity premia (a higher liquidity premium would increase the yield on real bonds relative to nominal bonds and recently a flight to safety lowered the nominal rate for US Treasury securities). Thus, the break-even rate appears to give a relatively noisy signal of inflation expectations at this time.

Some EMEs (eg Chile or Israel) have been able to develop inflation-linked government (or central bank) bond markets, but in most cases such markets do not exist.

Turning to actual experience, central banks vary in their use of surveys. Hungary and the Philippines survey both households and businesses. Korea surveys only households; and Thailand only businesses. Turkey surveys both businesses and the financial sector, while Brazil and Israel survey the financial sector alone. Finally, Chile surveys forecasters. There is wide variation in the frequency of the surveys; the nature of the questions, both the index and the horizon; the statistics reported (means, medians, etc); and the nature of publication – the Central Bank of Brazil publishes individual forecasters' responses on its public website.

A number of central banks report using a variety of financial market indicators (break-even inflation and swap market rates). The preferred financial market indicator reflects availability and market conditions. Brazil, Chile and Israel use inflation-linked bonds to compute break-even inflation rates. While Israel reports that this is useful, other authorities appear less sanguine about the guidance they receive from break-even measures, as the market for indexed bonds is not always very liquid. There are alternatives. For example, in Thailand, where there are no inflation-linked bonds, the central bank uses the implied forward yield curve; the risk premium is small and the long-term rate is stable so inflation expectations can be extracted, at least during periods when markets are functioning normally.

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<sup>20</sup> So long as the bias does not change much over time the solution, as suggested by the Hungarians, is to focus on changes in expectations rather than on their level.

## Expectations and the costs of disinflation

Inflation persistence is a key factor in the costs of disinflation. There are two possible explanations for the presence of inflation persistence: (1) backward-looking, or not fully rational expectations (possibly a result of explicit indexation); and (2) private agents having limited information about central bank objectives.

International experience is extremely diverse on this issue. In some countries, for example Brazil, Chile, the Philippines and Thailand, inflation expectations are quite persistent. And the extent to which forecasters are forward-looking clearly varies. In the Philippines and Thailand, expectations also appear to be backward-looking, based on past data. By contrast, in the Czech Republic, household expectations are backward-looking because people believe that the past is certain while the future is uncertain, while on the other hand, financial analysts are forward-looking.

While backward-looking expectations are a problem when the central bank is attempting to disinflate, they are not where there is low and stable inflation around the target. In Turkey, financial sector agents' expectations move much more closely with actual inflation, while real sector expectations are stickier. Nevertheless, in some countries expectations and costs of disinflation appear to be closely related. For example, in Colombia minimum wages and regulated prices are subject to indexation in spite of the adoption of inflation targeting 10 years ago. The result is that Colombia's disinflation process is slow.

## Anchoring expectations and the role of the monetary framework

One of the primary rationales for inflation targeting is to anchor inflation expectations. In fact, many people would say that this is the point: keeping expectations of inflation low keeps inflation low. But is this actually the case?

A few points are worth making in this regard:

- In the case of developed economies using a measure of inflation expectations implied by bond yields, studies find that in the United States long-term inflation expectations react to news, while in inflation targeting Sweden and Canada they do not!<sup>21</sup>
- Evidence from the United Kingdom also supports the view that (credible) inflation targeting anchors expectations, as expectations responded to news prior to 1997, when the Bank of England became independent, but not after.<sup>22</sup>
- A study of developed economies by Federal Reserve Board economists finds that lagged inflation is significantly correlated with expectations of future inflation in non-IT countries but not in inflation targeters.<sup>23</sup>

As for the EMEs, questionnaire responses and papers contributed to an earlier Deputy Governors meeting<sup>24</sup> provide the following insights into the behaviour of inflation expectations: a number of EME central banks find that inflation expectations have been better anchored in this decade and continue to highlight this success; a stronger reaction of financial markets to central bank policy announcements has been recorded; and there has been an improvement in central banks' ability to reduce the size of policy adjustments.

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<sup>21</sup> See Gürkaynak et al (2006, 2007).

<sup>22</sup> See Gürkaynak et al (2006).

<sup>23</sup> See Levin et al (2004).

<sup>24</sup> See BIS (2008).

## Fiscal dominance

Unsustainable fiscal policy can break the link between inflation expectations and the inflation target. If households, businesses and financial market participants can come to believe that, because of fiscal policy, it will become too costly to maintain an inflation target, then fiscal policy will dominate monetary policy. The story is a familiar one: with a large public debt, tighter monetary policy can lead to higher sovereign risk premia (by increasing the probability of default on debt), depreciation pressures and higher inflation. In the past, both Brazil and Turkey have been described in this way. And, notwithstanding significant gains in fiscal consolidation, public debt to GDP ratios remain high in a number of countries, suggesting the possibility that policies may be unsustainable. Are current fiscal policies designed to address only current challenges, sowing the seeds of even bigger future problems? After all, central banks cannot achieve their low inflation objectives on their own. They need fiscal cooperation.

## Conclusion

Price measurement is at the heart of macroeconomic stabilisation policy. Without adequate measures of inflation, monetary policymakers would have no final long-term objective at which to aim. And without a clear understanding of inflation dynamics, central bankers have nothing to guide their short-term policy actions. Building appropriate price indices for monetary policy, as well as models of their evolution that allow for control, is a significant challenge faced around the world. Today, emerging market economies are making substantial progress in meeting that challenge.

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# Some issues in measuring and tracking prices in emerging market economies

Ramon Moreno

## Introduction

Price stability is now generally accepted as a primary responsibility of central banks. However, in carrying out that responsibility, central banks must decide which price indicators are most suitable for monetary analysis. Two types of indicator are particularly relevant: one reflects the overall production of goods and services in the economy, and the other gives insights on the cost of living. In the first group are indicators that measure real GDP and its components, that is, consumption, investment, government spending and net exports. Indicators in the second group, such as the deflator for consumption expenditures in the national accounts and the consumer price index (CPI), focus on consumer spending.

The macroeconomic factors underlying the behaviour of the chosen price indicators must be well understood if the indicators are to be useful for monetary policymaking. Moreover, the chosen indicators must be relatively easy to understand and perceived to be accurate because they will often be used in government programs and contractual arrangements as well as for monetary policy.

This note highlights some of the issues surrounding the choice and use of price indicators through a discussion of the following five topics: (1) alternative price indicators; (2) measurement issues for the CPI, including bias and administered or regulated prices; (3) CPI coverage of owner-occupied housing; (4) pipeline inflation pressures; and (5) inflation persistence, shocks and core inflation.

## Alternative price indicators

### Measures based on the national accounts

An important source of indicators for inflation are price series based on the national accounts. These prices refer to goods and services *produced* in the entire economy (comprising consumption, investment, government spending and exports less imports). The decomposition of nominal GDP into price and quantities provides information that is essential for policy analysis.

Two issues may be highlighted here. First, precisely how this decomposition is performed has implications for the interpretation and usefulness of these price indicators. In particular, distortions arise in quantity and price measurement from the use of Laspeyres-type quantity indices. Advanced market economies have addressed this by resorting to chain-weighted quantity indices, but these measures are technically more demanding and pose problems of interpretation (see Box 1).

## Box 1

### Computing national accounts price and quantity indices

Three sets of statistics are usually involved in computing national account price and quantity indices: (1) output at current prices (eg millions of US dollars in sales); (2) output in real quantities (eg tons of steel or barrels of oil produced); and (3) price indices for a variety of products and services. Aggregate quantities are obtained by weighting different types of production volumes by their relative prices. The weights can be interpreted as relative costs of manufacturing or relative utilities of these products for consumers.

Changes in aggregate real output over time are measured by comparing the (price-weighted) sum of quantities in period 0 with that of quantities in period  $t$ , where the weighting in both periods reflects the price structure of period 0 (Laspeyres quantity or volume index). Changes in price are measured by comparing volume-weighted sums of prices in period 0 with that of prices in period  $t$ , where the weighting in both periods reflects the production structure of period  $t$  (Paasche price index). The product of a Laspeyres quantity index and the corresponding Paasche price index is equal to the change in the value, at current prices, of the goods or services between period 0 and 1. That relationship yields the following price-quantity decomposition of nominal GDP:

$$NGDP_t = P_t Q_t = \frac{\sum p_t q_t}{\sum p_0 q_t} \frac{\sum p_0 q_t}{\sum p_0 q_0} \quad (1)$$

where the left-hand side is the index value of nominal GDP (ie GDP at current prices) at  $t$ ,  $P_t$  is a Paasche volume-weighted price index corresponding to the first right-hand side term, and  $Q_t$  is the Laspeyres price-weighted quantity index corresponding to the second right-hand side term. An implicit price deflator can be obtained from some publicly reported GDP price series (eg the IMF's *International Financial Statistics*) by dividing GDP at current prices by GDP at constant prices. Equation (1) indicates that given a Laspeyres volume index, the implicit GDP deflator would correspond to a Paasche price index in which the quantity weights vary each period.

A shortcoming of the Laspeyres quantity index is that the price weights can increasingly diverge from the current price structure. That is, base weights are in many cases changed infrequently, so as time passes, the year 0 price structure, which provides the price weighting in all periods, increasingly differs from the current price structure, which provides the basis for agent decision-making. The resulting distortions can be considerable, particularly in sectors where relative price changes have been large. For example, Lequiller and Blades (2006, Box 2, p 54) estimate that in France, the Laspeyres quantity series for computers, which reported a cumulative increase in 1980–2000 of 316%, overstated the increase relative to that computed by a chained index by as much as 173 percentage points.

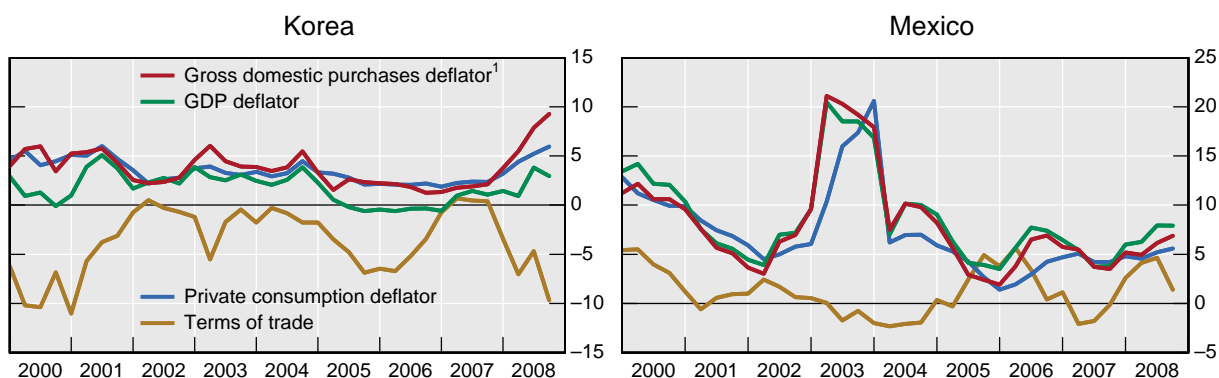
Because of the Laspeyres weakness, statisticians and agencies in a number of industrial countries and in some emerging-market economies have shifted to chain-weighted quantity indices. In this approach, quantities are calculated for every period using prices in the previous period (Laspeyres).<sup>1</sup> These quantities are then “chained” by multiplying each period’s quantity by the next. Finally the series are multiplied by the values of these products at the current prices of the reference year. This method produces far better estimates of changes in volume, but volume categories can no longer be added and are therefore much less intuitive. For example, the identity equating GDP to the sum of consumption, investment and net exports no longer holds; instead (appropriately measured) contributions of these components to GDP must be calculated for purposes of analysis.

<sup>1</sup> These Laspeyres indices are used by most countries that have switched to chaining. Two exceptions are the United States and Canada, which use an average of the current and previous periods, ie a Fisher index. The latter is a theoretically superior method of estimating volume changes. However, it has the disadvantage of not allowing quantities in the national income accounts to be added in any period. Also, the differences with chained Laspeyres appear to be relatively small.

Second, there is a set of national accounts prices<sup>1</sup> to choose from, including deflators or indices for GDP, domestic demand, consumption or investment. An important consideration is that the behaviour of the various series may differ considerably. For example, a GDP price index or deflator is a natural choice for the analysis of price movements because it refers to the overall production of goods and services of the economy. However, changes in the terms of trade can induce large and counterintuitive changes in the price of GDP. In particular, because imports enter with a negative weight, an increase in the price of imports tends to *lower* the GDP price. Some have argued that policymakers should focus on price measurements that exclude terms of trade effects, such as the gross domestic purchases deflator, comprising consumption, investment and government spending. However, partly due to a desire to address the cost of living discussed below, it has been argued that investment and government spending should be excluded to ultimately focus on consumer spending.<sup>2</sup> Terms of trade changes, and the behaviour of GDP prices and various GDP components are illustrated in Graph 1, with reference to the recent experiences of Korea and Mexico.

Graph 1  
**Alternative price deflators and the terms of trade**

Annual change, in per cent



<sup>1</sup> Gross domestic purchases comprise private consumption, government consumption and total investment.

Sources: Thomson Reuters Datastream; national data.

Since mid-2007, when Korea experienced a deterioration of its terms of trade, the gross domestic purchases and personal consumption expenditures deflators rose above the GDP deflator. The reverse occurred in Mexico, where the terms of trade improved, and the GDP deflator rose above the gross domestic purchases and personal consumption expenditures deflators.<sup>3</sup> These gaps in growth rates among alternative price series are generally temporary and not always large, but they are quite visible over certain periods.

<sup>1</sup> For a more detailed discussion of national income accounts and deflators, see Lequiller and Blades (2006).

<sup>2</sup> Government spending is often directly related to consumption expenditures so in principle should be retained. In practice there are difficulties in estimating price deflators for government expenditures, so some argue that these should be excluded for purposes of monetary policy analysis.

<sup>3</sup> See related discussions by Desormeaux, Garcia and Soto (2009); Leung, Chow And Chan (2009) and Waiquamidee et al (2009).

## Cost of living and consumer prices

Another reason for measuring prices is to assess changes in the cost of living faced by consumers. A cost of living index would attempt to measure what it costs a consumer to maintain a living standard as prices change.<sup>4</sup> This is important because it gives insights into how the population is affected by price changes and can be the basis for indexation schemes to compensate certain groups in society (eg retirees, taxpayers, workers, low income groups) for the erosion in their standard of living caused by price changes. However, the concept of living standards is based on consumer utility or preferences and is therefore unobservable, so changes in a consumer's cost of living cannot be measured precisely. Bearing in mind that price indices that refer to consumer expenditures are at best imperfect indicators of the cost of living, monetary authorities usually must decide whether to monitor consumer prices via the consumption expenditures deflator from the national income accounts or via CPI. A case could be made for the consumption expenditure deflator, as its coverage is generally broader than that of the CPI. However, almost all central banks in emerging market economies (EMEs) responding to a questionnaire use a CPI as their primary price indicator (Table A1).<sup>5</sup> Indeed few of the EME central banks in the survey report using a national income price deflator as a secondary indicator.

The widespread use of the CPI as the major price indicator reflects its perceived advantages. First, it is relatively easy to understand and is arguably the best available measure of the cost of living faced by consumers. The CPI is typically constructed as a weighted average of the prices of a basket of goods and services, with the weights reflecting the relative importance of each item in household consumption in some base period.<sup>6</sup> CPI weights are based on consumer expenditure surveys, while GDP price weights are based on surveys of businesses that provide only indirect estimates of consumption expenditure. Furthermore, GDP price index weights change every period, and the intuition is somewhat harder to explain.

Second, the CPI is familiar to large segments of the population. It is regularly reported in the news media and is often used as a reference in the provision of government benefits or in contracts (including wage negotiations). It is also widely followed as an indicator of macroeconomic stability.

Finally, the CPI is available frequently (typically monthly) and is not subject to many revisions, which enhances its transparency to the public and its usefulness for purposes of monetary policy. In contrast, national accounts prices are typically available only quarterly and with a significant lag. Because national accounts prices are Paasche indices (see Box 1), they are also affected by short-term and medium-term revisions in GDP volumes.

## CPI measurement issues

Notwithstanding its advantages, the CPI index poses a number of issues of interpretation.

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<sup>4</sup> For a more thorough discussion, see Schultze and Mackie (2002), pp 46 ff and pp 79–93.

<sup>5</sup> A related measure is a retail price index, which measures prices of goods sold at retail outlets. In Hong Kong, CPI and Retail Price index are highly correlated (Leung, Chow And Chan, 2009, Chart 4).

<sup>6</sup> Revisions of the weights in EMEs are typically made every five years; see IFC (2006).

## Measurement bias

EME central banks cite the four types of bias identified in the literature: new-product; quality-change; substitution; and outlet; but the ranking they assign to each varies (Table A2). New-product bias arises because the CPI does not adequately reflect the value of new products to consumers. Quality-change bias arises because quality differences between the goods priced in two consecutive periods cannot be accurately measured. Substitution bias arises because the CPI, which holds weights fixed at base period quantities, puts too much weight on the relatively more expensive items from which consumers have shifted away. Outlet bias reflects the fact that the CPI does not take into account the fact that consumers may switch to discount outlets.<sup>7</sup> Estimates of the size of these biases in EMEs are not widely available, although estimates reported for Colombia, Hong Kong SAR, and Korea (0.7% to 1.7%) appear to be comparable to biases reported in advanced market economies. However, in the Central Bank of Turkey's contribution for this meeting, Yorukoglu (2009) offers reasons why outlet and new-goods biases in particular may be much larger in EMEs than in advanced market economies.

Some EMEs have taken steps to deal with quality bias. However, the products covered vary, ranging from consumer durables or its components, including electronic goods (particularly computers) and cars, to education and apparel. The approaches to adjustment also vary, and include the use of hedonic regressions, adjustments in CPI compilation, and rebasing every five years. A number of countries report that the effects of quality adjustments are small. In some countries, statistical agencies do not provide information about quality adjustments.

Substitution bias is related to the weighting of the price index.<sup>8</sup> CPIs in EMEs are typically constructed with fixed weights that reflect expenditure shares in a base period (Laspeyres indices) and that are updated every 5 years (IFC (2006)). By construction, fixed weights assume no substitution away from high-priced products. During the interval until weights are revised, the effect of substitution bias rises, and the CPI increasingly overstates inflation relative to other indices that address the substitution effect.

One way of dealing with substitution bias is to use averaging methods (eg geometric weights) that make some assumption about substitution effects<sup>9</sup>. Another is to use indices that more closely reflect recent consumer behaviour and expenditures, such as the national account price indices discussed earlier. As noted earlier, in most countries a disadvantage of this solution is that expenditure data are available only with a lag. Furthermore, research on US prices cited by Clark (1999) suggests that the advantages offered by better indexing are small.

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<sup>7</sup> For these definitions, see, for example, US BLS (1997).

<sup>8</sup> Indeed, one difference between the CPI and a true cost of living index is that the latter explicitly takes into account how consumer spending responds to price changes (ie substitution effects). It is possible, however, to reach certain conclusions about how existing price indices are related to cost of living indices. For example, it can be shown that a base-period cost of living index will not exceed a Laspeyres price index, while a current period cost of living index is always at least as large as the Paasche price index. Furthermore, it may be possible to construct cost of living indices with existing data by making certain assumptions about substitution effects.

<sup>9</sup> For example, in 1999, the US CPI converted to a geometric-mean formula for the 61% of the index for which substitution is considered to be realistic. The geometric mean implicitly assumes constant relative expenditure on a given item rather than constant quantity. That is, an increase in the relative price implies a proportionate decrease in the quantity (unitary elasticity of substitution). This geometric-mean formula is used only in creating basic indexes, not in the aggregation of those indexes.

## Administered and regulated prices

Administered and regulated prices are heavily influenced by government policies (eg price or quantity controls, subsidies) rather than being set freely in the market (Table A3). The share of administered prices in many EMEs is significant, ranging from about 10% in Saudi Arabia to about 20% in Argentina or Hungary. The sectors covered include energy related items and other utilities (eg fuels and electricity, water and sewage), public transportation, rents, and public services (eg education, postal services).

While administered or regulated prices tend to be rigid and do not vary with the business cycle, recent experience reveals that sudden changes in these prices can induce sharp fluctuations in the CPI. For example, the impact on the CPI of this decade's rise in oil prices was muted in a number of EMEs where price controls or subsidies limited the price increases faced by consumers. However, the fiscal impact of those controls or subsidies became so large that a number of governments were prompted to reduce them resulting in sudden sharp increases in CPI inflation. Most central banks deal with administered prices by excluding them from official measures of core inflation (treated below, in the final section).<sup>10</sup>

## CPI coverage of owner-occupied housing

A number of issues pertain to CPI coverage, such as the segments of the population covered and the treatment of hard-to-measure services.<sup>11</sup> But whether and how to include owner occupied housing services in the CPI has attracted a great deal of attention in recent years. Reasons for the concern with owner occupied housing include (1) the large proportion of household expenditures devoted to it;<sup>12</sup> (2) the possible effect of recent boom-bust cycles in home prices that could affect the interpretation of inflation behaviour and purchasing power; and (3) the expectation that Eurostat will incorporate owner occupied housing in the Harmonised Indices of Consumer Prices (HICP) in 2009.

The extent to which the inclusion of owner occupied housing affects measured inflation appears to vary. Christensen, Dupont and Schreyer (2005) report that when using a rental equivalence measure of home costs, the effect is small for France, Japan and the United States. However, simulations suggest that the effect under a user cost approach (applied to Europe), and the effect under approaches for homes that include interest payments, are potentially quite large.

In EMEs, all respondent countries in Table A4 include rental values in the CPI. But although a majority of the EMEs for which responses are available now include owner occupied housing in the CPI, many do not (eg Argentina, Brazil, Chile, Indonesia, Korea, Malaysia, Poland, Russia and Turkey), perhaps because of data constraints and some perceived disadvantages in the measures for such housing.

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<sup>10</sup> However, it may be the case that headline inflation will be more stable than core inflation over some periods because of the effect of regulated prices (see Pesce, 2009, this volume).

<sup>11</sup> For discussion of some of these issues, see ILO (2004).

<sup>12</sup> For example, in Mexico, rental costs have a 2.52% weight in the CPI, but the rental equivalent cost of homes (described later in this section) is nearly 12%. Double-digit weights for homes using rental equivalents or user costs are also reported in Colombia, Israel and South Africa, and are also seen in advanced market economies (Table A4).



Assessing the merits of including owner occupied housing in the CPI is complicated by the fact that there are at least three widely used approaches<sup>13</sup> to their measurement. Some countries (eg Hong Kong SAR, Japan, Mexico, Thailand and the United States) use the *rental equivalence* approach, which imputes a rent to such housing. Other countries, such as Canada and China, apply *the user cost* approach, which covers various costs of home ownership (eg interest payments on mortgages, depreciation, opportunity cost of alternative investments, unrealised capital gains, repairs and maintenance, taxes and insurance). A third approach, known as the *net acquisition approach*, focuses on the average change in the price paid by a household to acquire a home.<sup>14</sup> Australia uses this approach, and European countries are expected to adopt it soon. It mainly measures the price of newly constructed properties (reflecting transactions between households and other sectors of the economy, and excluding purchases of dwellings from other households) and includes repairs and maintenance costs, insurance, and fees for real estate agents.

Which approach for owner occupied housing is best? It has been argued that the answer depends on whether the goods included in the CPI basket have been “used”, “acquired” or “paid” in the base period. For example, the rental equivalence or the user cost approaches to owner occupied housing are appropriate if the CPI goal is to measure the cost of living. The (net) acquisition approach would be appropriate for a CPI that seeks to measure household monetary expenditures (like the HICP used in Europe).<sup>15</sup>

A broader issue is whether the CPI should include *asset prices*, and particularly real estate prices. The rationale is that present and future prices of consumption are relevant in spending decisions, and although future prices are generally not observable, asset prices could provide an indicator. In line with this, some have argued that house prices may be a good approximation of owner occupied housing and should be included in the CPI, particularly to the extent that fluctuations in house price appear to be more closely related to future output growth and future goods and services inflation than do changes in other asset prices (eg equity prices). At this time, no CPI index reported by EMEs in Table A4 includes house prices. However, some central banks do track house prices separately, as these can influence monetary variables, macroeconomic activity and inflation.<sup>16</sup>

A number of implementation issues arise under the three approaches to owner occupied housing listed above.

1. *Data quality.* Indicators that rely on rental (rental equivalence) or house prices (eg net acquisition) require frequently updated, high quality data. Furthermore, the underlying assumption is that rental or housing markets are well developed and relatively free (of government controls). Neither of these conditions may be met in some EMEs.

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<sup>13</sup> A fourth, the payment approach, measures household payments for housing (mortgage interest, alterations and additions etc), but excludes transactions that have no net impact on the household balance sheet (eg down payments, mortgage principal).

<sup>14</sup> See Christensen, Dupont and Schreyer (2005), Table 1. This is regardless of whether they were wholly paid for or used in the period under consideration. Thus, the full value of a dwelling would be included in the CPI, regardless of the timing of its use.

<sup>15</sup> In line with this, the rental equivalence approach to OOH has been rejected by the European Commission because it involves imputation rather than actual transactions, which is not consistent with the HICP approach. For a discussion of the HICP approach, see Diewert (2002).

<sup>16</sup> For example, see discussion of Figure 6 in the paper contributed by the Central Bank of Peru to this meeting, Armas, Vallejos and Vega (2009). For a recent empirical study of links between housing prices and inflation in developed market economies, see Goodhart and Hofman (2008).

2. *Problems of interpretation.* Inclusion of mortgage interest payments in the CPI can raise measured inflation if the central bank raises the policy rate. The effect might be amplified in cases in which variable-rate mortgages or indexation are common. (To avoid this difficulty, the definition used for inflation targeting in South Africa (RPIX) until end-2008 excluded interest payments.) Another issue is whether owner occupied housing indicators based on house prices are misleading. Some approaches (eg net acquisition) require separating the investment component from the consumption component, which may not be feasible. For example, it is argued that excluding land (which is not consumed) is appropriate for the net acquisition approach, but that is hard to do in practice.
3. *Higher volatility.* Measures of owner occupied housing that include interest rates or housing prices may be highly volatile, introducing more noise in the CPI index.

## Pipeline inflation pressures and the PPI<sup>17</sup>

Monetary authorities need data that can help predict the behaviour of the CPI, particularly in the short run. An obvious place to start is by tracking the (output) producer price index (PPI), as so-called “pipeline” inflation pressures – that is, changes in the prices producers charge for goods and services – should eventually be reflected in changes in the prices ultimately paid by consumers (the difference would reflect distribution costs). A number of EME central banks monitor the PPI or similar measure as an indicator of inflation (Table A1). Market analysts’ commentary also frequently discusses pipeline inflation pressure with reference to the behaviour of the PPI.

One issue is the extent to which the aggregate PPI helps predict CPI behaviour. The two series could diverge for extended periods, as the purposes of the two series are quite different. Items included and corresponding weights in the CPI reflect its focus on demand and consumer spending behaviour. In contrast, the PPI has been designed to measure price changes for domestic goods production and for service transactions for which there is an intermediate demand. In some countries, the CPI coverage of services is much more extensive than PPI coverage, which can cause large divergences in the behaviour of the two series.

An open question is how much the PPI should cover final demand transactions, particularly those involving consumer that form part of the personal consumption expenditures (PCE) portion of GDP. Some argue against this, seeing it as “duplicative and costly” (IMF (2004), p 73, paragraph 3.5).<sup>18</sup> One possible solution is to coordinate surveys for the PPI and the PCE. Also, an implication of the paper by the Bank of Mexico (2009, this volume) for this meeting could be that the tracking or forecasting of CPI behaviour might be an important consideration in PPI design. This criterion might also be a factor in determining how much CPI and PPI coverage of final demand should overlap.

The underlying purpose of the PPI also influences recommended PPI coverage. As noted in the PPI manual (IMF, 2004) a PPI concept associated with output price change which is

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<sup>17</sup> The PPI is closely related to, and in many countries is the successor to, the wholesale price index, or WPI. The WPI was developed to measure price changes in markets other than retail. Compared with the WPI, the PPI covers more products and industries and conforms more closely to the System of National Accounts. See Chapter 14 of IMF (2004).

<sup>18</sup> It has also been noted that covering final demand is more feasible when a PPI program is industry based (rather than commodity based) as survey respondents for an industry-based PPI can usually provide data for final demand transactions (as well as for intermediate transactions).

appropriate for GDP deflation will generally include export prices (pertaining specifically to business establishments covered by the PPI) and exclude import prices. In contrast, the CPI, which is more consistent with a (domestic) demand-based index, excludes both, implying that there will be (export price-driven) movements in the PPI that are absent from the CPI. Related differences between production-based and demand-based concepts of inflation were highlighted in our earlier discussion of national account prices (see discussion of Graph 1).<sup>19</sup>

How much divergence is there in practice between PPI inflation and CPI inflation? As illustrated in Graph A1, divergences can be quite large and persistent, as the PPI tends to be much more volatile than the CPI. In this decade, PPI inflation has on average been significantly higher than CPI inflation. Against this, the median correlation between the CPI and the PPI is high in Latin America and other EME regions, and has risen in recent years in Asia (Table 1). However, country detail reveals that the correlation remains quite low in many countries (Table A5).

Table 1  
**Consumer and producer price inflation in EMEs<sup>1</sup>**

EME	2001–08					2007–08
	CPI average	PPI average	CPI standard deviation	PPI standard deviation	Correlation CPI and PPI	Correlation CPI and PPI
Asia <sup>2</sup>	3.0	4.7	2.1	3.8	0.45	0.86
Latin America <sup>3</sup>	5.9	9.6	2.9	7.8	0.81	0.79
Other <sup>4</sup>	6.1	7.8	3.5	4.9	0.80	0.76

<sup>1</sup> Regional figures are the median of the economies listed in each group. Average, standard deviation and correlation coefficients are calculated using the 12-month changes in consumer and producer prices, in per cent. <sup>2</sup> China, Hong Kong SAR, India, Indonesia, Korea, Malaysia, the Philippines, Singapore and Thailand. <sup>3</sup> Argentina, Brazil, Chile and Mexico. <sup>4</sup> Poland, Russia, Saudi Arabia, South Africa and Turkey.

Sources: Thomson Reuters Datastream; national data.

Empirical evidence on the extent to which the PPI can help predict the CPI is mixed. Studies based on US data (Clark (1995); Blomberg and Harris (1995)) find no evidence that the PPI helps predict the CPI. In contrast, the Bank of Mexico's contribution to this volume finds that PPI inflation predicts CPI inflation in Mexico in a cointegrating regression that explains just under 60% (adjusted R-squared) of the variance of CPI inflation.<sup>20</sup> This reflects two improvements in the Bank of Mexico's study compared to earlier studies: the PPI data have been revised in Mexico so that services are included, reducing the divergence between the CPI and the PPI caused by the inclusion of very different items; time series analysis exploits the stationarity of the CPI and PPI series and the cointegration of these two series. Further study of the relationship between the CPI and PPI in EMEs (including analysis of out of sample forecast errors) can yield additional insights.

<sup>19</sup> Administered or regulated prices could also be a source of difference between the CPI and PPI if they apply to one and not to the other. Such prices account for a large share of the CPI in a number of EMEs (Table A3) even in cases in which producer prices are not subject to controls.

<sup>20</sup> The CPI responds to a lagged error-correction term reflecting long-run convergence of the CPI and the PPI.

## Inflation persistence, shocks and core inflation

An important challenge for monetary authorities is how to deal with persistence in inflation. Research (eg Angeloni, Coenen and Smets (2003)) indicates that higher inflation persistence amplifies and prolongs the output and inflation effects of a monetary policy shock, and that these effects can be large. Inflation persistence thus implies that monetary policy is more costly and can increase the risk that inflation will interact with expectations and institutional arrangements like indexation, producing undesirable effects such as wage-price spirals. However, the significant decline in inflation in recent decades has alleviated some of the concerns associated with inflation persistence; indeed a recent study finds that inflation persistence is not a major feature of inflation in industrial economies (Levin and Piger (2003)).

Persistence is related to inflation expectations (see Moreno and Villar (2009, this volume)) and particularly to the credibility of the target in an inflation targeting regime (see Central Bank of Chile's contribution to this meeting by Desormeaux et al (2009, this volume)). A study of advanced and emerging market economies (Kuttner and Posen (2001)) indicates that inflation persistence has declined in those EMEs that have formally adopted inflation targeting. However, concerns remain about inflation persistence in EMEs, in part because wage indexation is still significant in some countries (see companion background note). Also, Capistran and Ramos Francia (2006) find that while inflation persistence has declined in a number of countries in Latin America it remains high in others.

A related challenge is to interpret the behaviour of CPI inflation, and its consequences for monetary policy, when it is driven by temporary but possibly persistent external and domestic shocks. For example, as noted earlier, EMEs in recent years have experienced very large terms-of-trade shocks associated with sharp increases in the prices of oil and other commodities that lasted for an extended period (see Graph 1). A special challenge is to determine to what extent shocks to the prices of food commodities reflect cyclical factors or structural changes such as increasing demand due to rising incomes, the effects of globalisation and external demand, and reduced supply due to urbanisation (eg see Vargas et al (2009, this volume) or Yorukoglu (2009, this volume)). An additional consideration is the effects of commodity price shocks on the fiscal position of the government in a commodity exporting country (eg see Al-Hamidy (2009, this volume)). The transmission channels of these shocks are too complex to be identified or quantified informally or through simple pass-through assumptions (the pass-through would vary depending on a variety of factors, as discussed below).

How should these effects be interpreted or dealt with for purposes of policymaking? We highlight two approaches here. One approach is to isolate the effects of temporary shocks to the terms of trade using an economic model (typically a dynamic stochastic general equilibrium model) that can illustrate transmission channels and show how key features of the economy or policy affect the inflation response. For example, Desormeaux et al (2009, this volume) employ a model of a small, open economy (based on Medina and Soto (2007)) to show how CPI inflation responds to an oil price shock under alternative assumptions of monetary policy credibility and to a copper price shock under alternative fiscal rules (Chile is an oil importer and a copper exporter). Their simulations indicate that CPI inflation would rise by more and be more persistent in response to (1) a temporary increase in the oil price when monetary policy is less credible;<sup>21</sup> (2) a copper price increase if fiscal policy is expansionary

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<sup>21</sup> To analyse the effects of less monetary policy credibility, the authors assume that "since the oil price shock leads to a temporary increase in inflation ... private agents believe that part of this increase is due to a relaxation of the target by the monetary authority while in fact it is not" (Desormeaux et al (2009, this volume), p 103).

rather than constrained by following a fiscal surplus rule. For another example, Jakab and Karvalits (2009, this volume) show how in a small open economy like Hungary optimal monetary policy will respond to import price (or terms-of-trade) shocks if imports are production inputs but not necessarily if imports are used only in final consumption.

Because it clarifies the impact of shocks and transmission channels in a rigorous way, policy analysis using these types of models is becoming increasingly popular among central banks. However, the methodology is technically demanding and the accuracy of these types of simulation is still uncertain.

The second approach to be highlighted is to focus on measures of core (also called here “underlying”) inflation, which exclude or dampen the measured impact of temporary shocks. Three issues surrounding the design and use of core measures warrant particular attention.

The first is *how to measure underlying inflation*. EME central banks typically use statistical techniques that decompose transitory and underlying inflation.<sup>22</sup> However, the precise methods can vary considerably. The most popular approach (Table A6) is exclusion-based, ie a core inflation measure is obtained that excludes items on the basis of a variety of criteria such as volatility (eg raw food and energy), seasonal behaviour (eg raw food), a large effect of indirect taxation, or administered prices (eg energy in a number of countries).

Graph A1 illustrates the behaviour of measures of core inflation in EMEs. Central banks sometimes exclude several items at a time, to focus on a single core inflation series, or alternatively exclude one or few items at a time so that several core inflation indicators are monitored. One limitation of the exclusion approach is that it is not always clear which items, if any, should be removed. For example it has been argued that while demand for commodities from China has put upward pressure on headline inflation in EMEs, the increase in the global supply of manufactured consumer goods originating in China has had the opposite effect. It is then not clear why, when defining core inflation, commodity prices should be excluded while manufactured consumer goods prices are retained. A related difficulty is that the inflation signal from alternative measures of core inflation may differ significantly, and it is not always obvious which one to believe (see Vargas et al (2009, this volume)).

An alternative approach to measuring underlying inflation that is also popular in EMEs is to exclude the upper and lower segments of price changes in the components of headline inflation (trimmed means). The idea is that large relative price changes will be quickly reversed and can therefore be excluded in measuring underlying inflation. However, it has been argued that extreme price movements could contain useful information about future inflation that should be retained.<sup>23</sup>

A second issue is *the usefulness and reliability of measures of underlying inflation as indicators of the trend of headline inflation*. In particular, measures of headline and underlying inflation sometimes diverge for extended periods, raising the question of whether the core measure is indeed capturing the trend in inflation. A related question is which measure of underlying inflation is best as an indicator of the trend in headline inflation. Work by Rich and Steindel (2007) and a number of central bank contributions for this meeting (eg Armas et al(2009); Guinigundo (2009); Kim et al (2009), Leung et al (2009); and Wiesiolek and Kosior (2009)) apply criteria for judging indicators of underlying inflation. These include:

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<sup>22</sup> An alternative is to derive core inflation from an economic model. In this approach, restrictions in a multivariate (empirical) model of aggregate inflation and its determinants separate core from non-core inflation.

<sup>23</sup> For other approaches to measuring core inflation, see the contributions of Leung et al (2009); Wiesiolek and Kosior (2009) in this volume; and Rich and Steindel (2007). The Leung, et al paper discusses in detail the principal components method, which uses constituent items of the CPI to estimate a set of weights that explain the largest part of the variation in headline inflation.

- the transparency of the measure;
- computational effort;
- data consistency (eg the average of the core inflation measure should be close to the average of the headline measure, and the volatility of core inflation should be lower than that of the headline measure);
- information content (an underlying inflation measure that retains more information is preferred);
- cointegration between headline and underlying inflation, in which headline inflation reverts to the underlying rate and not vice versa (ie the underlying or core measure is exogenous); and
- in-sample and out-of-sample forecasting performance.

A third issue is *how the measure of underlying inflation should be used*. It could be argued that comparing a well-defined core inflation measure (one that is a good predictor of headline inflation and that adequately reflects its long-run trend) with the inflation target could be more relevant than comparing headline inflation with the target. In the short run, the gap between headline and target could be very wide but not reflect underlying trends that would be captured the gap between core and target. Indeed, in the Bank of Israel contribution to this meeting, Eckstein and Segal (2009) use a New Keynesian model of a small open economy and a loss function adapted to the Israeli economy and find that a Taylor rule that responds to core inflation is preferable to one that responds to the headline measure. However, all central banks participating at this meeting – with the exception of Thailand – target or focus on headline measures of inflation. Indeed, although measures of core inflation are often published and are monitored regularly, many central banks report that they are mainly for supplementary and internal use.

Why are measures of core inflation not used more often as policy targets? One reason is that headline inflation more accurately reflects the short run effect of prices on the cost of living or purchasing power of households. This is a very important consideration for policymakers and the public at large. Another is that core inflation poses difficulties in communication. For example, it involves additional statistical manipulation and can be defined in a variety of ways; those characteristics can reduce its credibility and its transparency as an indicator of inflation.<sup>24</sup>

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<sup>24</sup> Further discussion of the issues in selecting a measure for core inflation is provided in the Bank of Thailand's contribution to this meeting (see Waiquamdee (2009)).

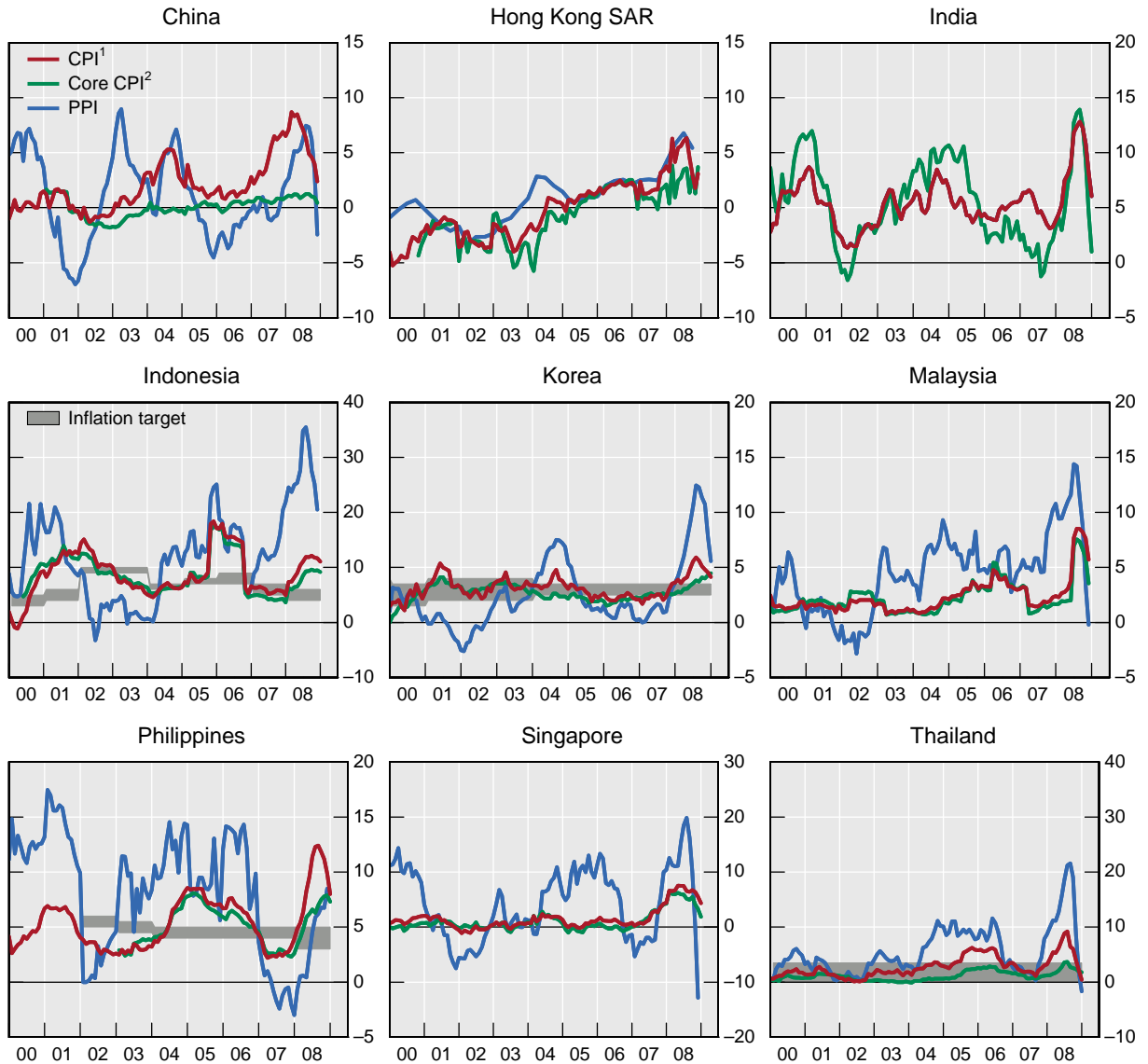
# Annex Graphs and tables

Graph A1

## Price developments

Annual changes, in per cent

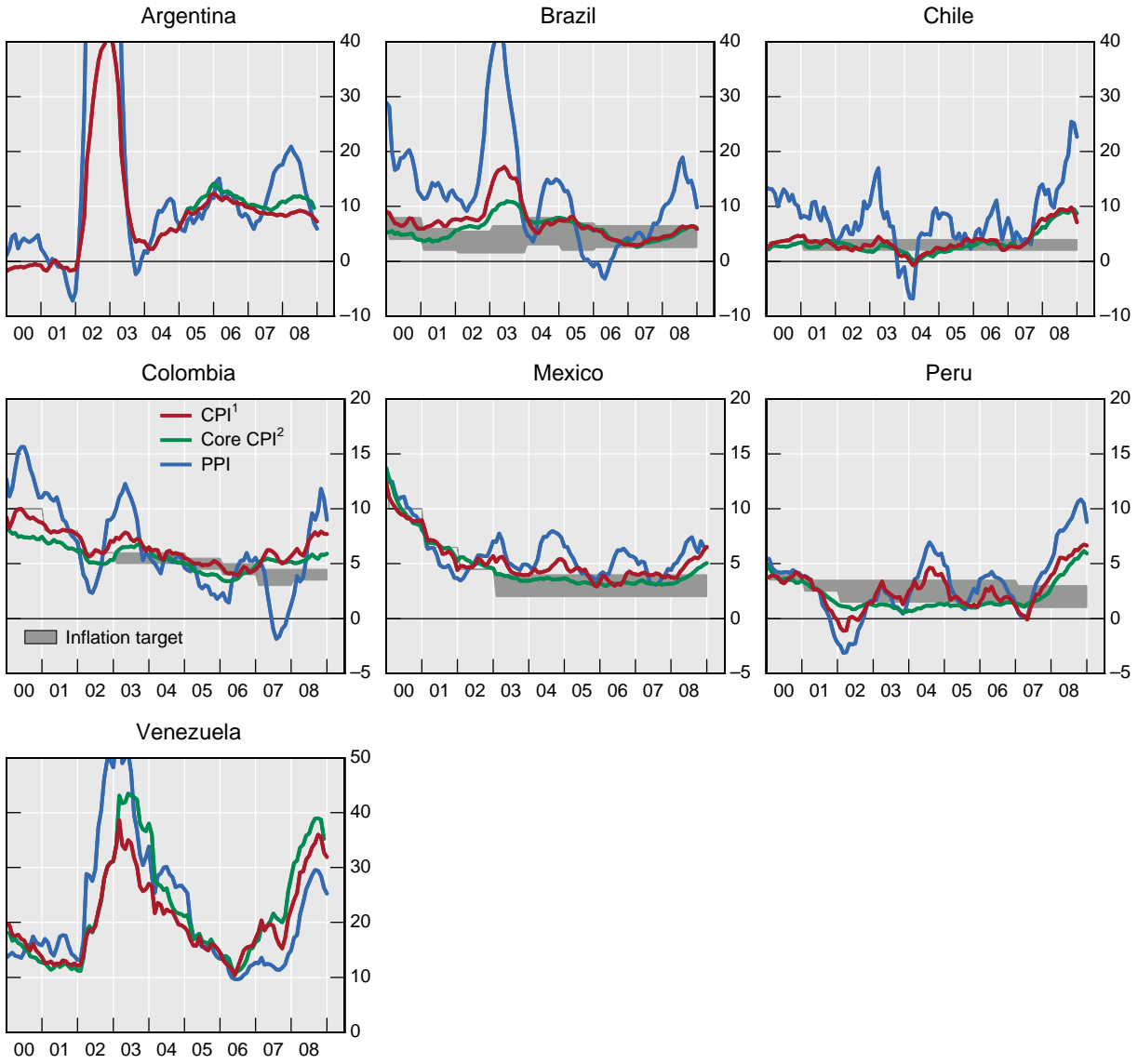
Asia



<sup>1</sup> For India, wholesale prices. <sup>2</sup> Data are not comparable across countries due to differences in the scope of items in the core measure: For the Czech Republic, Hungary, Korea and Mexico, core is the OECD CPI non-food non-energy series. For China, Indonesia, Hong Kong, India and Singapore, core consists of BIS calculations excluding food and energy. Official data otherwise.

Graph A1 (cont)  
**Price developments**  
 Annual changes, in per cent

Latin America



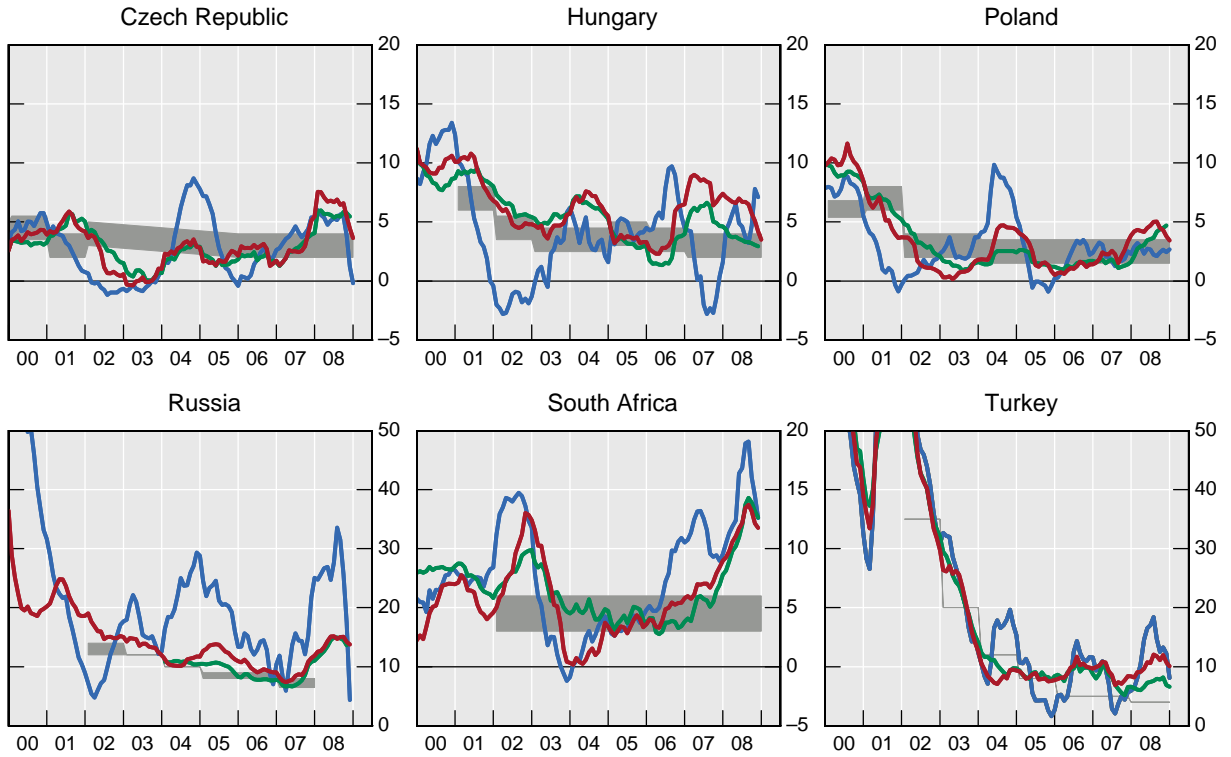


Graph A1 (cont)

**Price developments**

Annual changes, in per cent

Other emerging economies



Sources: Thomson Reuters Datastream; CEIC; national data.

Table A1  
Inflation measures and their use by central banks

Central bank	Inflation measure	Target, objective, guideline, reference rate, indicator, benchmark	Other price indices <sup>1</sup>
Argentina	CPI GBA	Benchmark	Producer price index, construction cost index, export and import prices, GDP deflator, index of commodity prices, CPI for other provinces
Brazil	IPCA	Target	INPC (CPI for low-income population) IPC-Fipe (CPI for Sao Paulo – City) IGP-DI and IGP-M (general price indices, including CPI, construction index and wholesale price index) Import and export prices
Chile	CPI	Target	Producer price index (PPI) Wholesale price index (WPI)
China	CGPI (corporate goods price index) CPI		Retail prices Ex-factory price indices of industrial goods Purchasing price indices of raw materials Fuel and power Price indices of investment fixed assets Price indices for real estate
Colombia	CPI	Target	PPI (Includes Import Prices) Export prices (at the producer level) Used/new house prices Construction cost index
Czech National Bank	CPI	Target	GDP deflator PPI Import prices Unit labour costs

Table A1 (cont)  
Inflation measures and their use by central banks

Central bank	Inflation measure	Target, objective, guideline, reference rate, indicator, benchmark	Other price indices <sup>1</sup>
Hong Kong SAR	CPI	Not used for monetary policy (Objective of HKMA: exchange rate stability through currency board arrangement)	PCE deflator GDP deflator Rental index Retail sales deflator
Hungary	CPI	Target (within inflation targeting framework)	Pensioners price index, constant tax index, HICP
Indonesia	CPI	Target, objective, benchmark	Wholesale price index Producer price index Construction price index Unit value index
Israel	CPI	Target	Unit labour cost indices Business sector product deflator Import prices
Korea	CPI	Target	Producer price index Import price index Housing price index
Malaysia	Headline CPI	Benchmark	Producer price index Import/export value index House prices
Mexico	CPI	Target	PPI ITPI (international trade price index). CCI (construction cost index)
Peru	Headline CPI	Target (1%–3%)	Wholesale price index
Philippines	Headline CPI	Target	Core inflation
Poland	Monthly CPI, y-o-y, not seasonally adjusted	Inflation target	Agricultural price indices Import price index Industry, services and construction price indices World markets commodities prices
Russia	CPI	Objective	Wholesale price index Cost indices Import/export prices

Table A1 (cont)  
Inflation measures and their use by central banks

Central bank	Inflation measure	Target, objective, guideline, reference rate, indicator, benchmark	Other price indices <sup>1</sup>
Saudi Arabia	CPI	Price stability, financial stability, and exchange rate stability	Wholesale price Index, GDP deflator, non-oil GDP deflator
Singapore	Headline CPI MAS underlying inflation (CPI excluding private road transport and accommodation costs)	Both inflation measures are used as a benchmark for monetary policy	Import and export prices Domestic supply index Manufacturer price index
South Africa	1. CPIX up to the Dec 2008 data point  2. Headline CPI from Jan 2009	1. Target range between 3 and 6% in CPIX  2. Target range between 3 and 6% in headline CPI	1. CPIX excl. food and petrol, trimmed mean CPIX  2. Headline CPI excl. food and petrol, trimmed mean headline CPI
Thailand	Core inflation (CPI excluding prices of fresh food and energy) Headline inflation	Target  Guideline/indicator	<ul style="list-style-type: none"> <li>• Producer price index</li> <li>• Import/export price index</li> <li>• GDP deflator</li> <li>• Nominal/real unit labour costs</li> </ul>
Turkey	CPI	Target	<ul style="list-style-type: none"> <li>– Producer price index</li> <li>– Import and export prices</li> <li>– World market commodity prices</li> <li>– Unit labour costs</li> </ul>
<i>Memo:</i> Canada	<i>CPI</i>	<i>Target</i>	<i>PCE</i> <i>GDP deflator</i> <i>Commodity price index</i>
<i>Euro area – ECB</i>	<i>HICP</i>	<i>Index of reference in the definition of price stability (to compute the euro area average)</i>	<i>Producer prices</i> <i>National account deflator</i> <i>Labour costs</i> <i>Unit labour costs</i> <i>World market commodity prices</i>

Table A1 (cont)  
**Inflation measures and their use by central banks**

<b>Central bank</b>	<b>Inflation measure</b>	<b>Target, objective, guideline, reference rate, indicator, benchmark</b>	<b>Other price indices<sup>1</sup></b>
<i>Japan</i>	<i>CPI Core inflation (CPI excluding fresh food)</i>	<i>CPI is the benchmark to assess price stability in the long run  Core inflation is the benchmark to assess price stability in the current and near future</i>	<i>Corporate goods price index (domestic, import, export)  Corporate service price index GDP deflator</i>
<i>United States</i>	<i>PCE excluding food and energy</i>	<i>Guideline/indicator</i>	<i>Producer price index Import and export prices</i>

<sup>1</sup> Refers only to headline inflation; core inflation measures are listed in Table 3.

Source: Questionnaire responses of meeting participants or "Inflation measures from the perspective of monetary policy", IFC (2006), Table 1, p 47.

Table A2

**Ranking and estimates of the measurement bias in CPI statistics**

Central Banks	Ranking of bias	Estimates (sources)
Argentina	1. New-product; 2. Substitution; 3. Outlet; 4. Quality	...
Brazil	...	...
Chile	...	...
China	...	...
Colombia	...	Substitution bias: 0.7 percentage points 1989–98 (Caicedo, Banco de la República, WP152 (2000))  Total bias: 1.63–1.69 percentage points, based on Hamilton's methodology applied to the income/expenditure surveys of 1984/85 and 1994/95 (Langebaek and Caicedo, Banco de la República, WP435 (2007))
Czech National Bank	...	...
Hong Kong SAR	Substitution, quality, outlet, new-product	Around 1.0%
Hungary	...	...
Indonesia	1. Quality; 2. Substitution; 3. Outlet; 4. New-product	...
Israel	...	...
Korea	1. Quality; 2. Outlet; 3. Substitution; 4. New-product	0.7 percentage points (Chung et al (2007))
Malaysia	1. Substitution	...
Mexico	1. Quality; 2. Substitution; 3. Outlet; 4. New-product	...
Peru	...	...
Philippines	...	...
Poland	Quality, new-product, outlet, substitution	...
Russia	1. Quality; 2. Substitution; 3. New-product	...
Saudi Arabia	–	–
South Africa	No statistical ranking of biases exists	No estimates of biases exist
Thailand	1. Substitution; 2. New-product and new-outlet; 3. Quality	Very preliminary internal study
Turkey	...	...

Table A2 (cont)

**Ranking and estimates of the measurement bias in CPI statistics**

<b>Central Banks</b>	<b>Ranking of bias</b>	<b>Estimates (sources)</b>
<i>Memo:</i>		
<i>Canada</i>	1. <i>Quality (0.15)</i> ; 2. <i>Substitution (0.15)</i> ; 3. <i>New-product (0.10)</i> ; 4. <i>Outlet (0.10)</i>	0.58 with a upper bound of 0.75 (Rossiter, 2005)
<i>Euro area – ECB</i>	1 <i>Quality and new-product</i> ; 2. <i>Substitution</i>	1–1.5 (Wynne, 2005)
<i>Japan</i>	1. <i>Quality</i> ; 2. <i>New product</i>	Not yet available
<i>United States</i>	1. <i>Quality (0.4)</i> ; 2. <i>Upper-level substitution (0.3)</i> ; 3. <i>Measure errors in expenditure weights (0.1)</i> ; 4. <i>Lower-level substitution (0.05)</i> ; 5. <i>New-outlet (0.05)</i>  <i>The figures in brackets are reported by Lebow and Rudd (2003)</i>	0.4–1.5 (Lebow, Roberts and Stockton, 1994) 1.0 (Shapiro and Wilcox, 1996) 1.1 (Boskin Report, 1996) 0.8 (GAO update of Boskin Report, 1999) 0.9 (Lebow and Rudd, 2003)

– Not applicable.

... Not available.

Source: Questionnaire responses of meeting participants or IFC (2006).

Table A3  
Administered and regulated prices

Central bank	Categories	Weight in CPI	Treatment in assessing inflation
Argentina	Fuels for housing (1.57%), electricity (1.60%), water and sewage services (0.55%), public transport (6.31%), vehicle maintenance (5.31%), postal services (0.08%), phone services (3.70%)	19.1%	Excluded from main official core inflation indicator
Brazil	Housing (water, electricity, gas) (6.14%) Transportation (bus, subway, gasoline, ethanol, vehicle gas etc) (11.71%) Healthcare (medicines and health insurance) (6.21%) Communication (post and telephone) (5.15%) Other (0.40%)	29.62%	...
Chile	Electric power (1.6%); water distribution (1.1%); telecommunications (2.3%); public transport (3.0%); and certain local taxes (2.7%)	10%	Excluded from a central bank measure of underlying inflation
Colombia	Natural gas (home use) 0.60; electric energy 1.46; water, sewage and garbage collection 1.29; urban public transportation 3.81; intermunicipal transportation 0.78; fuel (gasoline, diesel) 1.08	9.04%	All or some regulated prices are excluded from the core inflation measures
Czech Republic	Electricity 3.5%; heating 2.9%; natural gas 2.3%; transport 1.7%; regulated rents 1.6%; health 1.3%	16.4%	A secondary measure of core inflation excludes administered prices. However, monetary policy discussions focus on core inflation without energy and headline inflation net of the impact of indirect taxes



Table A3 (cont)

**Administered and regulated prices**

<b>Central bank</b>	<b>Categories</b>	<b>Weight in CPI</b>	<b>Treatment in assessing inflation</b>
Hong Kong SAR	Public housing rents in the rental component of the CPI are set and reviewed by the government. Periodic adjustments reflecting the movement in the median household income of the tenants	...	For one-off waivers on property rates, public housing rents and other short-term relief measures implemented by the government, their effects on the headline CPI inflation will be removed in assessing the underlying inflation pressure
Hungary	Energy related items including heating (central heating, natural gas) and electricity (7%); utilities (water, sewerage, refuse collection) 3%; telecom services (4%) and travel-related expenses (local and domestic public transport) 2%; medicines represent an additional 2.5% and regulated house rent 0.4%	21%	The main underlying inflation measure is based on core inflation, which includes traded goods, market services, processed food, alcoholic beverages and tobaccos, covering 65% of the total CPI basket; administered prices are excluded from the core. The calculation of underlying inflation also takes into account the price effects of indirect tax changes (eg VAT rates changed three times in Hungary in the past four years)
Israel	Two groups: controlled prices and supervised prices –  Controlled prices: prices in public services such as education (elementary and high school), public health services, public transportation and communications  Supervised prices: prices of monopolistically manufactured products such as fuel and dairy products and bread prices	Controlled prices, about 16%; supervised prices, about 4.5%	Because the administered prices are dealt with by various government ministries and are not grouped in a usable manner, the Bol does not adjust its assessments of underlying inflation to take them into account. A project is in progress to collate these prices so that they can be taken into account in inflation assessments

Table A3 (cont)

**Administered and regulated prices**

<b>Central bank</b>	<b>Categories</b>	<b>Weight in CPI</b>	<b>Treatment in assessing inflation</b>
Korea	Postal and telephone services, 4.12%; electricity, city gas and regional heating charges, 3.67%; medical services, 3.06%; transportation services, 2.73%; tuition(public), 1.14%; water and sewage disposal charges, 0.78%; others, 0.81%	16.31%	City gas charge (weight in CPI, 1.16%), which is an administered price, is excluded in calculating core inflation
Mexico	Administered prices are energy products (gasoline, electricity, propane and natural gas) prices set by the federal government (7.77%)  Regulated prices by different government levels: goods and services such as public transportation, telephone service, property taxes, road fees, parking fees, passports and licenses (9.39%)	17.17%	Administered and regulated prices are excluded from the core inflation measure
Peru	Electricity, 2.2%; telephone services, 1.3%; water services, 1.0%	4.5%	Administered prices are excluded from core CPI measure
Philippines	Transportation: the Land Transportation and Regulatory Board regulates the adjustment in land and transportation fares by reviewing and approving petitions filed by transport and consumer groups  Utilities: the Energy Regulatory Commission regulates the adjustment in electricity rates by reviewing/approving petitions filed by Meralco	Transportation and communication comprises 7.52% of CPI; light (under fuel, light and water) is 2.35% of CPI.	The BSP regularly and carefully monitors developments as well as the outlook in the petitions for fare and rate increases. Upside risks in higher utility rates as well as transport fares figure prominently in the assessment of the BSP's inflation outlook. Transport fares and utility rates are treated as sensitivity additions based on their CPI weights relative to the multi-equation and single equation model baseline

Table A3 (cont)

**Administered and regulated prices**

Central bank	Categories	Weight in CPI	Treatment in assessing inflation
Poland	Water supply, 1.040%; electricity, 3.767%; natural gas, 1.650%; heat energy, 2.680%; actual rents paid by tenants including other actual rentals, 0.538%; sewage collection, 0.493%; other services relating to the dwelling nec, 0.293%; other services in respect of personal transport equipment, 0.113%; by railway, 0.266%; by road, 0.903%; by air, 0.115%; by sea and inland waterway, 0.010%; combined passenger transport, 0.197%; postal services, 0.042%; telephone and telefax services, 5.121%; fees for TV and radio, 0.419%; other services nec, 0.370%	All administered prices: 18.017%	<p>The NBP's macroeconomic model, Necmod, divides CPI inflation into three components: core inflation, energy prices and food prices. Forecasts from the energy prices equation are then judgmentally corrected to account for administrative decisions (energy prices are the largest component of administered prices). No use has been made of corrections to account for the impact of administrative measures on other inflation sub-indices other than energy</p> <p>The NBP also maintains a disaggregated short-term inflation forecast (unpublished) that directly takes into account many of the administrative measures that influence prices</p>
Saudi Arabia	Main sectors: petroleum products, 6.0%; electricity 3.1%	Less than 10%	SAMA does not issue the inflation index. The CPI and the wholesale price index (WPI) are issued monthly by the Central Department of Statistics and Information. The indices are issued with the relevant detailed information, including the relative shares of the administered prices. Given that the administered prices are usually set for a long period of time, those prices have no upward or downward effect on the underlying inflation

Table A3 (cont)  
Administered and regulated prices

Central bank	Categories	Weight in CPI	Treatment in assessing inflation
South Africa	<p>Housing (sanitary fees, refuse removal, assessment rates, water and university boarding fees), 3.57%</p> <p>Fuel and power (electricity and paraffin), 3.21%</p> <p>Medical care (public hospitals), 0.09%</p> <p>Communication (telephone calls, telephone rent and installation, postage, cell phone connection fees and cell phone calls), 2.90%</p> <p>Education (school fees and university, technicons and college fees), (2,70%)</p> <p>Transport (petrol, public transport – municipal buses and trains, motor licenses and registration); and (5,21 %)</p> <p>Recreation and entertainment (television licence) (0,21%)</p>	17.89%	To account for the effect of administered price changes on underlying inflation, the SARB also, when deemed necessary, analyses core inflation excluding administered prices. When deemed necessary, specific administered price increases, such as electricity, may also be excluded from inflation indicators
Thailand	Administered to energy and public utilities (11.1%) and public transportation (4.1%)	Price controls account for 38% of the CPI basket (2007 as base year)	Calculate, and use internally, CPI ex. administered prices
Turkey	Main sectors: public health and transportation services, medicines, government education fees, alcoholic beverages and tobacco products (through tax policies), fuel prices (through tax policies). There are also some minor sub-items, such as lottery games, water fees (set by municipalities), fees for legal services	...	There are special CPI aggregates in Turkey. Some of them are designed to make adjust for administered prices, including the effect of indirect taxes. For example, special CPI aggregate F (CPI excluding energy, alcoholic beverages, tobacco products – the products having administrated prices and indirect taxes) is largely constructed with these considerations in mind.

Source: Questionnaire responses of meeting participants or IFC (2006).

Table A4

## The treatment of housing services in the CPI

Central bank	Rental values		Owner-occupied housing		
	Collection practices	Weight (%)	Is OOH included?	Valuation methods for OOH	Weight (%)
Argentina	Survey sample of rented houses	5.37	No	–	–
Brazil	Surveys (1) house to house (not very important); (2) major private rental companies	2.71	No	–	–
Chile	Survey panel of households that pay rent	4.43	No	–	–
China	...	13.00	Yes	User cost	...
Colombia	Sample unit: lessee that pays rent for an apartment, house or room, polled once every four months (ie sample rotates every month in a four-month period)  Lessee population is stratified by city and income level according to sample areas	5.06% of CPI basket	Yes	Rental equivalence (impute to the homeowner the percentage change in rental value nearest to the homeowner)	15.06
Czech National Bank	Survey sample of rented houses (net rent, cooperative dwellings)	13.3	Yes	Cost-based (mainly prices of construction work and materials)	9.8
Hong Kong SAR	Public rental values: administrative records  Private rental values: Survey	29.86	Yes	Rental equivalence	...
Hungary	Only public rents (administered price), monthly	0.4	Yes	Simple average of house maintenance products and services	5.4
Indonesia	Survey (cost of living and routine survey of prices)	26.2486	No	–	–
Israel	Survey of rental houses	3.97	Yes	User cost approach	16.32
Korea	Monthly survey of tenant households	9.75	No	–	–
Malaysia	Quarterly survey	...	No	–	–

Table A4 (cont)

**The treatment of housing services in the CPI**

Central bank	Rental values		Owner-occupied housing		
	Collection practices	Weight (%)	Is OOH included?	Valuation methods for OOH	Weight (%)
Mexico	Survey of housing sample divided into six subgroups, each surveyed twice per year	2.52	Yes	Rental equivalence adjusted by construction cost variations	11.97
Peru	Survey in sample of rented houses	2.3	No	–	–
Philippines	Housing and repairs component of CPI (includes only minor repairs and rentals). Rent control is still in effect, an increase of no more than 10% is allowed	16.8	No	–	–
Poland	Actual rent paid by tenants	0.54	No	–	–
Russia	Price survey of households and real estate firms	12.53	No	–	–
Saudi Arabia	Data collected every six months. Data for one-sixth of the rent sample are collected each month	18 (1999 weights)	Yes	Rental equivalence (included in rent weight)	–
Singapore	Rent survey conducted by DOS. Data obtained from relevant public sector agencies	14	Yes	Rental equivalence	...
South Africa	Quarterly visits to rental agencies to track actual rent values for specific houses, flats and townhouses	4.76 (CPIX)	Yes	Rental equivalence (use of interest on home loans discontinued from January 2009)	12.2 (headline CPI)
Thailand	Housing units are surveyed every 6 months on a rotating basis	15.2 (Including rental values and owner-occupied housing)	Yes	Rental equivalence	...

Table A4 (cont)

## The treatment of housing services in the CPI

Central bank	Rental values		Owner-occupied housing		
	Collection practices	Weight (%)	Is OOH included?	Valuation methods for OOH	Weight (%)
Turkey	Rent index based on monthly survey of a fixed sample of dwellings. Household budget surveys determine weights	4.74	No	–	–
<i>Memo:</i>					
Canada	<i>Monthly survey of tenants, based on the framework of the Labour Force survey (15000 dwellings)</i>	6.14	Yes	<i>User cost approach</i>	15.98
Euro area – ECB	<i>Weighted average of the member states</i>	6.321	No	–	–
Japan	<i>Monthly price survey for selected areas for 22 000 rental units (rotation over time)</i>	3.48	Yes	<i>Rental equivalence</i>	13.60
United States	<i>Survey to a sample of households (50 000 landlords and tenants)</i>  <i>Rental values are quality adjusted</i>	5.832	Yes	<i>Rental equivalence</i>	23.442

– Not applicable.

... Not available.

1. Represents the component "Residence", which contains, among other items, water, electricity and fuels, house construction and decoration materials and house renting. No breakdown is available for the sub-components.
2. Includes rental values but also water, electricity, gas and fuels.
3. Includes rental values, water, electricity, gas and other fuels.
4. Includes rental values and owner occupied housing.

Source: Questionnaire responses of meeting participants or IFC (2006).

Table A5  
Consumer and producer price inflation<sup>1</sup>

	2001–08					2007–08
	CPI average	PPI average	CPI standard deviation	PPI standard deviation	Correlation coefficient of CPI and PPI	Correlation coefficient of CPI and PPI
Asia	3.0	4.7	2.1	3.8	0.45	0.86
China	2.4	0.7	2.5	3.8	0.45	0.50
Hong Kong SAR	0.2	1.0	2.6	2.6	0.87	0.99
India	5.0	5.4	1.8	2.3	0.43	0.86
Indonesia	9.5	12.2	3.7	8.6	0.33	0.80
Korea	3.3	2.6	1.0	3.3	0.65	0.97
Malaysia	2.5	4.7	1.7	3.7	0.45	0.31
Philippines	5.5	7.6	2.6	5.5	0.40	0.86
Singapore	1.6	3.4	2.1	6.6	0.52	0.74
Thailand	3.0	5.9	2.0	4.7	0.87	0.95
Latin America	5.9	9.6	2.9	7.8	0.81	0.79
Argentina	10.3	19.9	10.2	31.6	0.96	0.00
Brazil	7.1	11.8	3.5	10.1	0.84	0.91
Chile	3.7	7.5	2.3	5.6	0.77	0.81
Mexico	4.7	5.4	1.0	1.3	0.46	0.77
Other EMEs	6.1	7.8	3.5	4.9	0.80	0.76
Poland	2.7	2.6	1.8	2.2	0.29	0.30
Russia	13.4	17.5	4.0	6.7	0.17	0.76
Saudi Arabia	2.0	2.8	3.3	3.4	0.89	0.93
South Africa	6.1	7.8	3.5	4.9	0.80	0.73
Turkey	21.0	23.3	18.9	23.1	0.98	0.86
Total EMEs	4.2	5.6	2.5	4.8	0.58	0.80

<sup>1</sup> Average, standard deviation and correlation coefficients are calculated with the 12-month changes in consumer and producer prices, in per cent. Regional figures are the median of the economies listed in each group.

Sources: Thomson Reuters Datastream; national data.



Table A6  
Number of core inflation measures and their use by central banks

Central bank	Specific product exclusion measures	Trimmed means or related	Other core inflation measure	Purpose
Argentina	2 (i) Excludes highly volatile items or those with a seasonal pattern; items largely affected by indirect taxation or administered prices (published); (ii) food and energy (unpublished).	...	1 CPI weighted by persistence (Cutler)	Internal use to assess inflationary pressures
Brazil	1 Excluded: administered prices and food at home	3 (i) Excludes percent changes in prices with cumulative weight less than 20% or higher than 80%; (ii) same as (i) but smoothing price increases of some utilities; (iii) excludes percentage changes in prices for which cumulative weight is less than 14.4% or more than 90.4%	...	As an "auxiliary tool" in determining the interest rate  For both internal and external communication of monetary policy
Chile	4 All published. Excluded: (i) fruits, fresh vegetables and fuels; (ii) like (i) minus perishable foods, regulated tariffs, indexed prices, financial services; (iii) like (ii) minus all foods; (iv) all food and energy	1 Truncated mean of CPI index	...	Provide a general and robust measure of the trajectory of underlying inflation
China	...	...	...	...

Table A6 (cont)

## Core inflation measures and their use by central banks

Central bank	Specific product exclusion measures	Trimmed means or related	Other core inflation measure	Purpose
Colombia	6 Excluded: (i) food; (ii) unprocessed food and utilities; (iii) most volatile items 1990–99 accounting for 20% of the CPI basket; (iv) food and regulated prices; (v) food and energy; (vi) the average of indicators (iii) and (v). First three measures are regularly published.	...	...	Not a target Identify “transitory” or supply shocks Help explain and justify policy decisions to the public Used in CB reaction functions in internal policy simulation models
Czech	2 Excluded: (i) regulated and very volatile prices; (ii) energy	...	...	Monetary policy considerations: to see the evolution of CPI after regulated and very volatile prices are set aside
Hong Kong SAR	1 Excluded: basic food and energy	...	...	Remove the effect of transitory supply shock on general consumer prices
Hungary	1 Excluded: more volatile elements of CPI (traded goods, market services, processed food and alcoholic beverages). Unofficial short-term indices are also calculated from seasonally adjusted core and its components	...	...	To better capture the inflation trend
Indonesia	1 Excluded: administered prices and volatile food	...	...	External communication

Table A6 (cont)

**Core inflation measures and their use by central banks**

Central bank	Specific product exclusion measures	Trimmed means or related	Other core inflation measure	Purpose
Israel	2 Excluded: (i) food, energy, fruit and vegetables; (ii) like (i) excluding housing	...	...	Analysed internally on a regular basis  Starting February 2008 (unofficial) core inflation measures are in policy press release
Korea	3 Excluded: (i) petroleum products and non-grain agricultural products (published National Statistical Office); (ii) petroleum products; (iii) food and energy	1 Trimmed mean (18%)	...	Assess underlying trend of changes in prices and to forecast headline CPI.
Malaysia	1 Excluded: price volatile and price administered items	...	...	External and internal communication of the central bank, economic analysis and monetary policy decisions; forecasts of headline inflation
Mexico	1 Excluded: energy, raw food, administered and regulated prices	...	...	Assess medium term inflation trend  External communication
Peru	1 Excluded: most volatile food prices, fuel, utilities, transportation	...	...	Inflation trend measure

Table A6 (cont)

## Core inflation measures and their use by central banks

Central bank	Specific product exclusion measures	Trimmed means or related	Other core inflation measure	Purpose
Philippines	1 Net of volatile items. Items excluded: fresh food and oil	2 Trimmed mean; weighted median	...	Official core inflation rate first published by the National Statistics Office in February 2004 (with CPI headline inflation)  Exclusion method chosen because: (a) easier to understand (specially by the general public); (b) more transparent and can be replicated by others using CPI data; (c) available at the same time as the headline inflation rate; and (d) in line with international practice
Poland	5 Excluded: (i) administratively controlled prices; (ii) most volatile prices; (iii) like (ii) less fuel prices; (iv) food and energy; (v) food and fuels	1 15% trimmed mean	...	Support decisions of the MPC  When the MPC considers core inflation measures in their decisions, that fact appears in the after-meeting statements and minutes  Used in forecasting model Necmod and in internal forecasts
Russia	1 Excluded: volatile and administered items	...	...	To eliminate the impact of short-term market shocks and seasonal and administrative factors. Used as a benchmark for monetary policy

Table A6 (cont)

**Core inflation measures and their use by central banks**

Central bank	Specific product exclusion measures	Trimmed means or related	Other core inflation measure	Purpose
Saudi Arabia	...	...	...	
Singapore	1 Excluded: private road transport costs and accommodation costs	...	...	Internal and external communications. Assessing the persistent part of cost and price pressures  Contribute to monetary policy decision process
South Africa	1 Excluded: fresh and frozen meat and fish, fresh and frozen vegetables and fresh fruit and nuts; interest rates on mortgage bonds and overdrafts/ personal loans and property insurance; value added tax	...	...	Capture underlying inflationary pressures, ie the trend in the general price level which reflects the balance between aggregate demand and supply in the economy over the medium term
Thailand	1 Excluded: raw food and energy	...	...	CPI inflation is used as a guideline/indicator; core CPI inflation is the target

Table A6 (cont)

## Core inflation measures and their use by central banks

Central bank	Specific product exclusion measures	Trimmed means or related	Other core inflation measure	Purpose
Turkey	9 Excluded: (i) seasonal products; (ii) unprocessed food; (iii) energy; (iv) unprocessed food and energy; (v) energy, alcoholic beverages and tobacco; (vi) like (v), products with administered prices, and indirect taxes; (vii) like (vi), and unprocessed food; (viii) unprocessed food, energy, alcoholic beverages, tobacco products and gold; (ix) food, energy, alcoholic beverages, tobacco products and gold	...	...	All the measures are considered in regular price analysis (sources of change etc)  Not used in forecasting
<i>Memo:</i> Canada	2 <i>Excluded:</i> <i>(i) eight most volatile components with adjustments of remaining components for changes in indirect taxes; (ii) food, energy and the effect of indirect taxes</i>	...	1 <i>Weighted variance</i>	<i>Internal analysis, published in monetary policy report</i>  <i>Predictive power of core inflation for future headline inflation is limited</i>

Table A6 (cont)

## Core inflation measures and their use by central banks

Central bank	Specific product exclusion measures	Trimmed means or related	Other core inflation measure	Purpose
<i>Euro area – ECB</i>	2 <i>Excluded:</i> <i>(i) energy and unprocessed food;</i> <i>(ii) energy</i>	(1) <i>Trimmed means</i>	...	<i>Used in regular analysis. For external communication, HICP excluding energy and unprocessed food is used. First step of analysis of sectoral inflation developments</i>  <i>Not considered as a leading indicator for future headline inflation</i>
<i>Japan</i>	1 <i>Excluded:</i> <i>Fresh food</i>	...	...	<i>External communications (monthly report)</i>
<i>United States</i>	2 <i>Excluded: (i) food and energy (CPI);</i> <i>(ii) food, alcoholic beverages and energy (PCE)</i>	4 <i>Trimmed mean (CPI, PCE)</i> <i>Weighted median (CPI, PCE)</i>	...	<i>Monitoring and forecasts; in general, non-energy, non-food indices are combined with separate forecast for food and energy to yield a forecast of headline CPI</i>

– Not applicable.

... Not available.

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# Wages, productivity and “structural” inflation in emerging market economies

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## 1. Introduction

Wage and price setting in advanced economies is well documented in the literature, but little work has been done on this topic for the emerging market economies. The aim of this paper is to start filling this gap by discussing how central banks in emerging market economies (EMEs) take account of wage inflation, productivity and some structural characteristics of their economies in analysing inflation.

Keeping the growth of real wages in line with labour productivity is widely viewed as a necessary condition for long-term macroeconomic stability – it helps preserve country competitiveness while limiting inflationary pressures and risk of a wage-price spiral. Yet increases in real wages in EMEs often exceed productivity gains. In recent years, many observers have highlighted skilled labour shortages, spillovers from terms-of-trade shocks and loose public sector wage policy as factors driving real wage growth above labour productivity. Other possible explanations are rapid urbanisation; gradual transformation of the “grey” economy into official economic activity; and rapid productivity growth of the tradable goods sector, in which the resulting fast growth of wages spreads to the rest of the economy, where prices are insulated from international competition and productivity grows more slowly.

We proceed by providing a simple analytical framework for integrating wages, productivity and certain structural features of EMEs in the analysis of inflation (Section 2). We then discuss various data issues that central banks confront in empirical applications of such frameworks (Section 3). Finally, we illustrate some key developments in wages, productivity and consumer price inflation for a sample of EMEs participating in this meeting (Section 4). The appendix provides central bank responses to a questionnaire on the measurement of wage and productivity data and on the significance of various institutional and structural characteristics of labour and product markets in central bank assessments of inflation.

## 2. Analytical framework

Consider a simple aggregate model of the economy with a Cobb-Douglas constant-returns-to-scale production function,

$$Y = AL^\gamma K^{1-\gamma} \quad (1)$$

where  $Y$  is output,  $A$  is total factor productivity,  $L$  and  $K$  are labour and capital inputs, and  $\gamma$  is the labour elasticity of output (labour intensity). The profit function for this economy is given by:

$$\Pi = PY - RK - WL \quad (2)$$

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where  $\Pi$ ,  $P$ ,  $R$  and  $W$  are, respectively, the profit, the price of output, the interest rate (or the capital rental price) and the wage. If product and factor markets operate under conditions of perfect competition, profit maximisation implies that the marginal product of labour and capital are equal to the wage and the interest rate

$$W = P \cdot A \cdot \gamma \cdot \left(\frac{K}{L}\right)^{1-\gamma} \quad (3)$$

$$R = P \cdot A \cdot (1-\gamma) \cdot \left(\frac{L}{K}\right)^\gamma \quad (4)$$

Solving equation (1) for  $(K/L)$  and substituting into (3) and (4) yields:

$$W = P \cdot \gamma \cdot \left(\frac{Y}{L}\right) \quad (3')$$

$$R = P \cdot (1-\gamma) \cdot \left(\frac{Y}{K}\right) \quad (4')$$

A useful property of the Cobb-Douglas constant-returns-to-scale production function is that the labour share of output, or the real unit labour cost, is equivalent to the labour elasticity of output,  $\gamma$  – thus, from (3'), unit labour costs can be expressed as:

$$\frac{W \cdot L}{P \cdot Y} = \gamma \quad (3'')$$

Taking the logs, totally differentiating (3''), and assuming that  $\gamma$  is constant gives the familiar condition that the growth of real wages should not exceed the growth of average labour productivity:

$$\hat{w} = \hat{p} + \left(\frac{\hat{Y}}{L}\right) \quad \text{or} \quad \hat{w} - \hat{p} = \left(\frac{\hat{Y}}{L}\right) \quad (5)$$

where the lower-case letters stand for variables expressed in logarithms and the hat symbol (^) denotes the growth rates of variables,  $dx/x$ . The simplest way to monitor the emergence of wage pressures is therefore to compare real wage growth with labour productivity growth.

One simple extension of this model is to assume that the output price is fixed in the world market, so that domestic inflation is given by the sum of changes in the world price measured in foreign currency ( $\hat{p}^*$ ) and changes in the exchange rate ( $\hat{e}$ ),  $\hat{p} = \hat{p}^* + \hat{e}$ :

$$\hat{w} = (\hat{p}^* + \hat{e}) + \left(\frac{\hat{Y}}{L}\right) \quad (6)$$

Different versions of (6) were widely used in the 1970s and the 1980s in OECD countries. At that time, the coincidence of oil shocks and a sharp fall in the growth of labour productivity led to a search for the so-called “warranted” rate of wage growth – a measure of nominal wage change that, given productivity changes and terms-of-trade developments, would be associated with stability in the share of wages in national income.

Analysis based on economy-wide measures of wage and productivity growth is often usefully supplemented by more disaggregated measures derived from two-sector models. One of the most widely used two-sector models is that of differential productivity growth in tradable and non-tradable industries.<sup>2</sup> Historically, productivity growth in the tradable goods sector has

<sup>2</sup> Appendix Box A1 discusses other two-sector models potentially relevant for the analysis of inflation in EMEs.

been faster than in the non-tradable goods sector. By the law of one price, the prices of tradables tend to get equalised across countries. Higher productivity in the tradable goods sector will bid up wages in that sector and, with labour being mobile, wages in the entire economy will rise. In general, to pay the higher wages, producers of non-tradables will raise the relative price of their goods, which will lead to an increase in the overall price level in the economy.

Starting from the definition of consumer price inflation ( $\hat{p}$ ) as a weighted average of tradable ( $\hat{p}^T$ ) and non-tradable ( $\hat{p}^{NT}$ ) goods price inflation:

$$\hat{p} = \alpha \hat{p}^T + (1 - \alpha) \hat{p}^{NT} \quad (7)$$

where  $\alpha$  is the share of tradable goods in the CPI basket, and using Cobb-Douglas production functions for tradables and non-tradables, the difference between inflation rates of non-tradables and tradables can be expressed as the difference between the growth rates of average labour productivity in tradable ( $\hat{a}^T$ ) and non-tradable ( $\hat{a}^{NT}$ ) industries:

$$\hat{p}^{NT} - \hat{p}^T = \left( \frac{\delta}{\gamma} \right) \hat{a}^T - \hat{a}^{NT} \quad (8)$$

where  $\gamma$  and  $\delta$  are labour intensities (ie factor income shares) in tradable and non-tradable industries.<sup>3</sup> Assuming that  $\gamma = \delta$ , and using the above decomposition of the growth rate of tradable prices into the growth rate of world prices of tradables, equations (3) and (4) can be combined to give the following expression for inflation in a two-sector open economy model:

$$\hat{p} = (\hat{p}^{T*} + \hat{e}) + (1 - \alpha)(\hat{a}^T - \hat{a}^{NT}) \quad (9)$$

Equation (9) implies that the rate of inflation can be decomposed into “imported” inflation ( $\hat{p}^{T*} + \hat{e}$ ) and “structural” inflation  $(1 - \alpha)(\hat{a}^T - \hat{a}^{NT})$ , where the latter is determined by the sectoral productivity trends (assuming that factor income shares are constant). This equation provides several valuable insights for the analysis of inflation in EMEs:

- Changes in world market prices of tradables and exchange rates will be fully transmitted to domestic inflation at given rates of productivity growth and weights of tradables in the consumption basket.
- If world market prices for tradables and the exchange rate are constant (or move at the same rate in the opposite direction), domestic inflation will increase by a fraction  $(1 - \alpha)$  of the sectoral productivity growth differential.
- Faster productivity growth of non-tradables will *decrease* the rate of inflation, while faster productivity growth of tradables will *increase* inflation. The intuition behind this conclusion is that faster productivity growth for tradables results in a faster rate of wage increase for both sectors, which speeds up the rate of price increase for non-tradables without affecting the price trend for tradables, the latter being determined by the path of world market prices and the exchange rate.
- Countries with particularly large differences in productivity growth between the tradable and non-tradable sectors will, *ceteris paribus*, have higher inflation relative to countries with small differences in sectoral productivity growth.

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<sup>3</sup> Versions of this model of “structural” inflation were developed independently by Balassa (1964), Samuelson (1964), Baumol and Bowen (1966) and several Scandinavian economists (see eg Aukrust (1977) and Lindbeck (1979)). For a derivation of the above equations, see eg Mihaljek and Klau (2004).

The inflation differential between two countries can be expressed as the sum of changes in the exchange rate and (weighted) productivity growth differentials between the two sectors at home and abroad (foreign country variables are denoted by the symbol \*):

$$\hat{p} - \hat{p}^* = \hat{e} + (1 - \alpha)[\hat{a}^T - \hat{a}^{NT}] - (1 - \alpha^*)[\hat{a}^{T*} - \hat{a}^{NT*}] \quad (10)$$

When used as a positive theory of inflation, the basic insight of this model is that the rate of wage increase tends to adjust for the “room” for wage increase in the tradable sector, as defined by the sum of the (exogenous) increase in world market prices for tradables and the (exogenous) rate of productivity increase in that sector.

A broader insight is that not all inflation in the catching-up economies is “pathological” – faster productivity growth in industries producing tradable goods and services is part of the “physiology” of economic development (Padoa-Schioppa (2003)). If labour and capital markets are unencumbered, there is not much that monetary policy could or should do to control this source of inflation. This insight seems particularly relevant for the economies moving rapidly towards higher living standards – for instance, as a result of economic and financial integration with a neighbouring advanced economy.

Over the years, such aggregate models have been extended by providing a much richer description of the micro foundations of labour and product markets. One widely used characterisation of the joint behaviour of wage and price inflation is a model including a “price equation” and a “wage equation” such as:

$$p = \left( w - \frac{Y}{L} \right) + \mu \quad (11)$$

$$w = -\beta u + \frac{Y}{L} + \theta(p^* + e) + z \quad (12)$$

where  $\mu$  is the mark-up resulting from imperfect competition in the goods market;  $\beta$  measures the responsiveness of wages to unemployment,  $u$ ;  $\theta$  measures the pass-through from import prices to wages; and  $z$  includes a range of institutional factors such as unemployment benefits, minimum wages, restrictions on firing or hiring, the degree of unionisation, the tax wedge (in terms of earnings and payroll taxes), skills mismatches and information problems.<sup>4</sup> Equation (11), which describes labour demand, states that firms set prices at a markup,  $\mu$ , over unit labour costs. Equation (12), which describes labour supply, states that the workers’ desired wage level depends on the unemployment rate, labour productivity, the pass-through from terms-of-trade shocks to wages, and various institutional characteristics of the labour market, which may lead to nominal wage rigidities.

These models have been used to test a wide variety of hypotheses about wage and price formation, including whether wage-price dynamics are consistent with the view that prices are set after wages are known (the so-called “cost push” view of inflation – see eg Angeloni et al (2006)); the spillover effects of nominal adjustments across labour and product markets (the “wage spiral” – see eg Kandil (2003)); the extent to which changes in the degree of price flexibility modify the ranking of alternative monetary policy regimes in an open economy framework (see eg Devereux and Engel (2003)). To support the implementation of monetary policy, several central banks, including a few in EMEs, have developed more fully specified dynamic stochastic general equilibrium (DSGE) models founded on the new open economy macroeconomics paradigm advanced by Obstfeld and Rogoff (1996).<sup>5</sup>

<sup>4</sup> For a more complete specification of this model, see eg Blanchard and Katz (1997) or Layard, Nickell and Jackman (2005). For an empirical application to the emerging European economies, see Goretti (2008).

<sup>5</sup> For an overview of the use of DSGE models in central banks, see Tovar (2008).

### 3. Data issues

The advanced economies have a long tradition of analysing the wage-price mechanism in assessing inflation coming from the labour market and in forecasts of inflation. For example, the OECD has published its annual *Employment Outlook* for several decades now.<sup>6</sup> The European Commission started a similar annual exercise in the early 2000s.<sup>7</sup>

Countries in the euro area, for instance, focus on three main measures of the growth in nominal labour costs: negotiated wages, the labour cost index and compensation per employee.<sup>8</sup> The assessment of inflationary pressures stemming from the labour market focuses on nominal unit labour costs by quantifying their contribution to the increase in the final demand deflator. In addition, to separate the influence of external and domestic cost components, the final demand deflator is decomposed into import deflator and income components of the GDP deflator, ie nominal unit labour costs, gross operating surplus and net indirect taxes. The requirement that wage developments contribute to price stability translates into the condition that nominal increases in compensation per employee should not exceed the sum of productivity and the ECB inflation target of close to, but below, 2%. The application of this rule distinguishes between actual and long-term productivity and between the cyclical and long-term situations of the labour market.

The lack of good labour market data has until recently limited this type of analysis in most EMEs. For instance, many EMEs use payroll statistics or narrower estimates of employment instead of the more comprehensive labour survey data. That choice can lead to underestimation of the number of employees in the economy; the resulting overestimation of productivity can lead policymakers to conclude that a higher-than-warranted growth rate of wages is acceptable at a given rate of inflation.

Another frequent data problem in EMEs is the lack of adequate price deflators, which makes it difficult to identify the sources of external and domestic cost pressures. However, widespread adoption of inflation targeting frameworks by central banks has provided an incentive to compile better labour market data and has enabled central banks to use productivity and unit labour costs more widely in their inflation forecasts.

In the survey conducted among emerging market central banks participating at this meeting, central banks noted that they use a variety of **measures of wage inflation** for the gross wages whole economy (Hungary, Korea and Poland) and for individual sectors (eg industry for Argentina, public and private sectors for the Czech Republic) (see Appendix Table A1). Central banks also monitor hourly compensation (Israel, Mexico and Thailand), compensation per employee (Hong Kong SAR, Israel, South Africa and Turkey) and unit labour costs (Colombia, Hong Kong SAR, Hungary, South Africa and Thailand). They view an increase in any of these costs as a potential source of wage pressure that could spill over to higher prices. To gauge demand-side inflationary pressures, some central banks also track real wages (Colombia, the Czech Republic, Poland and Turkey).

The majority of inflation targeting central banks in the sample (Chile, the Czech Republic, Hungary, Korea, Poland, Thailand and Turkey) follow **labour productivity and unit labour**

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<sup>6</sup> The reports for the past 20 years are available at [www.oecd.org/document/0/0,3343,en\\_2649\\_33927\\_40774656\\_1\\_1\\_1\\_37457,00.html](http://www.oecd.org/document/0/0,3343,en_2649_33927_40774656_1_1_1_37457,00.html).

<sup>7</sup> See the annual series *Labour market and wage developments* at [http://ec.europa.eu/economy\\_finance/publications/specpub\\_list9266.htm](http://ec.europa.eu/economy_finance/publications/specpub_list9266.htm).

<sup>8</sup> Compensation per employee includes gross wages and salaries (ie wages plus employees' social security contributions) and employers' social security contributions. When disaggregated, compensation per employee, together with negotiated wages, gives an indication of labour cost pressures coming from a particular sector (public/private, industry/services). The labour cost index (which does not cover government activities) captures the evolution of hourly labour costs, correcting for the changes in overtime hours and part-time employment.

**cost measures** very closely, using them in both short-term and medium-term forecasts of inflation (Appendix Table A2).<sup>9</sup> Other inflation targeters (Colombia, Israel, Mexico, Peru and South Africa) use unit labour cost indicators mainly in the assessment of inflation trends rather than as an input for inflation forecasts. The central bank of Argentina (which is not an explicit inflation targeter) follows a similar approach. Inflation reports produced by central banks in all these countries analyse the labour market and wage developments.

Although many emerging market economies today face the combination of increased labour productivity (allowing higher nominal wages) and substantial terms-of-trade shocks, only a few EME central banks consider **measures of “warranted” wage growth** such as equation (6): in Colombia and Poland, warranted wage growth is considered in minimum wage negotiations; in Korea, it is calculated by the Korea Labour Institute; and in Israel, a measure of warranted wage growth is used to assess changes in business sector costs and competitiveness.<sup>10</sup>

Measures of price inflation for **tradables and non-tradables** are widely used by central banks (Appendix Table A3), and they are monitored on a systematic basis except in Hong Kong SAR, Israel, Saudi Arabia, South Africa and Thailand. CPI aggregates of goods price inflation are often used to assess the extent of “imported” inflation and the pass-through of exchange rate changes into inflation; while the CPI aggregates of service price inflation are generally considered a good proxy for the domestic sources of inflation.

In Chile, Colombia, the Czech Republic, Hungary, Poland and Turkey, the split of inflation into tradable and non-tradable components is considered particularly important and is used in macro forecasting models, either directly or via the real exchange rate (as in Poland). Several central banks have also produced estimates of the Balassa-Samuelson effect (Chile, Colombia, the Czech Republic, Hungary, Israel). In Hungary, the definition of price stability incorporates the Balassa-Samuelson effect.

Only a few central banks seem to closely monitor the evolution of wage differences between **formal and informal** or **urban and rural** sectors (Appendix Table A4). One reason is the lack of data (eg in Chile, Hong Kong SAR, Israel, Korea, Peru, Saudi Arabia and Thailand); another is that these differences are not considered important (eg in the Czech Republic). In Hungary, wages in the informal sector are estimated by statistical methods and used to forecast wage dynamics in the entire economy (see Eppich and Lörincz (2007)). In Colombia, wage data for the informal and rural sectors are not timely, but employment trends for these two sectors are followed closely throughout the cycle (see Leibovich, Nigrinis and Ramos (2006)). In Poland, wage data for the rural sector are fragmentary and unreliable, but differences between urban and rural wages are considered to be important for overall wage dynamics because of the large number of self-employed farmers. In South Africa, minimum wages for farm workers and urban/rural CPI data provide some indication of the urban/rural wage gap and its impact on overall wages.

The relevance of institutional characteristics of the labour market for the assessment of inflation is generally smaller in the emerging markets than in advanced economies, and it is smaller today than it was a couple of decades ago. **Wage indexation** was quite common before the 1990s, when many emerging market countries experienced episodes of high inflation (see Box A2 in the Appendix for the experiences of Chile and Brazil). However, as a

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<sup>9</sup> Measures of labour productivity in manufacturing are available monthly and are widely used. For other sectors as well as the whole economy, real output measures are generally available only quarterly and are used by inflation targeters for medium-term forecasts. Central banks also look closely at various time series for wages and employment (eg average wage vs compensation per employee, total employment vs hours worked). Information on the price deflators used to obtain estimates of real wages was not readily available.

<sup>10</sup> See Barnea and Djivre (2004) and Lavi and Sussman (2001).



result of low and falling inflation in most EMEs, automatic wage indexation schemes are no longer significant (Appendix Table A5).

Certain exceptions nonetheless exist. Pensions (Argentina, Thailand) and public sector wages (Columbia, South Africa, Turkey) are still indexed to inflation. In Columbia, minimum wages are indexed because of the high percentage of workers earning the minimum wage and its use in the setting of other wages; in Thailand, minimum wages are generally adjusted once a year according to the previous year's inflation rate. In Chile, 70% of labour contracts are adjusted every six months according to past CPI inflation. Israel abolished the cost of living adjustment for senior officials in the public sector in 1996, but it established a mechanism that links the allowances of other employees – and, since 2008, unfunded pension payments – to the CPI. In Hungary, past and expected inflation are taken into account in the wage setting process. In Poland, inflation is taken into account in public sector wage negotiations. In Thailand, most firms in the private sector also use backward indexation. Some firms even use year-ahead forecasts of inflation for wage indexation. Inflation also affects wage agreements made through collective bargaining in Korea and South Africa, although no explicit indexation schemes are used there.

With the exception of Argentina, the Czech Republic, Mexico and South Africa, most central banks have concluded that **collective bargaining and negotiated wages** were no longer important for the dynamics of inflation (Appendix Table A6).<sup>11</sup> In South Africa, the number of bargaining councils was in decline, and only 25% of the active labour force was covered by bargaining council agreements. Even where labour unions are more active, their bargaining powers have diminished. In Hungary, for instance, the tripartite National Interest Reconciliation Council only provides recommendations for wage increases and sets the legally guaranteed minimum wage. In Thailand, the presence of migrant labour, weak labour unions and government regulations considerably limit the impact of collective bargaining on economy-wide wages.

#### 4. Empirical illustrations

Consumer price inflation and nominal wage inflation in EMEs have generally moved close together over the past decade (Appendix Graph A1), which warrants a look at wage dynamics in the analysis of inflation in emerging markets. Countries with high average annual inflation tended to have higher annual wage growth during 2000–08 (Graph 1, left-hand panel). The sensitivity of that relationship has changed over time: given a 1 percentage point increase in inflation, wage growth increased 1 percentage point during 2000–03 (Graph 2, left-hand panel), but 1.2 percentage points during 2004–08 (right-hand panel). Between the 2000–03 period and the 2004–08 period, the correlation between inflation and wage growth increased significantly for China, Chile, the Czech Republic, Hong Kong SAR, Korea, the Philippines and Thailand (Table 1). Positive correlations suggest that wages do adjust for inflation, even if automatic indexation is no longer as prevalent as in the past.

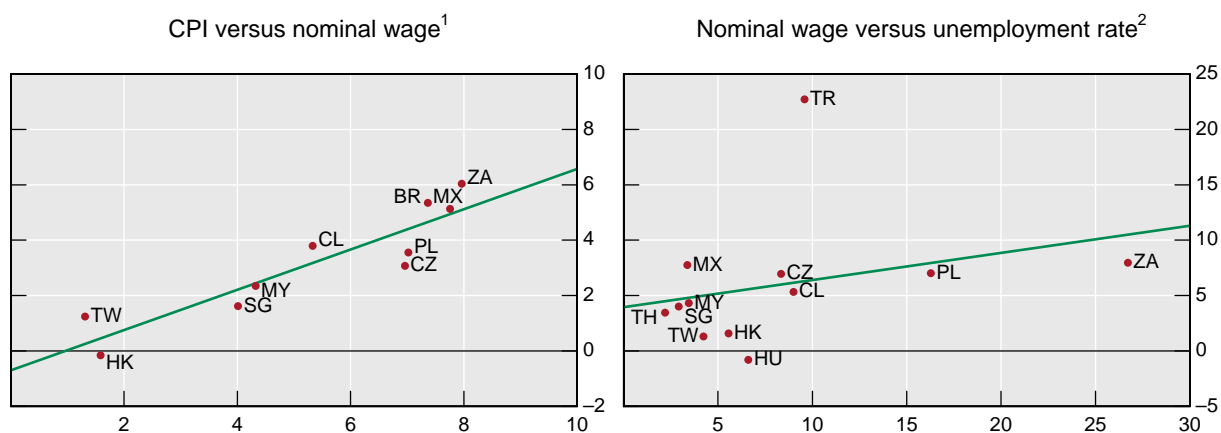
Higher wage growth also has a (weak) positive association with a higher unemployment rate (Graph 1, right-hand panel). That relationship contrasts with most estimates of the Phillips curve for advanced economies and might reflect the greater importance of supply shocks in EMEs than in advanced economies.

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<sup>11</sup> For recent central bank studies of wage bargaining and labour market flexibility in EMEs more generally, see Du Caju et al (2008), which also covers advanced EU economies; Godfrey, Theron and Visser et al (2007); Horváth and Szalai (2008); Pauwels and Zhang (2008); and Waiquamidee, Sutthasri and Tanboon (2009).

Graph 1  
Wages, inflation and unemployment, 2000–08

In per cent



BR = Brazil; CL = Chile; CZ = Czech Republic; HK = Hong Kong SAR; HU = Hungary; MX = Mexico; MY = Malaysia; PL = Poland; SG = Singapore; TH = Thailand; TR = Turkey; TW = Chinese Taipei; ZA = South Africa.

<sup>1</sup> Vertical axis: average annual CPI inflation, average for 2000–08. Horizontal axis: average annual growth of nominal wages for the same period. <sup>2</sup> Vertical axis: average annual growth of nominal wages for 2000–08. Horizontal axis: average annual unemployment rate for the same period.

Sources: Datastream; national data.

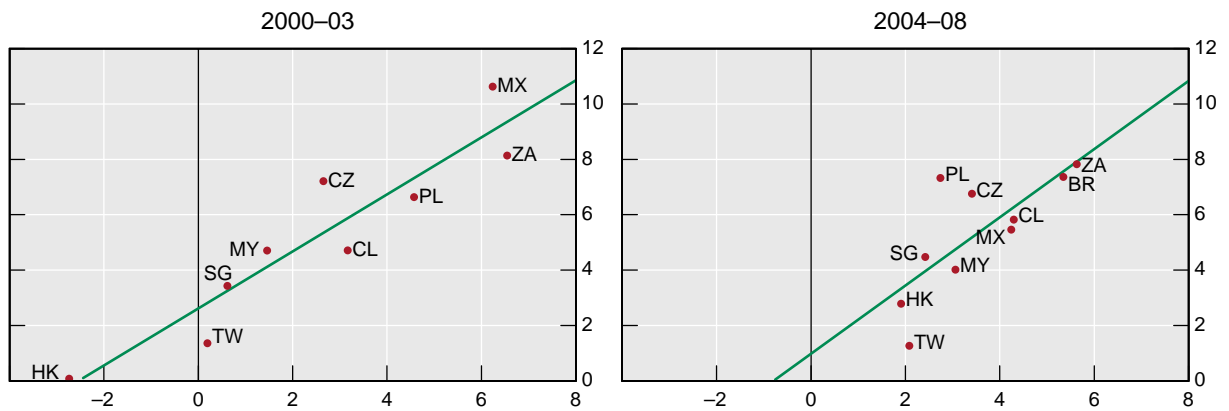
Table 1  
Correlation between wages and CPI inflation<sup>1</sup>

	2000–03	2004–08	2000–08
China	-0.79	0.78	0.43
Indonesia	0.98	0.09	0.13
Hong Kong SAR	0.48	0.86	0.78
Korea	-0.31	0.31	0.01
Malaysia	0.09	0.10	-0.13
Philippines	0.33	0.83	0.70
Singapore	0.89	0.81	0.57
Thailand	0.29	0.87	0.91
Argentina	...	0.36	0.36
Brazil	...	-0.45	-0.45
Chile	0.43	0.89	0.86
Mexico	0.82	0.22	0.86
Peru	...	0.20	0.20
Venezuela	...	0.40	0.40
Czech Republic	0.39	0.77	0.46
Hungary	-0.10	-0.11	-0.04
Poland	0.89	0.32	0.84
Russia	0.79	0.13	0.87
Turkey	0.55	-0.18	0.85
South Africa	-0.21	-0.17	-0.18

<sup>1</sup> Correlation between annualized changes in quarterly average nominal wages, and year-on-year changes in quarterly average CPI inflation.

Sources: Datastream; national data.

Graph 2  
**Changes in CPI inflation and nominal wages<sup>1</sup>**  
 In per cent



BR = Brazil; CL = Chile; CZ = Czech Republic; HK = Hong Kong SAR; HU = Hungary; MX = Mexico; MY = Malaysia; PL = Poland; SG = Singapore; TH = Thailand; TR = Turkey; TW = Chinese Taipei; ZA = South Africa.

<sup>1</sup> Vertical axis: average annual growth of nominal wages; horizontal axis: average annual CPI inflation for the same period.

Sources: Datastream; national data.

Many EMEs experienced very strong **real wage growth** during 2005–07, reaching in some cases 5–10% per year on average (eg in China, the Czech Republic, Korea and South Africa; Graph 3, top left-hand panel). For the most part, however, real wage growth was offset by fairly high **productivity growth** (Graph 3, top right-hand panel), so that real unit labour costs – measuring the difference between real wages and labour productivity – were stable or falling in about half of EMEs in the sample, with Chile, Indonesia, Malaysia and Poland experiencing a more pronounced decline (Graph 3, bottom right-hand panel).

As indicated in the third panel of Graph 3, observations on average growth rates of labour productivity and real wages were closely aligned for most EMEs in the sample. The exceptions were Brazil, China, Korea and South Africa. In these countries, real wages grew faster than average labour productivity during 2005–07, implying rising real unit labour costs and, hence, rising inflation pressures coming from the labour market.

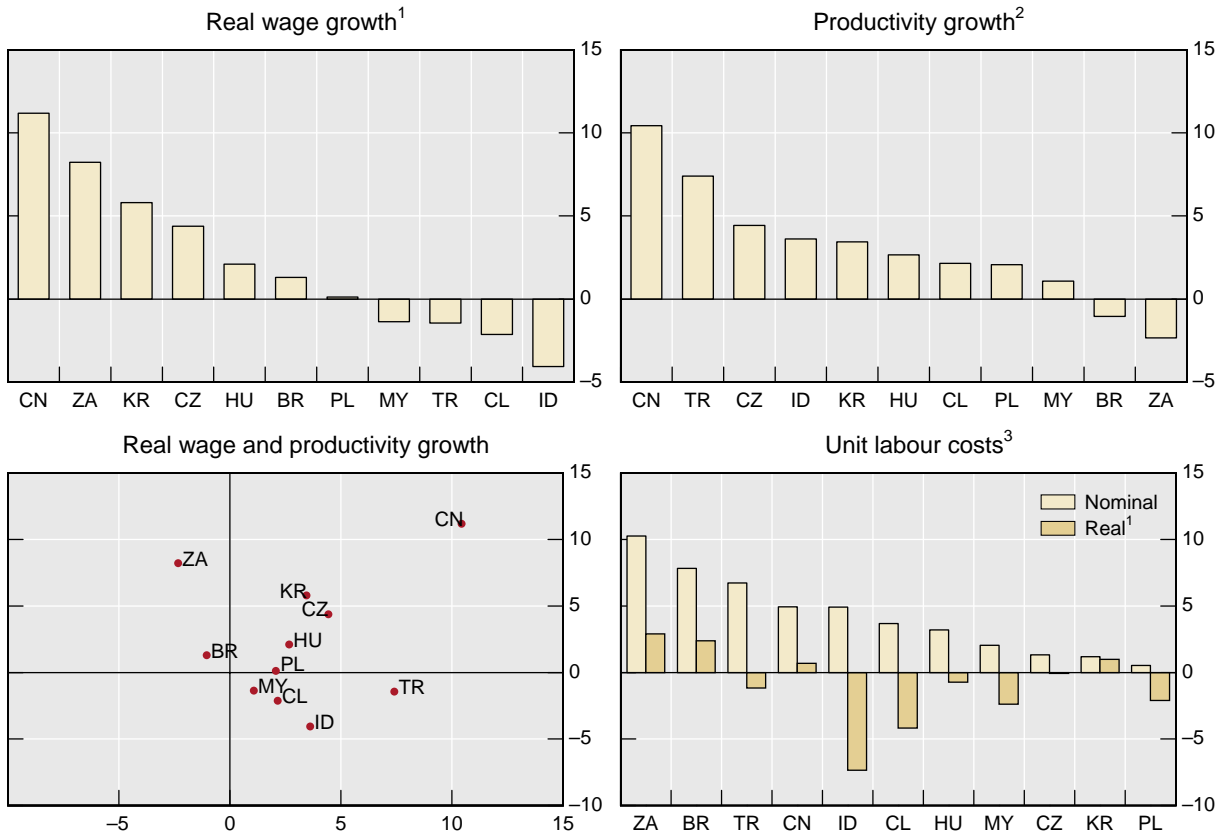
The “structural” sources of inflation in EMEs discussed in Section 2 have not received much empirical attention. One exception is the pass-through of exchange rate changes into domestic inflation.<sup>12</sup>

<sup>12</sup> For a recent overview, see eg Ca’ Zorci, Hahn and Sánchez (2007).

Graph 3

**Productivity, wages and unit labour costs**

Average annual changes, in per cent, 2005–07



BR = Brazil; CL = Chile; CN = China; CZ = Czech Republic; HU = Hungary; ID = Indonesia; KR = Korea; MY = Malaysia; PL = Poland; TR = Turkey; ZA = South Africa.

<sup>1</sup> Deflated by the GDP deflator. <sup>2</sup> Change in real GDP divided by change in employment. Coverage of employment differs across countries. For the Czech Republic, Hungary, Poland and Turkey, change in real GDP per occupied person. For Korea, OECD data.

<sup>3</sup> Change in total labour cost, divided by the change in real output. For the Czech Republic, Hungary, Poland and Turkey, European Commission data. For Korea and South Africa, OECD data. <sup>4</sup> Unit labour costs in the manufacturing sector.

Sources: European Commission; IMF; OECD; CEIC; national data; BIS calculations.

Another is the difference in productivity growth between tradable and non-tradable goods industries and the related **Balassa-Samuelson effect**. The issue is of particular importance for the new EU member states from CEE because of their obligation to join the euro area in the foreseeable future. If the productivity growth differential between the tradable and non-tradable goods sectors is larger in an EMU candidate country than in the euro area, overall inflation will be higher in the candidate country. Under a fixed exchange rate regime, that will result in real appreciation of the candidate country's currency. Under a flexible exchange rate regime, it will result in some combination of nominal appreciation and CPI inflation. If the Balassa-Samuelson effect is particularly strong, the candidate country might violate the inflation criterion for membership in the euro area.<sup>13</sup>

<sup>13</sup> According to the Maastricht inflation criterion, EMU candidate countries must demonstrate sustainable price stability and an average rate of inflation (observed over a period of one year before the examination) that does not exceed by more than 1½ percentage points the average rate of inflation of, at most, the three EU member states with the best price stability performance.

This is not likely to be the case according to most studies – the Balassa-Samuelson effect is usually estimated to add around 0.2–2.0 percentage points to the CPI inflation (see eg Mihaljek and Klau (2008), Égert (2005), and Égert, Halpern and MacDonald (2006)), but for some countries with a fixed exchange rate regime the effect could be much larger. The authorities in such countries might therefore feel compelled to maintain, at least temporarily, relatively restrictive monetary and fiscal policies in order to meet the inflation criteria, which might dampen economic growth and job creation.

The literature has also identified some puzzles related to the operation of the Balassa-Samuelson effect. On the one hand, the evidence suggests that this effect is not the main driving force of the observed relatively high inflation rates of 3–6% per year in most CEE countries. On the other hand, although productivity growth in the tradable sectors has indeed been high, it has not led to correspondingly high inflation rates. Explanations of these puzzles include a trend increase in tradable prices due to quality improvements (Cincibuch and Podpiera (2006)); the role of regulated price adjustments in overall inflation; a disconnect between productivity growth and real wages in the manufacturing sector (Égert (2007)); incomplete wage equalisation and substantial productivity gains in market non-tradables; and the low share of market non-tradables in consumer price indices of CEE countries (Égert, Halpern and MacDonald (2006)).<sup>14</sup>

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<sup>14</sup> Several central banks participating in the meeting conducted studies of the Balassa-Samuelson effect or, more generally, appreciation of the “equilibrium” real exchange value of the currency in the past few years. See Caputo, Nuñez and Valdes (2007), Kiss and Krekó (2004), Kovács (2002), Oliveros and Huertas (2002), Romanov (2003) and Vilagi (2004).

## Appendix

### Box A1

#### **Informal economy, public sector and urban vs rural sector in EMEs**

Besides differential productivity growth, inflation in EMEs can be affected by other structural features, such as the relative size of the informal sector; wage formation in the public vs. private sectors; and differences between urban and rural wages. Better statistical coverage of the **informal economy** will boost the official figures for output, employment and wages without necessarily boosting inflation. Conversely, when the informal economy expands (eg in a recession), inflation could remain sticky despite the fall in the official employment and wage figures.

Shifts in **public sector** labour demand and a loose wage policy may have a demonstration effect on the private sector. In some countries, collective bargaining at the national level may set by law the minimum conditions for all of the economy, thereby generating a wage-push effect.

Another consideration is the difference between **urban and rural wages**. Higher urban wages, the typical case in EMEs, will attract rural workers to cities in search of jobs. The prediction of a standard model is that such rural-urban migration would apply downward pressure on wages and hence on inflation.<sup>①</sup> However, congestion effects created by the growing number of city dwellers can be so large as to lead to higher prices of non-tradables such as transportation, utilities and rents, especially in those market segments that are not subject to price controls, and eventually result in higher overall inflation.

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<sup>①</sup> In the model of Harris and Todaro (1970), the expected income of an urban dweller is equal to that of a rural dweller: the rural worker earns a low wage without being laid off, while urban employees earn a high wage for some of the time and are laid-off on zero income for the rest of the time. This model has been used to explain the coincidence of high unemployment and high wages on the basis of macro data. However, on the basis of micro data, Blanchflower and Oswald (1994) discovered for a number of advanced economies a robust empirical relationship (the “wage curve”) between higher unemployment in a region or industry and lower wages.

## Box A2

### Experience with indexation in Chile and Brazil

High inflation in the 1960s provided a rationale for indexing all contracts in **Chile**, including wages, house rentals, tuition and health insurance; financial instruments (consumer loans, mortgages, corporate bonds, all fixed income securities with a maturity of one quarter or longer); and policy instruments (exchange rates, interest rates on public debt, income tax brackets and public sector wages) (see Lefort and Schmidt-Hebbel (2002)). The indexed unit of account, called *Unidad de Fomento* (UF) and introduced in January 1967, related the currency to the Chilean CPI. The UF was originally calculated three times a year; then, between 1975 and 1977, monthly; and after 1977 daily. In the financial sector, the UF was widely adopted in the early 1980s. By 1983, more than 60% of total bank loans in Chile were tied to the UF. The UF was a lagged daily interpolation of the monthly CPI. The formula for computing the UF on day  $t$  was given by:

$$UF_t = UF_{t-1} \times (1 + \pi)^{1/d}$$

where  $\pi$  was either the inflation rate for the  $t - 1$ st calendar month (for  $t$  between the 10th and the last day of the month), or the inflation rate for the  $t - 2$ nd calendar month (for  $t$  between the 1st and the 9th day of the month);  $d$  was the number of days in the  $t - 1$ st calendar month. For instance, the UFs for 1–9 April depended on the CPI for January and February; and the UFs for 10–30 April depended on the CPI for February and March. The UFs for a given month thus depended on the CPI for each of the preceding three months.

To reduce the prevalence of indexation, the Central Bank of Chile in September 1990 adopted a monetary framework based on public announcement of an explicit, forward looking annual inflation target. This helped reduce the annual rate of inflation from 27% in 1990 to 3% in 2001. Although the prevalence of indexed contracts has declined in recent years, the Chilean economy remains heavily indexed: about 70% of all labour contracts are adjusted every six months for past inflation.

Indexation in **Brazil** was institutionalised in 1964, when the government introduced *correção monetária*, a sophisticated indexation mechanism that adjusted taxes, tariffs and some financial contracts (see Goldfajn (2002)). The exchange rate, wages and bank deposits were initially not indexed, but over time they too became indexed in various ways. Indexation came to an end only with the *Real Plan* of 1994 (see Goldfajn and Valdes (1999)).

Table A1

**Measures of wage inflation used in inflation analysis**

<b>Measure</b>	<b>Country</b>	<b>Comment</b>
Gross wages	Argentina	Industrial wage index for industrial sector
	Czech Republic	For public and private sectors
	Hungary	For economy-wide analysis, inflation analysis and forecasting
	Korea	Gross nominal wages
	Mexico	36% of employees; gross wage increments negotiated for next 12 months for contractual employees
	Peru	Gross nominal wages estimated semiannually by labour ministry
	Turkey Poland	Per hour in manufacturing
Net wages	Argentina	Wage index for all workers
Hourly net wages	Mexico	Hourly compensation per employee
	Thailand	Hourly compensation
Compensation per employee	Hong Kong SAR	Nominal payroll per person
	Turkey	Nominal and real earnings per employee
	Israel, South Africa	
Unit labour costs	Colombia	For manufacturing and retail sectors
	Hungary	For inflation analysis and forecasting
	Israel	Hourly nominal wages adjusted for labour productivity
	South Africa	Total salaries and wages as a ratio to real GDP in the formal non-agricultural sector
	Chile, Hong Kong SAR, Thailand	
Nominal wages	Colombia	For manufacturing, retail and construction sectors
	Czech Republic	For public and private sectors
	Thailand	Including minimum wage
	Turkey	Per hour in manufacturing
	Chile, Korea, Poland	
Real wages	Colombia	For manufacturing, retail and construction sectors
	Czech Republic	For public and private sectors
	Turkey	Per hour in manufacturing
	Chile, Poland	
CPI/Non-oil GDP deflator	Saudi Arabia	

Source: BIS survey of central banks.



Table A2

**Measures of productivity and unit labour costs used in inflation analysis**

Country	Measure	Data
Argentina	Labour productivity	Industry; based on employment and hours worked
	Unit labour costs	Considered but not included in forecast calculations
Chile	Labour productivity	Four alternative measures, by sector (excluding agriculture and natural resources); monthly and (for projections) quarterly
	Unit labour costs	
Colombia	Labour productivity	Overall economy, considered in assessment of cost pressures, aggregate demand/supply trends
	Total factor productivity	
	Unit labour costs	Manufacturing and retail
Mexico	Labour productivity	Whole economy (quarterly) and manufacturing (monthly and quarterly) considered in forecast calculations
	Unit labour costs	
Peru	Labour productivity	Corporate sector, biannual
	Unit labour costs	Preliminary use as a leading indicator of inflation pressures
Hong Kong SAR	Labour productivity	Used to analyse the effect of labour costs on inflation
	Unit labour costs	
Korea	Labour productivity	Non-farm sectors, quarterly
	Unit labour costs	Calculated using gross nominal wages, quarterly; used in evaluating and forecasting inflation
Thailand	Labour productivity	Whole economy and industries
	Unit labour costs	Whole economy and industries
Czech Republic	Labour productivity	Whole economy
	Unit labour costs	Whole economy and sectors; nominal; used as an explanatory variable in short-term inflation forecasts
Hungary	Labour productivity	Market sector excluding agriculture; as a whole and disaggregated; used in evaluating inflation
	Unit labour costs	Private sector as a whole, plus manufacturing and market services; quarterly; used in inflation forecasts
Poland	Labour productivity	Whole economy and main sectors (excluding agriculture)
	Unit labour costs	Based on average wage, used in inflation forecasts (ex post also look at compensation/employee)
Turkey	Labour productivity	Manufacturing and major sectors; based on employment and hours worked
	Unit labour costs	Manufacturing; nominal and real; used in inflation forecasts
Israel	Labour productivity	Whole economy and export manufacturing; monitored on a regular basis
	Unit labour costs	
Saudi Arabia	Labour productivity	Calculated independently by the government and private sector; not regularly monitored
	Unit labour costs	
South Africa	Labour productivity	Formal non-agricultural economy
	Unit labour costs	Based on gross salaries and wages

Source: BIS survey of central banks.

Table A3

**Measures of tradable/non-tradable goods inflation  
used by EM central banks**

<b>Country</b>	<b>Data</b>
Argentina	Goods and services inflation closely followed; used to assess exchange rate pass-through
Chile	Goods and services price inflation closely followed; used in analysis of inflation
Colombia	Very important in analysis of inflation, used in macro forecasting model
Mexico	Monitored on a systemic basis and reported (bi-weekly) to the Board; used to assess domestic/external inflation pressures
Peru	Tradable/non-tradable price data available monthly, not used in analysis of overall inflation
Hong Kong SAR	Tradable/non-tradable inflation not monitored, but non-rental component of CPI is forecast
Korea	Tradable/non-tradable price data regularly monitored
Thailand	Not monitored (labour market data not detailed enough); real exchange rate stable
Czech Republic	Tradable/non-tradable price data closely followed; used as input to policy decisions and to assess the exchange rate pass-through
Hungary	Very important in analysis of inflation; definition of price stability incorporates the BS effect
Poland	Tradable/non-tradable inflation not monitored systematically, but BS effect included in inflation projections via real exchange rate equation
Turkey	Goods and services price inflation closely monitored and analysed in detail
Israel	Tradable/non-tradable inflation not monitored on a systematic basis
Saudi Arabia	Tradable/non-tradable inflation monitored and incorporated in quarterly analysis of inflation
South Africa	Tradable/non-tradable price data yet to be compiled; BS effect not considered relevant for inflation analysis in an inflation targeting framework

Source: BIS survey of central banks.

Table A4

**Central bank assessment of the significance of differences in wage dynamics in formal/informal and urban/rural sectors**

<b>Importance</b>	<b>Country</b>	<b>Data</b>
<b>Wages in formal vs. informal economy</b>		
Differences important for assessment of inflation dynamics	Argentina	Wage evolution in the informal sector closely related to the cost of the basic food basket
	Colombia	Wage data not timely, but formal vs. informal employment data followed closely throughout the cycle
	Hungary	Wages in the informal sector estimated through statistical methods; used to forecast wage dynamics
	Mexico	Comprehensive data available, followed on a monthly basis
	Poland	Size of the informal economy estimated but wage data not available
Differences not important	Czech Republic	
Data not available	Chile, Hong Kong SAR, Israel, Korea, Peru, Saudi Arabia, South Africa, Thailand, Turkey	
<b>Urban vs. rural wages</b>		
Differences important for assessment of inflation dynamics	Colombia	Wage data not timely, but urban vs. rural employment data followed closely throughout the cycle
	Poland	Wage data fragmentary, unreliable; differences important because of large number of self-employed farmers
	South Africa	Minimum wage for farm workers, urban/rural CPI provide some indication of the urban vs. rural wage dynamics
Differences not important	Czech Republic	
Data not available	Chile, Hong Kong SAR, Israel, Korea, Peru, Saudi Arabia, Thailand, Turkey	

Source: BIS survey of central banks.

Table A5

**Central bank assessment of the significance of wage indexation  
for inflation dynamics**

	<b>Countries</b>	<b>Comments</b>
High significance	Chile	About 70% of labour contracts adjusted every six months for past CPI inflation
	Colombia	Important for the public sector and the minimum wage
	South Africa	Applies to multi-year wage agreements, which are fairly common in South Africa, eg multiyear agreement in the public sector during the past three years links CPIX inflation plus a certain percentage point above that
	Turkey	Public sector wages mostly indexed to inflation targets. When inflation targets are missed within a certain margin, employees are protected against inflation
Low/no significance	Argentina	Except for pensions
	Hong Kong SAR	Some companies set wage levels making reference to CPI inflation
	Israel	Has become insignificant in light of low inflation in the past ten years
	Thailand	Public pension benefits indexed to inflation in the previous year (most important form of indexation). Most firms in the private sector also use backward indexation. Few firms use year-ahead forecast inflation. Minimum wage generally adjusted only once a year, indexed to the previous year's inflation rate
	Czech Republic, Hungary, Korea, Mexico, Peru, Poland, Saudi Arabia	

Source: BIS survey of central banks.

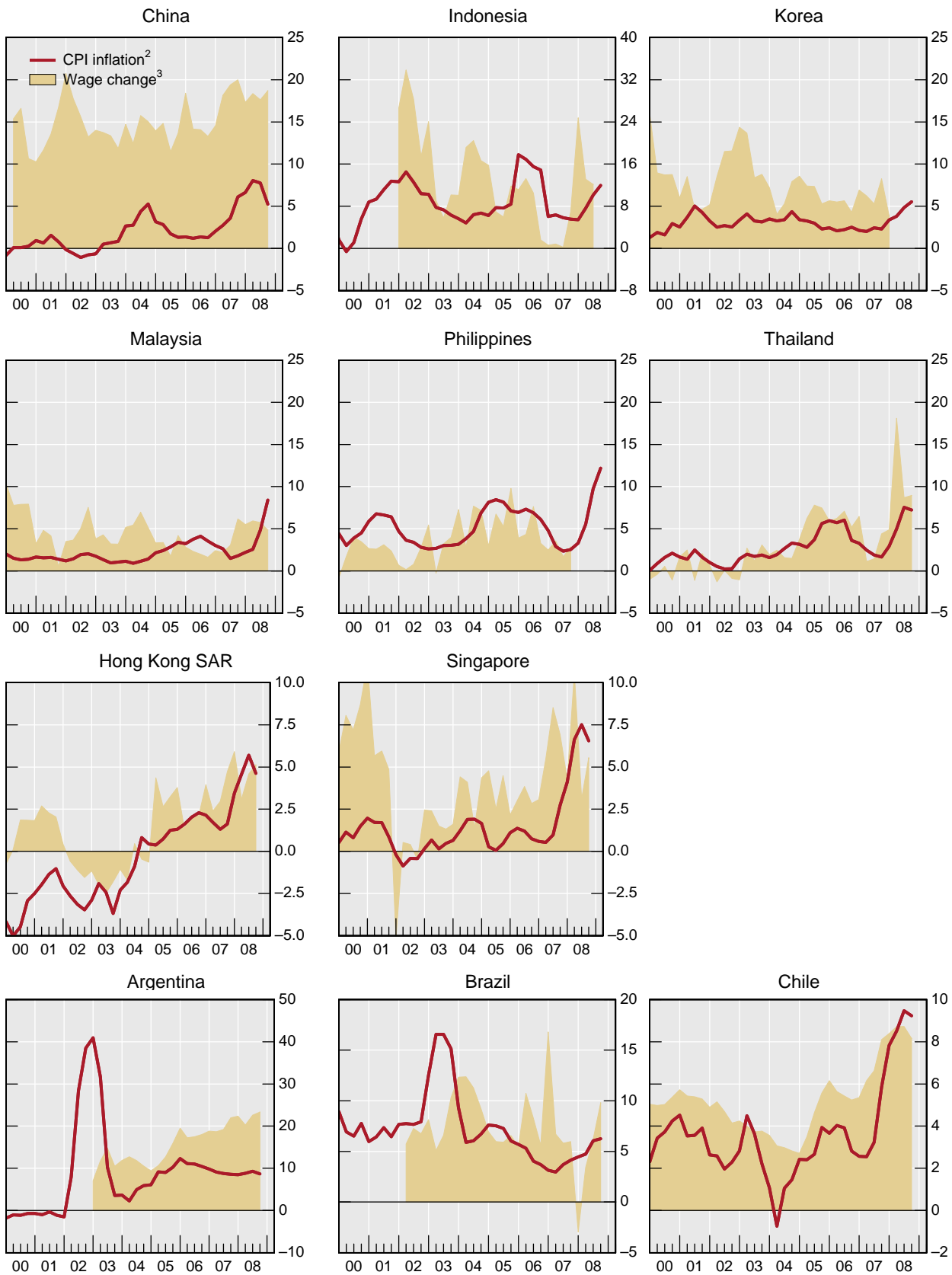
Table A6

**Central bank assessment of the significance of collective bargaining  
for inflation dynamics**

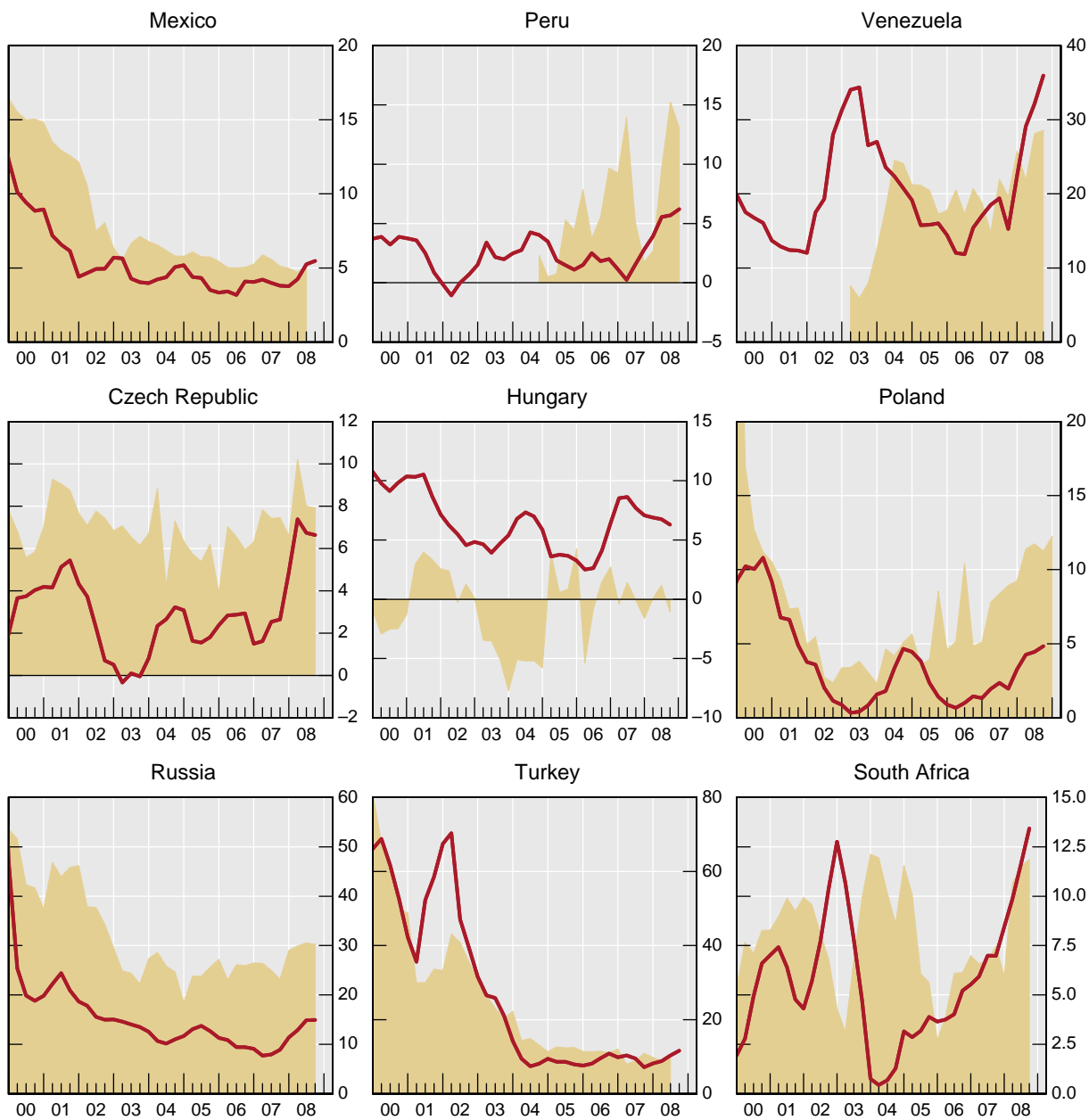
<b>Importance</b>	<b>Country</b>	<b>Comment</b>
High significance	Argentina	Collective bargaining takes place annually since 2005
	Czech Republic	30–40% of wages covered by collective bargaining.
	Mexico	9% of total contractual wages are negotiated (does not include teachers' unions)
	South Africa	25% of labour force covered by bargaining council agreements; 75% by ministerial decrees and legislation (which offer minimum levels of protection). Number of bargaining councils declined from 80 to 57 between 1995 and 2005 (51 councils in the private sector, of which 41 are functional, and 6 in the public sector)
Low/no significance	Colombia	Collective bargaining important only for large firms
	Hong Kong SAR	Labour unions/organisations have limited wage bargaining power
	Hungary	Wage setting process largely conducted at company or plant level
	Poland	Collective bargaining mostly takes place at firm level
	Thailand	Presence of migrant labour, weak labour unions and regulations limit the size of negotiated wage increases
	Peru, Saudi Arabia	
Not applicable	Chile, Korea, Turkey	

Source: BIS survey of central banks.

Graph A1  
**CPI and nominal wage inflation<sup>1</sup>**  
 In per cent



Graph A1 (cont)  
**CPI and nominal wage inflation**  
 In per cent



<sup>1</sup> Argentina, average monthly wage; Brazil, average monthly earnings; Chile, hourly wage index; China, cumulative salary of employed persons divided by employed persons; Czech Republic, average monthly wages; Hong Kong SAR, nominal payroll per person; Hungary, employee gross wages; Indonesia, monthly average wage (manufacturing); Korea, monthly earnings; Malaysia, earnings in manufacturing sector; Mexico, average monthly wage; Peru, average monthly income; Philippines, manufacturing industry wage index; Poland, average monthly wage; Russia, average monthly wages; Singapore, average monthly earnings; South Africa, average monthly earnings in manufacturing; Thailand, average wage rate; Turkey, hourly wages (manufacturing); Venezuela, wage index. <sup>2</sup> Annual change of CPI inflation. <sup>3</sup> Annual change of nominal wage.

Sources: Datastream; national data.

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# Inflation expectations, persistence and monetary policy

Ramon Moreno and Agustín Villar

Monetary policy is often based on the idea that policymakers can achieve reductions in inflation by producing some economic slack. How much slack is needed in turn depends on the degree of inflation persistence; if persistence is low, the output costs to disinflation will be small. Inflation persistence has posed a major challenge for monetary authorities in emerging market economies (EMEs) over the years and is believed to have been a factor behind the failure of a number of stabilisation programmes seeking to end periods of very high inflation.<sup>1</sup> Even in areas where inflation has been relatively moderate, such as the euro area, inflation persistence has been a special concern because of the perceived costs of price and wage rigidity.

Contemporary macroeconomic analysis (including now standard open economy models relying on the New Keynesian Phillips curve or extensions) identifies inflation expectations as the key determinant of inflation persistence. In this scenario, a monetary policy framework that can successfully anchor inflation expectations can reduce or eliminate persistence.

To shed further light on the role of expectations this note briefly reviews: (1) factors that can lead to inflation persistence and how a monetary policy framework such as inflation targeting can offset these; (2) whether inflation persistence has declined in recent years; (3) whether inflation targeting has succeeded in anchoring inflation expectations and factors that could loosen this anchoring effect; and (4) the measurement of inflation expectations in EMEs.

## Inflation expectations, persistence and inflation targeting

One of the key issues for monetary policy is how to lower inflation persistence, so as to lower the costs of disinflation. Recent research suggests two general explanations for such persistence.

First, ***backward-looking expectations***. Some research for developed countries suggests that some proportion of agents is backward-looking (Roberts (1998)) although the proportion may be small (Galí and Gertler (1999)). One interpretation of backward-looking expectations is departures from rationality. While such departures are usually seen as a shortcoming when attempting to explain data, there is some empirical support for them. For example, a recent study (Mankiw et al (2003)) finds that survey data from both consumers and professional economists show significant departures from rationality, including substantial disagreement about expected future inflation, autocorrelated forecast errors, and insufficient sensitivity to recent macroeconomic news.<sup>2</sup>

Inflation may also behave as if there were backward-looking expectations in the presence of wage and price indexation (see, for example, Vargas et al (2009, this volume), Fraga et al (2003)). This may be particularly important in EMEs, where such indexation is much more

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<sup>1</sup> See the studies cited by Lefort and Schmidt-Hebbel (2002) and De Gregorio (1992, 1995).

<sup>2</sup> Their empirical tests suggest partial but incomplete updating in response to news, but a more sophisticated view than adaptive expectations.

prevalent than in developed economies (see Moreno (2009, this volume) and Lefort and Schmidt-Hebbel (2002)).

Second, inflation persistence can arise because **private agents have limited information about central bank objectives**. Models in which agents learn about policymakers' objectives over time include those found in Erceg and Levin (2003) and Orphanides and Williams (2007). They show that inflation tends to be less persistent if agents are more certain about the central bank's inflation objectives.<sup>3</sup>

While further research is needed to uncover how inflation expectations could be best anchored to reduce persistence, it is apparent that inflation targeting could play an important role. For example, in Erceg and Levin's model, agents need to disentangle whether a given inflation outcome reflects a shift in the inflation target or a transitory disturbance. This provides a rationale for a monetary framework that is transparent and credible, as well as for effective communications by the central bank. Agents would then find it easier to recognise the inflation target more quickly, thus reducing the persistence of inflation and output.<sup>4</sup> Many of these characteristics (eg transparency, communications procedures) are formally incorporated into inflation targeting regimes, which a number of EME central banks have adopted over the past two decades.

An important question is the extent to which a monetary framework such as inflation targeting could also reduce the prevalence of backward-looking expectations or departures from rationality. For example, it would be desirable to have a better understanding of whether inflation expectations in EMEs exhibit similar departures from rationality to those apparently observed in developed economies and to assess possible explanations (eg Mankiw et al (2003) argue that, in the United States, updating expectations is costly). This could suggest solutions that would improve forecast efficiency. Research on this topic could draw on the data on inflation expectations now collected in EMEs (see discussion below).

A better understanding of the effects of price and wage indexation on persistence under a more transparent monetary regime would also help shed light on this question. Fraga et al (2003) argue that better anchored expectations due to a credible inflation targeting regime could also lead to a fall in the fraction of backward-looking agents caused by indexation, thus reinforcing the reduction of inflation persistence. They cite some evidence for Brazil consistent with this view.<sup>5</sup>

### Has inflation persistence fallen?

There is a fair amount of evidence that inflation persistence has fallen in some developed countries; but the experience of EMEs appears to vary. For example, one measure of inflation persistence is the sum of coefficients on lagged inflation. Williams (2006) estimates a Phillips curve model for the United States in which current quarter inflation depends on four lags of inflation, the unemployment rate in the previous quarter (which controls for the effect of labour market slack on inflation), and a constant. He finds that the sum of coefficients on lagged inflation appears to have fallen considerably, with point estimates for coefficient sums ranging from around unity for the 1980–Q2 2006 sample, to 0.6 for core personal

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<sup>3</sup> Desormeaux et al (2009) apply a similar kind of reasoning in the Central Bank of Chile's contribution to this volume. Also in line with this view, Vargas et al (2009, this volume) cite a Colombian central bank study by Gonzalez and Hamman that suggests that lack of credibility may have played a role in explaining high persistence of inflation in Colombia.

<sup>4</sup> Fraga et al (2003) stress the importance of greater transparency and communications to offset factors that may weaken the credibility of an inflation target (see below).

<sup>5</sup> See also Vargas et al (2009, this volume) and Lefort and Schmidt-Hebbel (2002).

consumption expenditures (PCE) inflation and 0.4 for core CPI inflation for the Q4 1999–Q2 2006 period. However, the decline in persistence is not statistically significant, reflecting the imprecision of the estimates and the difficulties in reaching conclusions about whether inflation persistence has indeed fallen. Nevertheless, the impression of reduced inflation persistence in the United States is reinforced by a recent study by Stock and Watson (2007). They decompose inflation into a trend component that follows a random walk (ie no reversion to mean) and a serially uncorrelated shock (implying transitory deviations around the trend), and show that the volatility of the (highly persistent) trend component has fallen while that of the temporary component has risen. One implication of this is that, because shocks are now largely mean-reverting, the persistence of inflation has tended to fall. A study of developed economies by Levin and Piger (2002) also finds that inflation persistence has declined.

Some of the evidence from recent studies, or reported in papers for this meeting, suggests that inflation persistence may still be high in a number of EMEs. For example, Capistrán and Ramos Francia (2006) find that inflation persistence has fallen in some EMEs while remaining high in others. In the Colombian central bank's contribution to this volume, Vargas et al (2009) report that consumer price inflation in Colombia during 2003 and 2006 exhibits some persistence related to the long-lasting response of tradable and regulated price inflation to overall inflation shocks and persistence in some shocks (eg tradable goods and food). For another example, in Peru shocks to core inflation die out only after about two years (see Armas et al (2009, this volume)).

As to whether inflation persistence has fallen more in countries that target inflation, a study of advanced economies and EMEs (Kuttner and Posen (2001)) suggests that inflation persistence has indeed declined more in those EMEs that have formally adopted inflation targeting.

### **Has inflation targeting resulted in better anchored expectations?**

Research relating to developed economies generally suggests that inflation targeting has resulted in better anchored expectations (see Walsh (2008)).<sup>6</sup> Furthermore, using a measure of inflation expectations implied by bond yields, Gürkaynak et al (2006, 2007) find that in the United States, long-term inflation expectations react to news while they do not in inflation targeting Sweden, Canada or Chile. Evidence from the United Kingdom also supports the view that (credible) inflation targeting anchors expectations, as expectations responded to news prior to 1997, when the Bank of England became independent, but not after. In a study of developed economies, Levin et al (2004) find that lagged inflation is significantly correlated with expectations of future inflation in non-IT countries but not in inflation targeters. Ravenna (2008) estimates a DSGE model of Canada to generate counterfactual experiments; these predict lower inflation volatility under inflation targeting largely because of the effect of IT on expectations.

Questionnaire responses and papers contributed to an earlier Deputy Governors' meeting (see BIS (2008)) provide further insights into the behaviour of inflation expectations in EMEs. Summarising some of the results of papers and questionnaire responses, Mohanty and Turner (2008, p 20) report that a number of EME central banks find that inflation expectations have been better anchored in this decade, as indicated by growing convergence of private sector inflation expectations around the central bank's inflation target (eg in Colombia, the Czech Republic, Mexico and South Africa); a stronger reaction of financial markets to central

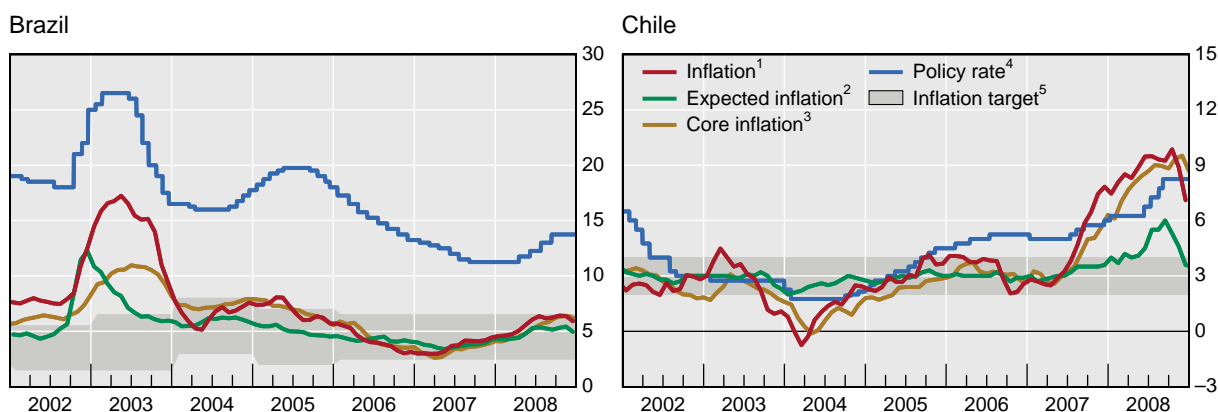
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<sup>6</sup> An exception is a study of six inflation targeting and six non-targeting developed economies (Johnson (2002)). This study finds that while the adoption of inflation targeting was followed by a significant decline in expected inflation, the variability of expected inflation in targeters and non-targeters remained the same, suggesting that inflation targeting does not anchor expectations.

bank policy announcements has been recorded; and there has been an improvement in central banks' ability to reduce the size of policy adjustments. Some of the findings are illustrated by a paper in that volume by Bevilaqua et al (2008). They cite: (1) a decline in inflation uncertainty, as indicated in lower forecast errors measured as the difference between 12-month actual and expected inflation; (2) reduced dispersion of inflation expectations, as measured by reduced disagreement among survey respondents providing a point inflation forecast; (3) a lower risk premium implicit in longer-term interest rates; and (4) the fact that inflation targets are significant attractors for inflation expectations. In particular, a regression of inflation expectations on a constant and the inflation target during a recent "normal" period shows an intercept of zero and a slope coefficient close to unity.

While expectations appear to have become better anchored in EMEs in this decade, an important concern is that large shocks that have periodically affected EMEs could loosen inflation expectations from their anchor. For example, in Brazil, according to the indicators cited by Bevilaqua et al (2008), inflation expectations do not appear to have been well anchored in the period around 2002 and early 2003, when there was great uncertainty about fiscal policy. However, they were relatively well anchored before and after that period (see Figures 5–11 of their paper, and also Graph 1 below). Significant changes in the behaviour of inflation expectations in Turkey are also discussed by Basci et al (2008).

Graph 1  
**Inflation and policy rates**  
 In per cent



<sup>1</sup> Twelve-month changes in consumer prices, in per cent. <sup>2</sup> Twelve months ahead. Based on surveys conducted by the respective central bank; observations are positioned in the month when the forecast was made; annual changes, in per cent. <sup>3</sup> Twelve-month changes in core consumer prices, national definition, in per cent. <sup>4</sup> Brazil, overnight SELIC rate target; Chile, official monetary policy rate. <sup>5</sup> Announced targets, in terms of CPI inflation.

Sources: IMF; Bloomberg; Consensus Economics; national data.

In this context, one could ask whether inflation expectations have become more loosely anchored in the most recent period of financial turbulence, large fluctuations in commodity prices in EMEs, and concerns about the outlook for growth. More systematic analysis is needed but some perspective can be gained from Graph 1, which shows inflation expectations and inflation indicators for Brazil and Chile. In Brazil, both actual and expected inflation began rising in 2007 and by mid-2008 exceeded the midpoint of the target range (but remained within the target ceiling). In Chile, inflation expectations had remained stable for a long period, but large terms-of-trade movements were eventually associated with a sharp rise in inflation, and an eventual rise of expectations above target as well. In Israel, inflation expectations have recently become more volatile and in some cases more dispersed

(see discussion of Figure 4 in Eckstein and Segal (2009), the Bank of Israel's contribution to this volume). In contrast, Hampl (2009), in the contribution of the Czech National Bank to this volume, finds that inflation expectations have remained well anchored by the inflation targeting framework.<sup>7</sup>

One explanation for why expectations lose their anchor is that the public may perceive that institutional or economic factors may make it very difficult for the central bank to meet its inflation target. Fraga et al (2003) cite three factors that remain relevant today.

1. *Fiscal dominance*. Here unsustainable fiscal policies delink inflation expectations from the target because agents believe the target would be too costly to maintain. One concern is that with a large public debt overhang, tighter monetary policy could lead to higher sovereign risk premia (by increasing the probability of default on debt), depreciation pressures and higher inflation (see Blanchard (2004)). EMEs have made significant gains in fiscal consolidation but public debt to GDP ratios remain high in a number of countries, and the perceived need for fiscal stimulus in response to weakening global demand could pose concerns.

2. *Financial dominance*, in which weak financial sectors could make it too costly for monetary authorities to stick to their inflation targets. Here, improvements in banking supervision and regulations appear to have led to more robust EME banking sectors. However, continued pressures in global financial markets pose risks, particularly in the aftermath of the disruptions observed since September 2008.

3. *Large external shocks*. While EME resilience has increased, exposure to external shocks has also increased due to growing trade and financial integration. For example, starting around the first half of 2008, capital inflow reversals and sharp depreciation pressures accentuated inflation concerns, prompting central banks to intervene in foreign exchange markets, to tighten monetary policy or to defer easing. However, such actions had to be weighed against the risks of sharp slowdowns in growth. Real shocks also pose important concerns. As noted in a number of central bank contributions to this volume, terms-of-trade shocks have contributed to inflationary pressures in recent quarters that have in some cases pushed actual and expected inflation well above the ceilings of the inflation target (see eg Graph 1). At this time, disinflationary or deflationary pressure due to weak demand and sharp declines in commodity prices could generate a new set of challenges through their impact on expectations.

## Measuring inflation expectations

The previous sections have highlighted some channels by which inflation and inflation expectations could interact. However, inflation expectations are not directly observable, and this has resulted in significant efforts to measure them (Table A1). A natural place to start is those markets in the economy where inflation expectations play a central role.

### Household and business surveys

Inflation expectations are crucial for the functioning of labour markets, as they are a primary consideration in wage negotiations. Wage pressures in turn can influence pricing behaviour. In economies where labour market developments are thought to have a greater impact on inflation dynamics, inflation expectations of labour market participants are important for policymakers. The inflation expectations of workers and firms are usually measured through

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<sup>7</sup> See also Holub and Hurník (2008).

household and (non-financial) business surveys. However, such surveys raise a number of issues.

First, household surveys are expensive because the population surveyed tends to be relatively large and heterogeneous.

Second, heterogeneity can pose problems of interpretation. Brischetto and de Brouwer (1999) find that average inflation expectations can vary widely for different types of survey respondents. People with better access to information or more developed information processing skills tend to have more accurate inflation expectations.

Third, surveys could be subject to large measurement errors. The incidence of measurement errors is a key determinant of the quality of the inflation expectations estimate, and these errors can be large when measuring inflation expectations through household surveys. In economies where expectations are volatile, answers could be affected by unfolding events if the time span between interviews of survey respondents is long. Smyth (1992) tests errors in the measurement of inflation expectations in households and concludes that such estimates are (positively) biased, because households tend to overestimate the inflation rate they experience. Policy decisions based on biased inflation expectations could raise concerns.

Fourth, surveys (particularly household surveys) are not conducted often, so they generate relatively low-frequency data. In economies where inflation is muted this is not a problem but when inflation is a major policy concern their usefulness might be reduced.

### **Professional forecasters and financial market participants**

Surveys of financial market participants' or corporate sector expectations on inflation (conducted by central banks or the private sector) are now relatively common in EMEs. While a smaller and homogeneous population helps attenuate some of the concerns associated with household surveys, there are other concerns.

One concern is that market participants might not face adequate incentives to provide their best prediction, leading to biased estimates.<sup>8</sup> Producing an "unbiased" estimate would require information on the direction of the bias, which might not be possible in a relatively small sample. One solution has been to increase the payoff to market participants who give accurate estimates. In Brazil, the central bank survey has asked market participants to forecast price indices at one month and up to two years. The forecasts are collected weekly and the central bank computes several statistical measures that are published according to a schedule. More significantly, the central bank publishes monthly the forecasters' ranking according to the accuracy of their forecast. It is known that this ranking implies commercial and financial gains for those in the top places. This approach appears to be particularly appropriate if updating expectations is costly, as in the analysis of Mankiw et al (2003). It is worth noting that in their contribution to this volume, Central Bank of Brazil researchers provide evidence that inflation expectations in Brazil are unbiased (Araujo and Gaglianone (2009)).

One survey of market analysts widely used in producing estimates of inflation expectations is the Consensus Forecast. This commercial survey is produced monthly for a large number of EMEs. It provides inflation forecasts one and two years ahead. Disclosure of the individual respondents' forecasts helps alleviate some of the concerns cited earlier. Another advantage is that the forecasts are produced independently from the government. While many central

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<sup>8</sup> In the United States bias exists but appears to be relatively small. For further discussions of bias in the US context see Mankiw et al (2003).



banks have been granted operational independence, faced with a possible conflict with the government a central bank might opt for self-censorship.

Central banks may also produce and publish their own inflation forecasts, which can provide an estimate of inflation expectations over the forecasting horizon. A shortcoming is that these forecasts assume policy invariance: the central bank performs its computations under the assumption that its monetary policy instruments remain unchanged. This might be supplemented with some forecast discussion that might provide some additional information about likely policy direction and how it might affect the forecast. Central banks in some small open advanced economies have tried to improve this inflation expectation estimate by incorporating the most likely policy interest rate paths over the forecasting horizon.

### **Financial market measures**

Financial markets have become a major field for gauging inflation expectations. The growth of financial markets has raised the availability and profile of asset price based measures and of financial market participant surveys. The high-frequency data in financial markets can provide timely observations of inflation expectations. Furthermore, because financial markets tend to process large and frequent amounts of information about the economy, market participants are very well informed and capable of fairly sophisticated analysis. One advantage of these measures is that estimation bias is likely to be small: financial market participants back their views on inflation by taking positions that expose them to risk.

In many developed financial markets the existence of inflation-linked financial securities provides a market-based measure of inflation expectation as well as attitudes toward inflation risk. Long-term inflation-linked government bonds in principle create opportunities for deriving inflation expectations from asset prices. The difference in the rate of return of inflation-linked bonds and a nominal rate (the “break-even rate”) would offer a market-based measure of inflation expectations. Some EMEs (eg Chile or Israel) have been able to develop an inflation-linked government bond market, but in most cases such markets do not exist. An important issue is how to disentangle inflation expectations from other factors that may be embedded in the break-even rate. Break-even rates can be decomposed into at least three components: (i) expected inflation during the remaining maturity of the bonds; (ii) inflation risk premia; and (iii) liquidity premia. Technical factors specific to each market may also play a role. Sometimes, the expected inflation component is extracted by using expectations from professional forecasts (see above). In the case of the United States such (longer-run) expectations have been stable, and it appears that most of the recent volatility in the break-even rate is attributable largely to liquidity premia (a higher liquidity premium would increase the yield on real bonds relative to nominal bonds and recently a flight to safety lowered the nominal rate for Treasury securities). Thus, the break-even rate appears to give a relatively noisy signal of inflation expectations at this time.

To sum up, the measures of expectations discussed above can offer very useful sources of information for purposes of macroeconomic analysis, for central banks and researchers. Among the questions one could ask are: (1) what are the properties of the data (eg forecast accuracy, autocorrelation) and what do they reveal about how agents form expectations (eg are they rational, do they use information efficiently and so on); (2) what do measures of expectations tell us about how expectations behave over the business cycle and the main drivers of such expectations; (3) how well anchored are inflation expectations, during normal times and during episodes of economic or financial stress; and (4) what are the implications for monetary policy frameworks and implementation?<sup>9</sup>

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<sup>9</sup> Some relevant questions are addressed in Araujo and Galianone (2009, this volume) and also by Waiquamidee et al (2009, this volume).

Table A1

## Central bank surveys on inflation expectations

Economy	Survey	Frequency/ conducted as from	Data collection technique	Population (type and size)	Selection criteria/ number of respondents	Inflation expectations measure	Notes
Argentina	REM (Market Expectations Survey)	Monthly/ since December 2003	Census	Participation is voluntary and opened to institutions that provide well grounded forecasts on a regular basis	49 participants (10 banks, seven investment banks and brokerage firms, 14 financial and economic consultants, eight foundations and think tanks, and 10 universities)	Expected CPI change in one, two and 12 months and expected CPI change in current year and next (average and year- end)	Results are published every month. The survey is carried out weekly
Brazil	Focus Report	Weekly	Census	Firms, financial institutions and economic consultancies		CPI and PPI inflation two and three years ahead. Expectations of the same variables on a monthly basis	<a href="http://www.bcb.gov.br/pec/notastecnicas/ingl/2003nt36SistemaBacenExpectMercadoi.pdf">http://www.bcb.gov.br/pec/notastecnicas/ingl/2003nt36SistemaBacenExpectMercadoi.pdf</a>
Chile	Economic Expectations Survey	Monthly/ since February 2000	Fixed sample	Financial institutions' consultants, executives and advisers	Excellence/ around 40 participants	Inflation	The survey is closed once CPI t-1 or IMACEC t-2 is known. The results are published on the central bank's website ( <a href="http://www.bcentral.cl/index.htm">http://www.bcentral.cl/index.htm</a> ).
Colombia	Encuesta de expectativas económicas	Quarterly/ since 2000	Random sample	Business managers	Probabilistic, 170 participants	Expected annual inflation at one, two, three and four quarters ahead	

Table A1 (cont)

## Central bank surveys on inflation expectations

<b>Economy</b>	<b>Survey</b>	<b>Frequency/ conducted as from</b>	<b>Data collection technique</b>	<b>Population (type and size)</b>	<b>Selection criteria/ number of respondents</b>	<b>Inflation expectations measure</b>	<b>Notes</b>
Colombia	Encuesta de inflación y tasa de cambio a expertos financieros	Monthly/ since 2003	Census	Professional forecasters in the financial sector	Probabilistic, 41 participants	Expected inflation: month-end, year-end and 12 months ahead	Beginning of each month
Czech Republic	Inflation expectations of financial markets	Monthly/ since May 1999	Survey of fixed sample	Financial market analysts very active in capital and money markets from large banks and brokerages	15 financial market analysts	Expected CPI change in one year and three years ahead	The Czech National Bank also conducts an inflation expectations survey covering non-financial corporations and firms
Czech Republic	Inflation expectations of managers of non-financial corporations	Quarterly/ since June 1999	Fixed sample: survey using standardised questionnaire	Stratified sample of non-financial corporations and companies of the region, by activity and role in Czech economy	Fixed sample, 62 respondents	Year-on-year consumer price changes in the next 12 and 36 months	Quantitative survey. Respondents provide their quantitative estimates of expected inflation figures, ie the specific annual prices for the one-year and three-year horizons. The simple arithmetical average is computed

Table A1 (cont)

## Central bank surveys on inflation expectations

Economy	Survey	Frequency/ conducted as from	Data collection technique	Population (type and size)	Selection criteria/ number of respondents	Inflation expectations measure	Notes
Czech Republic	Inflation expectations of households	Quarterly/ since June 1999	Telephone sample survey based on the CATI method (Computer Assisted Telephone Interviewing)	Household members between 15 and 79 years old, randomly selected in 14 regions	600 respondents selected according to gender, age, occupation, region, size of town, education, average net income, number of household members, type of employment	Year-on-year consumer price changes in the next 12 and 36 months	Quantitative survey. Respondents provide their quantitative estimates of expected inflation figures, ie the specific annual prices for the one-year and three-year horizons. Extreme values are excluded (5% highest, 5% lowest), and the simple arithmetical average is computed
Hong Kong SAR		The Hong Kong Monetary Authority does not conduct any surveys on inflation expectations					
Hungary	Households' inflation expectations survey	Quarterly	Random sample	Households	Personal interview	Perceived inflation in the last 12 months; expected inflation in next 12 months	Results are published
Hungary	Firms' inflation expectations survey	Quarterly	Random sample	Firms	Telephone interview	Perceived and expected change in general domestic sale prices and in perceived and expected inflation	Results are not published
India	Inflation expectations survey for households	Quarterly/ since September 2005	Sample survey: a two-stage sampling design is used	All households in the country		Expected inflation for next quarter and year	

Table A1 (cont)

## Central bank surveys on inflation expectations

Economy	Survey	Frequency/ conducted as from	Data collection technique	Population (type and size)	Selection criteria/ number of respondents	Inflation expectations measure	Notes
Indonesia	Consumer survey	Monthly/ since October 1999	Sample survey	Respondents are selected by sampling from the number of households over 18 cities	About 4,650 households	Price change expectation	This survey seeks information about the growth of demand in the short term as reflected in the changes in consumer expectations on spending. Data canvassing is carried out through telephone interviews and direct visits in particular cities. The balance score method (net balance + 100) has been adopted to construct the index; values above 100 points indicate optimism and vice versa
Indonesia	Markets perception survey	Quarterly/ from September 2001 to December 2006	Sample survey	Respondents are selected by sampling from 11 big cities	The survey covers 100 respond- ents including economists, economic researchers, capital market analysts, academic societies and bankers	Inflation rate expectations	This survey is used to collect experts' predictions on changes in selected macroeconomic indicators. Data are collected by mail, fax and e-mail. The survey focuses on predictions made by a majority of respondents. See <a href="http://www.bi.go.id/web/en/Publikasi/Survei/Survei+Persepsi+Pasar/">http://www.bi.go.id/web/en/Publikasi/Survei/Survei+Persepsi+Pasar/</a>
Israel	Companies Survey  Professional forecasters	Quarterly/ since September 1983 at least twice a month	Sample of private companies: random sample, by industry	Private companies (excluding banks), main industrial categories	About 600 companies	Expected change in CPI, three months and one year forward	Participants are asked to report on the degree of change expected (great, slight)

Table A1 (cont)

## Central bank surveys on inflation expectations

<b>Economy</b>	<b>Survey</b>	<b>Frequency/ conducted as from</b>	<b>Data collection technique</b>	<b>Population (type and size)</b>	<b>Selection criteria/ number of respondents</b>	<b>Inflation expectations measure</b>	<b>Notes</b>
Korea	Consumer sentiment survey	Monthly	Specially designed form and telephone interviews	Households	Stratified sample of 2,000 households	Expected CPI change in one year	
Korea	Survey of inflation expectations of experts	Quarterly	Specially designed form	Fixed sample	45–50 professional forecasters	Expected CPI change in two quarters	Not published
Mexico	Survey on the private sector's economic expectations	Monthly/ since September 1994	Fixed sample	Analysts from 37 private sector economic groups	Analysts willing to participate	Expected CPI and core CPI inflation: monthly for the next 12 months; end of year; four-year average after five years from the current date	The Bank of Mexico publishes a results document showing the average private sector economic expectations and a Confidence Index
Philippines	Business expectations survey (BES)	Quarterly/ since June 2001	Sample survey; stratified random sample by industry group	Top 5,000 corporations registered with the Securities and Exchange Commission (SEC)	Criteria: top 5,000 corporations in terms of gross revenue  Sample size: 1,087 corporations	Outlook for inflation	

Table A1 (cont)

## Central bank surveys on inflation expectations

Economy	Survey	Frequency/ conducted as from	Data collection technique	Population (type and size)	Selection criteria/ number of respondents	Inflation expectations measure	Notes
Poland	Consumer inflation expectations	Monthly/ 1992 (Ipsos) 2001 (GfK Polonia)	Monthly	Quota random sampling method	Men and women aged 15+	Ipsos: inflation expectations GfK Polonia: inflation perception, inflation expectations	
Poland	NBP quarterly survey of producers' inflation expectations	Quarterly	Quarterly	na	na	Price of produced goods in three months and CPI and PPI in three and 12 months	Published
Saudi Arabia		The Saudi Arabian Monetary Agency does not produce any inflation expectations surveys					
South Africa	Survey of inflation expectations	Quarterly/ since fourth quarter of 2000	Direct (mail and e-mail) and personal interviews. Partly fixed/partly random sample	47 million people	2,500 rep- resentative households are sampled. Also fixed sample of non-financial firms, financial analysts and trade unions	Expectations for the current and next two years: average CPI inflation, average CPIX inflation rate	The South African Reserve Bank contracted the Bureau for Economic Research (BER) to conduct a quarterly inflation expectations survey, in view of the Bank's inflation targeting monetary policy framework. See <a href="http://www.ber.ac.za/RunTime/POPContentRun.aspx?pageidref=1778">http://www.ber.ac.za/RunTime/POPContentRun.aspx?pageidref=1778</a>
Turkey	Survey of expectations	Twice a month starting from August 2001 (first and third week)	Non-proba- bilistic samp- ling method based on the participation of selected volunteers	Experts and decision- makers from the financial and corporate sectors and professionals	120 persons/ 60 to 85%	Expectation of CPI, for the current month, next month, two months ahead, end of year, next 12 months and 24 months	The survey is carried out via e-mail

Table A1 (cont)

**Central bank surveys on inflation expectations**

<b>Economy</b>	<b>Survey</b>	<b>Frequency/ conducted as from</b>	<b>Data collection technique</b>	<b>Population (type and size)</b>	<b>Selection criteria/ number of respondents</b>	<b>Inflation expectations measure</b>	<b>Notes</b>
Turkey	Consumer tendency survey	Monthly/ since December 2003	Sample survey	All individuals aged 15 and above, having a job that provides income in urban and rural areas of Turkey	Approx 8,000 respondents are selected from the Turkish Statistical Institute's Household Labour Force Survey based on age, income and status in employment categories	Price expectations	<p>1. The survey is annexed to the Turkish Statistical Institute's Household Labour Force Survey in the form of a module</p> <p>2. Some questions in the survey are used to compile the Consumer Confidence Index</p>

Sources: Central banks; BIS.



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# Monetary policy and measures of inflation

Miguel Angel Pesce

## 1. Introduction

The way in which the purchasing power of money is measured poses some questions at the time of assigning it a clear meaning and determining how it should be measured properly. In spite of the differences that may arise from its definition, the concept of inflation proves to be quite understandable. Inflation is usually referred to as a process of sustained rise in the general level of prices. However, neither the meaning of sustained nor the general level of prices upon which inflation should be measured are usually explained. Irving Fisher holds that the general level of prices is the average price of all the transactions conducted within an economy over a certain period of time, regardless of the goods and services involved, namely: consumer goods or capital goods, inputs or products, intermediate or final goods, real or financial exchanges, domestic or overseas purchases. In this sense, therefore, a broad concept of “inflation” is more comparable to the gross value of production deflator than the consumer price index (CPI).

As with its definition, the best way of measuring inflation is not obvious, particularly if we focus on the different ways in which we may use the outcomes obtained. This is important in terms of guiding policy decisions and monitoring economic performance. Hence, choosing a particular index is critical for monetary policy since one of its main targets is to maintain the purchasing power of domestic money. Some countries have supplemented this objective with others such as the sustainability of other macro variables: the level of activity, of employment or of interest rates, *inter alia*.

As stated above, different price indices are intended to measure the impact of price increases upon people’s consumption capacity or, in terms more relevant to monetary policy, the changes in the purchasing power of money. The way the main groups of good and services are formed, the products included and the relative importance attached to each, when constructing an index, should account for the structure of household expenses in each country, which – according to these indices – show significant differences.

The CPI is usually used as the best indicator of the performance of retail prices or the purchasing power of money, due to the relevance that this kind of index gives to the total traded goods and services in the market within an economy. However, the CPI is not always deemed the most relevant indicator for monetary policy purposes. Moreover, from a technical point of view, it shows some weak points (Quah and Vahey (1995)).

It is worth mentioning that over recent years central banks have started to follow underlying inflation indices, core inflation, with the aim of analysing the development of medium-term trends underlying current price variation rather than temporary or seasonal fluctuations. In this sense, it has been confirmed that the instruments of monetary policy should be aimed solely at stabilising these indicators of underlying inflation. As from the introduction of this concept, core inflation, it is also necessary to find an appropriate measurement, which – as with the CPI – gives rise to other considerable difficulties and methodological disagreements.

Since mid-1980s, the development of the world economy has undergone major structural changes. These changes have had strong effects upon the role played by different variables over the inflation process. Broadly speaking, these changes resulted in an environment of strong real growth combined with low levels of inflation over the first years of the present decade. In the monetary field, the unprecedented growth of financial assets gave way to high levels of international liquidity together with low real interest rates. These structural changes

in the real, financial and monetary sectors have hindered the forecasting and measurement of inflation. In this scenario, in recent years the indicators used by monetary authorities to measure the compliance with their objectives in terms of inflation and those of economic policy have started to be questioned.

## **2. The factors of international economy that hinder the development of inflationary processes.**

Over the last few years major changes in the international economy have occurred, exerting effects upon inflationary processes. For instance, we may mention a sustained increase in international trade, particularly related to the role played by India and China and other emerging economies that led to an increase in competitiveness within international markets, and a flood of new financial instruments within a framework of abundant global liquidity.

There has been a strong growth of international trade from the mid-1980s, as statistics show. This increase came with a continuous decrease in tariff and trade barriers, which on average decreased from 26% in 1986 to 8.8% in 2007. Table 1 shows that in many countries from different regions the levels of commercial protection fell sharply from the 1980s.

Focused on the United States, given its importance and share in the world economy, we may note that its trade openness indicator has grown strongly, spurred by the rise in imports over the last 25 years. Graph 1 shows how the United States' imports increased by the end of the 1980s. If we take into account the different components of these imports, we can see in Graph 2 that the rise in consumer goods is above average.

Combined with an increase in quantity flows, import price in real terms showed signs of stability. Graphs 3A, 3B and 3C show that the import prices of manufactured products from both industrialised countries and the rest of the world followed a relative stable path between 1990 and 2002; this behaviour is further followed by non-manufactured products. As a result, the implicit import price deflator, which showed an increase during the 1970s, stabilised from the early 1980s to the early 1990s, and subsequently recorded a slight drop up to 2002, as can be seen in Graph 4.

Although it is obvious that the trade issue alone is not enough to explain the development of the different indicators of inflation, it may well have exerted some "control" over them. Hence, the different indicators used to measure inflation within the United States have benefited from an increase in the share of imported goods in local supply and, as we can see, in the last 10 years headline inflation has surpassed that observed for durable goods, which can be partly explained by the higher level of trade mentioned.

Graph 5 shows that the evolution of goods prices, which is more subject to competitiveness and trade, was much more favourable than that of services. We also emphasise that the development of the headline indicator (all items) is consistent with that of energy (Graph 6). This is due to the fact that, in general, the share of energy items in the consumer basket of developed countries is higher than that of emerging and developing countries where food items have greater weight (and therefore in these countries CPI is more closely related to the changes in the prices of foodstuffs).

This last concept is of vital importance when economic authorities have to design, implement and monitor the performance of economic variables. Therefore, the structure of each economy should be considered at the time of designing an index. In this sense, the consumer basket of developed countries, which is taken as a basis for weighing purposes, is markedly asymmetrically compared to that of emerging countries.

As mentioned above, in developing countries the components of food and goods have a higher weight in the consumer basket, while in developed countries consumption expenditure

is more related to industrial and technological goods and services. Furthermore, there is an inverse relationship between per capita income and the share of the food component in the indices in several countries: when per capita income is lower, the weighting of the food component in the index grows. In developing countries a greater percentage of the population live in poverty and are therefore more affected by food price increases.

At the same time, in each economy the evolution of relative prices is influenced by several elasticities – price and income – as well as the country’s trade situation (whether the country is a net exporter or importer of the product). Besides the mentioned difference in the composition of consumption baskets, emerging countries generally show higher values for demand elasticities than developed countries. Moreover, in recent years price increases for agricultural commodities have been accompanied by rises in the values of their respective demand elasticities; for example, the demand elasticity of inputs by foods increased from 0.3 to 0.36 between 2000 and 2008, maintaining an upward trend.

	<b>1980–1999</b>	<b>2000–07</b>
Growth in food demand, annual rate	1.02	1.35
Growth in relative prices of food, annual rate	0.12	1.60
Presentation by Mehmet Yorukoglu, CMBT, August 2008, Brasilia, Brazil, data based on IMF WEO		

The above-mentioned structural changes in the international economy and the structural characteristics of the individual countries are the basis for divergent inflationary dynamics between different groups of countries. As the component of expenses for food is higher in emerging countries, there were mounting pressures in the general price level, as has been seen in recent years.

In this sense, the weights of items in the indices used for monitoring policy targets become very relevant considering the trend described above. Shocks to food prices in emerging countries, where contribution to inflation indices is four times higher than in the developed ones according to some studies, require different policy responses.

On the other hand, given the divergence with respect to headline indicators in recent years, the use of underlying inflation indices as policy objective clearly indicates that core indices would not be key indicators to assess the current situation of the economic cycle. It seems that they are not suitable indicators of purchasing power of an important group of people in various countries, since they exclude food and energy, which are a significant part of the consumption basket.

Finally, in a context of low inflation and high growth, there was an impressive rise in financial assets and, as mentioned, the liquidity surge that supported it was not followed by inflationary pressures. As shown in Graph 7, monetary aggregates, (taken as liquidity proxies in the United States), particularly M2 and M3, have shown a strong expansion in real terms since 1995, which did not reflect on inflation indices. However, as headline inflation remained stable and in comfortable levels, asset prices were persistently climbing (technologicals’ first, mortgage and commodities related then followed, see Graph 8). This situation was worsening due to the weak framework of regulation and supervision of banking and capital markets that characterised the global economy in recent years.

In this context, if monetary policy objective is concentrated basically on a consumer inflation index that excludes particular items such as food and energy, it is possible that the effects of liquidity surge might arise somewhere else. It is important to remember that the nominal objective chosen to maintain stable, whatever it is, entails short- and long-run economic

aspects regarding activity and income distribution that are not explicitly acknowledged<sup>1</sup>. It is important to emphasise that in a headline CPI, even without exclusions, some prices such as physical assets, land and dwellings, or the prices of financial assets like bonds and securities purchased by households, are generally left outside the scope of the index.

In this respect, the ongoing financial crisis shows some inconsistencies in so-called “single objective” monetary policies characterised by having price stability as a unique target. In an environment of growing liquidity in financial international markets, the disequilibrium in some financial asset markets was absent from the setting of monetary policy objectives, as they were just designed to keep a nominal variable trimmed, in terms of the available basket of goods and services, such as the consumer price index or a core inflation indicator. Sooner or later the adjustment process would take place over the real economy. Besides, from a political economy perspective, it is difficult to stand for the efficiency of indicators that set aside some components that have strong and direct impacts on the purchasing power of a large part of the population.

### **3. Monetary policy objectives and inflation indicators: Argentine experience**

Based on the previous exposition, let us now turn to monetary policy objectives and inflation indicators for Argentina.

High macroeconomic instability and abrupt monetary regime changes over the last decades have made it more difficult to analyse the available historical data and to develop a reliable indicator for inflation trends.

It is worth noting that after the deep financial crisis of 2001/02, different price indices reveal divergent situations: some of them show core inflation running above headline inflation, while other indicators present the opposite situation. This could also arise from a peculiarity of the Argentinean case, where what we usually understand as a “core” CPI inflation index is more volatile than the headline (Graph 9). Analysing the methodology and figures, we could find an explanation for the situation that started after the end of 2001, as the prices of goods and services under public regulation have had few changes in the period, resulting in a more “stable” headline CPI as the share of regulated items on the indicators amounts to around 20% of the basket.

This fact takes us back to the issue of choosing the categories or types of expenditure, the goods and services to be included, as well as the weight of each item in the basket for the index. As mentioned, the composition of the index must reflect the consumption patterns of households, which might be significantly different across countries.

In the case of Argentina, the consumption basket is built from the National Households Expenditure Survey (Encuesta Nacional de Gastos de los Hogares, ENGH) undertaken by the Statistics and Census National Institute (INDEC), which provides information on both the goods and services purchased by families and the share of each item in total consumption expenditure.

Something important to take into account in the construction of price indices is the need for keeping up to date the information on household expenditure patterns, as well as goods and services availability given the usual changes in habits and tastes of the population. At the

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<sup>1</sup> Even if real economy aspects are set aside, inflationary or deflationary environments impose distributional effects between population segments according to whether one is a creditor or a debtor.

same time, keeping an updated record of the outlets where prices are collected is also most important. All of these adjustments are even more relevant in a context of extreme relative prices changes, such as those seen in Argentina after leaving the convertibility regime in 2002 (Graphs 10 and 11).

Consumers usually react to changes in relative prices by reassigning expenditure depending on their price elasticity between goods and services. For instance, if the price of red meat is about to increase relative to that of poultry, demand for the latter might go up as it becomes relatively cheaper. This expenditure adjustment is absent in a Laspeyres-type CPI, the most used methodology for price indices, and red meat will be more strongly weighted against poultry, leading to an overstatement of inflation. Also, our experience during the 2002 crisis showed that people changed their consumption pattern significantly, particularly regarding food, housekeeping supplies and personal care products, replacing usually purchased branches by so-called “second branches”. However, if the price items with inelastic demand go up, the index will indeed show an accurate inflation figure as the share of those items in households’ total expenditure will certainly increase.

Considering the previous year, the base period for the current official CPI was changed to April 2008, taking as a reference the last ENGH for 2004/05, with a geographic scope of Buenos Aires city and the Greater Buenos Aires area. The previous index was based on the expenditure survey for the years 1996/97, and lacked the effects of the changes in consumer demand in the last 10 years, and particularly after the relative price adjustments undergone by the economy in the aftermath of the convertibility regime breakdown. This omission made a clear case for updating the base period, the basket composition, and the outlet sample.

As a result, the new CPI based on April 2008 takes into account the information from the last ENGH, and excludes some expenditure that was included in previous index as a means to make the current indicator more representative of middle and lower-income households

<b>CPI weights, April 2008 base period</b>	
<b>Major groups</b>	<b>Weights</b>
General level	100.00
Food and beverages	37.87
Apparel	7.33
Housing	12.14
Household furnishing and operation	4.89
Medical care	5.58
Transport and communications	16.56
Recreation	5.08
Education	4.26
Other goods and services	6.31
Source: Indec	

Regarding underlying inflation indicators intended to grasp the persistent and generalised effects of price evolution on the economy, which are usually prescribed as being appropriate for monetary policy analysis, INDEC has released different CPI categories in Argentina since 2004: seasonal, regulated and other components. The CPI other components is considered as a proxy for core inflation as it is stripped of seasonal items and items whose prices are linked to administrative decisions on taxes or tariffs.

Although core inflation is expected to be less volatile than headline inflation, the CPI other components behaves in more erratically than the CPI headline. This has to do with the exclusion of regulated items from the overall index, as those goods and services show discrete and unusual changes over time, and accounts for around 20% of the CPI. At the same time, seasonal products explain nearly 9% of the headline, adding little volatility to the CPI.

It is worth noting again that exclusion methodology might leave out valuable information regarding inflationary trend. The larger the share of excluded items from the CPI, the more underlying inflation could deviate from the figures reported by the core index. As an example, in the context of the recent oil price increases lasting for more than five years (giving rise to the question of whether it was a temporary shock or a permanent relative price adjustment), as well as those of foodstuffs, it is not clear that excluding those prices from the underlying inflation measures has been an accurate way to measure inflation. It is particularly important when discussing monetary policy actions to prevent second-round effects, and when food and energy inflation erodes households' purchasing power. As noted, the impact from energy and food items on the CPI depends on its weights in the basket, and one can see that increases in food prices have a more direct effect on the headline index and also an earlier pass-through to core inflation than in the past.

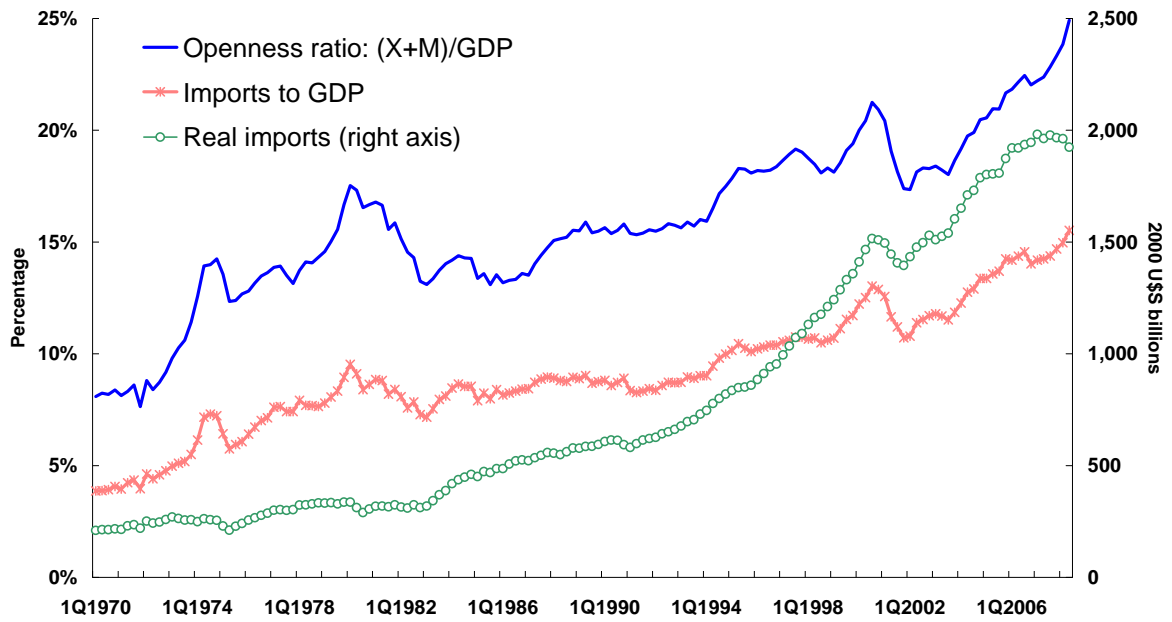
Within this scenario, where different kind of shocks have been hitting economies such as Argentina's in recent years, exclusion methodology for core inflation indices are not a definite gauge of the phase of the business cycle.

Another relevant issue for countries like Argentina, a net exporter of agricultural commodities, is the pass-through of the volatility on international quotes to local prices via changes in the terms of trade. This particular situation raises the question of the proper monetary and exchange rate policies for emerging economies in that context, mainly due to the impact on domestic consumption of this relative price adjustment.



Graph 1

**USA: Real imports, openness ratio and imports to GDP**

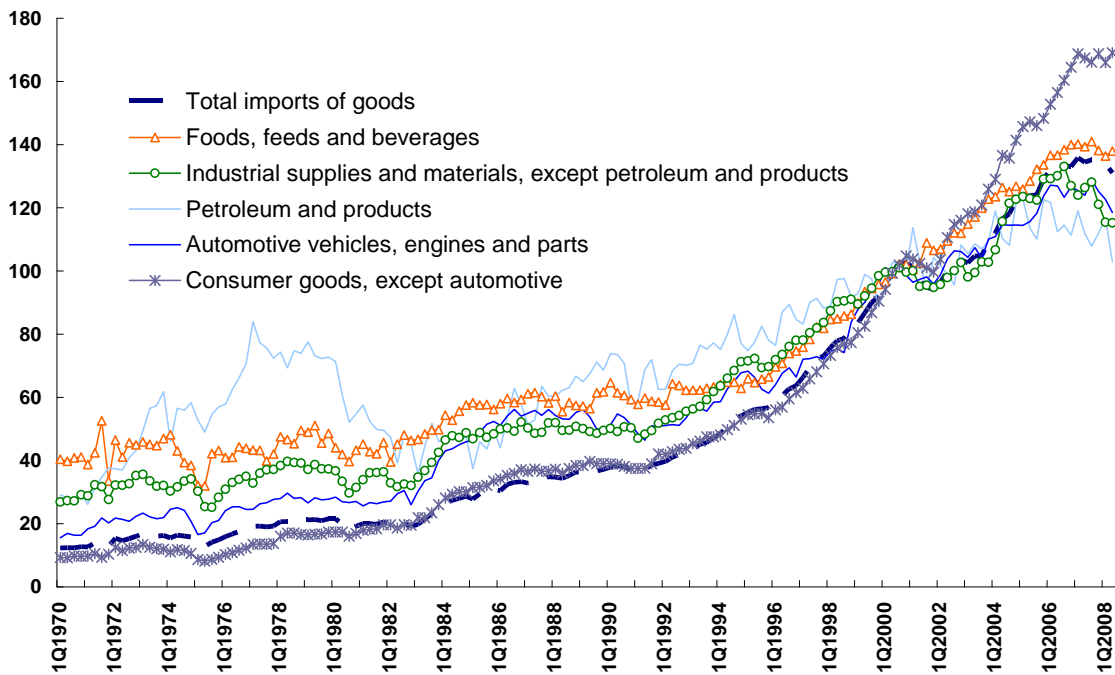


Source: Bureau of Economic Analysis

Graph 2

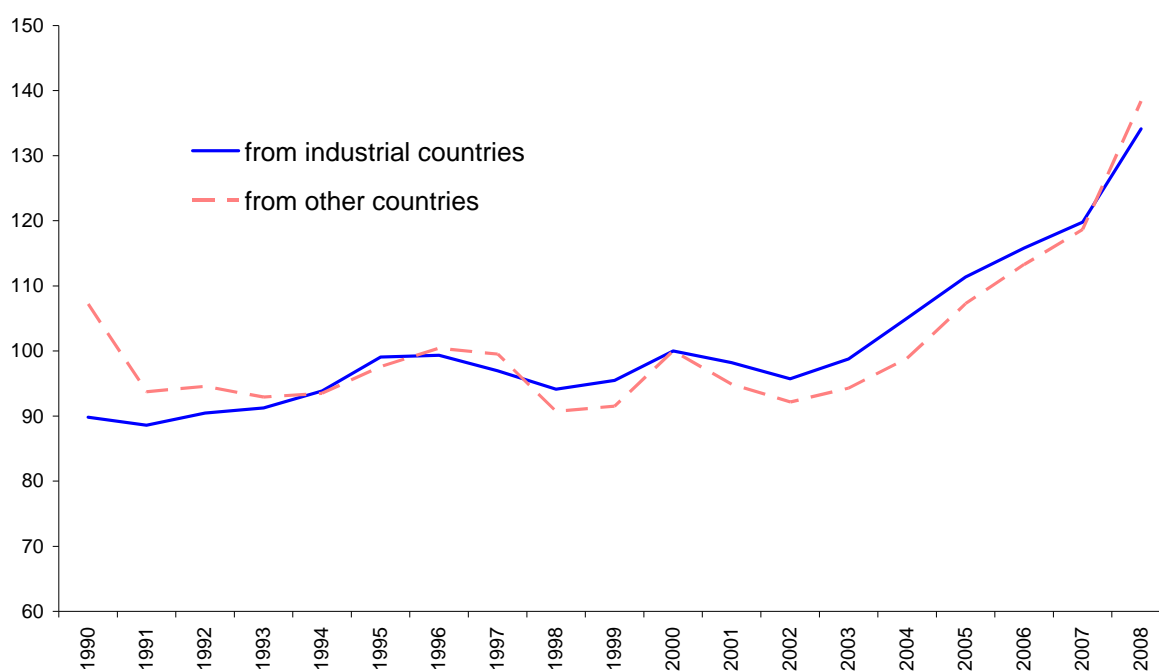
**USA: Real imports by type of product**

2000=100 index



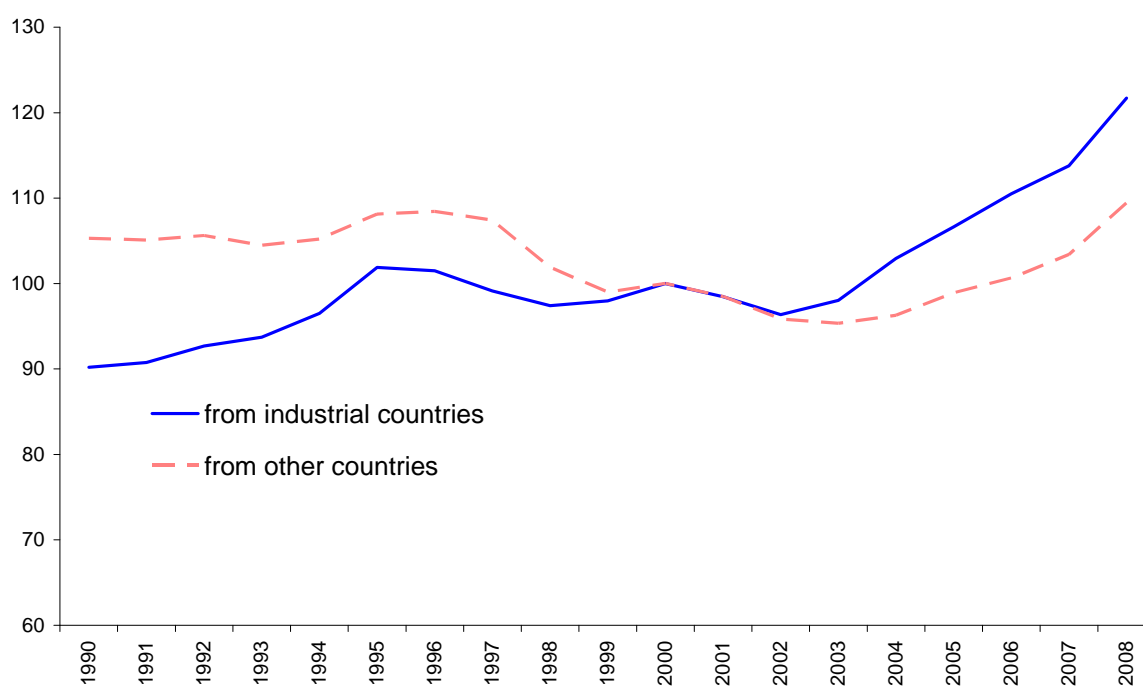
Source: Bureau of Economic Analysis

Graph 3.A  
**USA: Price of total imports**  
 2000=100 index



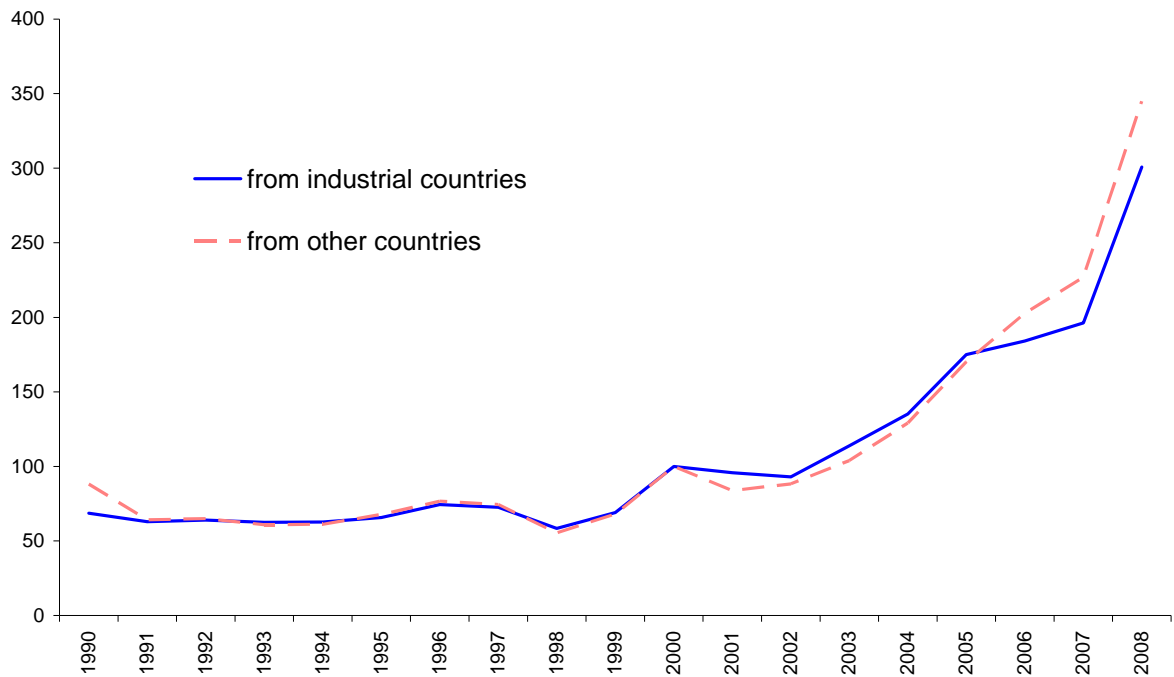
Source: Bureau of Labor Statistics

Graph 3.B  
**USA: Price of manufactured goods imports**  
 2000=100 index



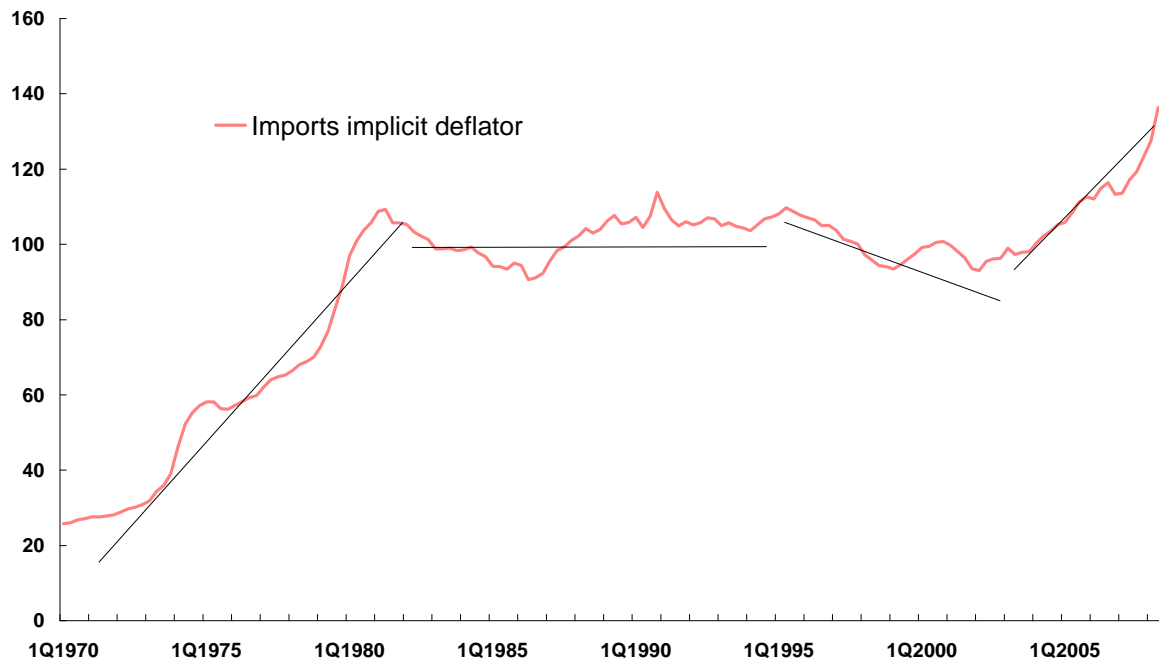
Source: Bureau of Labor Statistics

Graph 3.C  
**USA: Price of non-manufactured goods imports**  
 2000=100 index



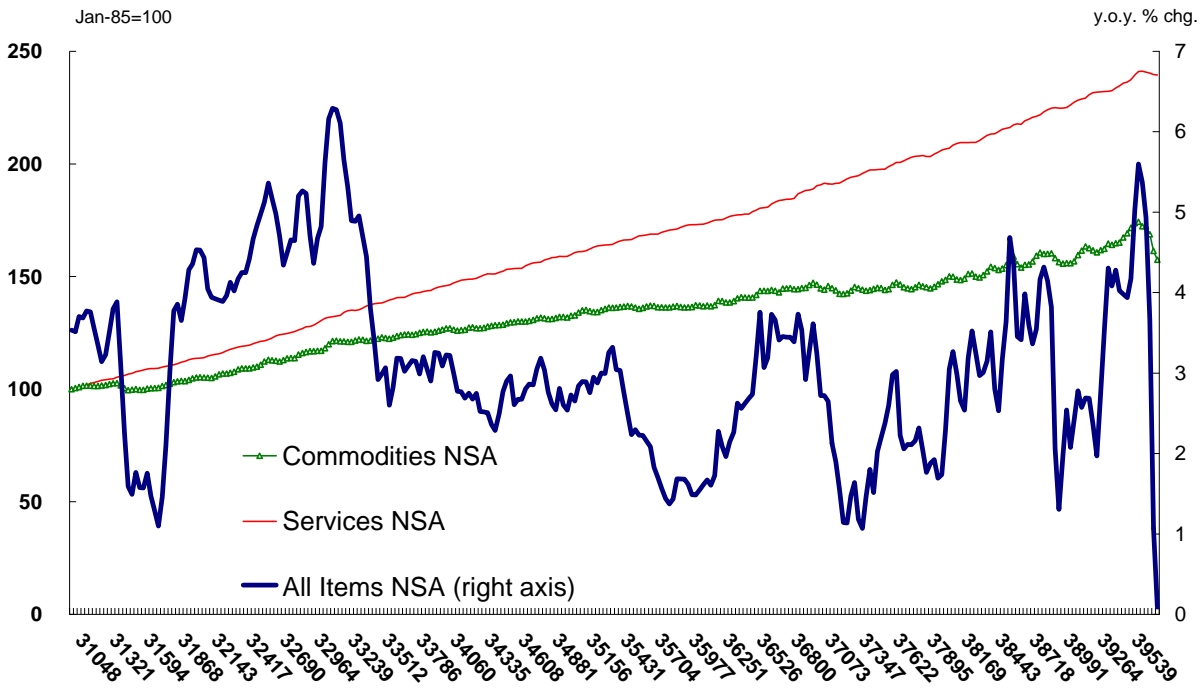
Source: Bureau of Labor Statistics

Graph 4  
**USA: Price of total imports**  
 2000=100 index



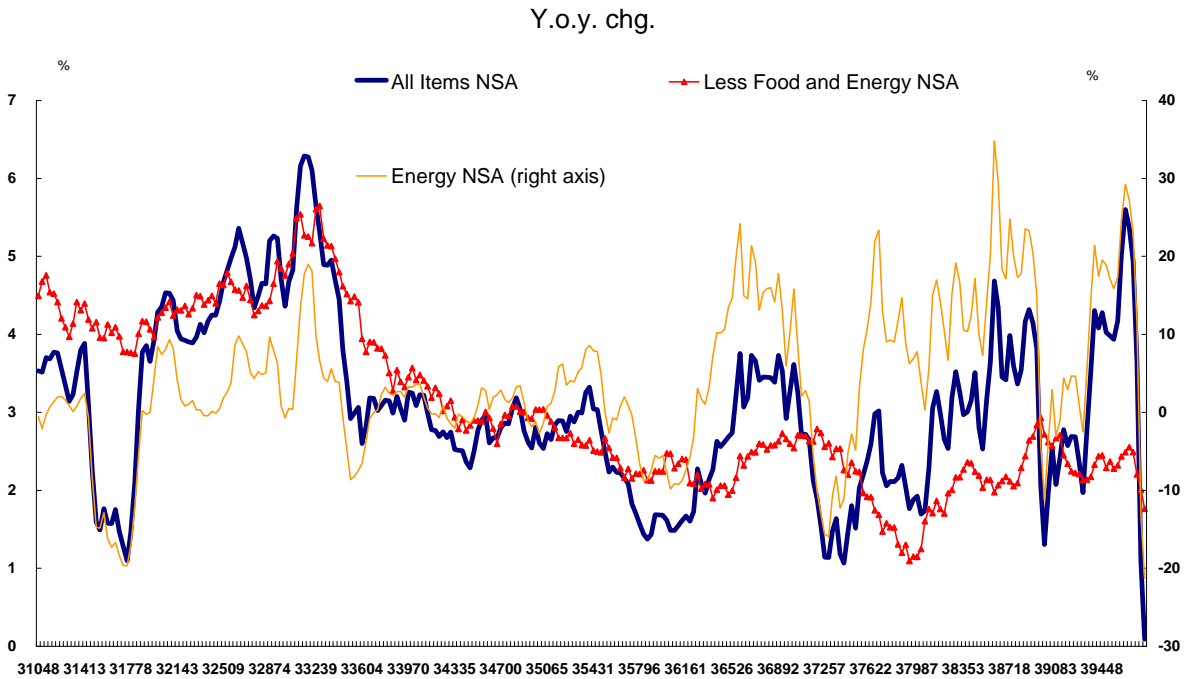
Source: Bureau of Economic Analysis

Graph 5  
**USA: CPI for all urban consumers**



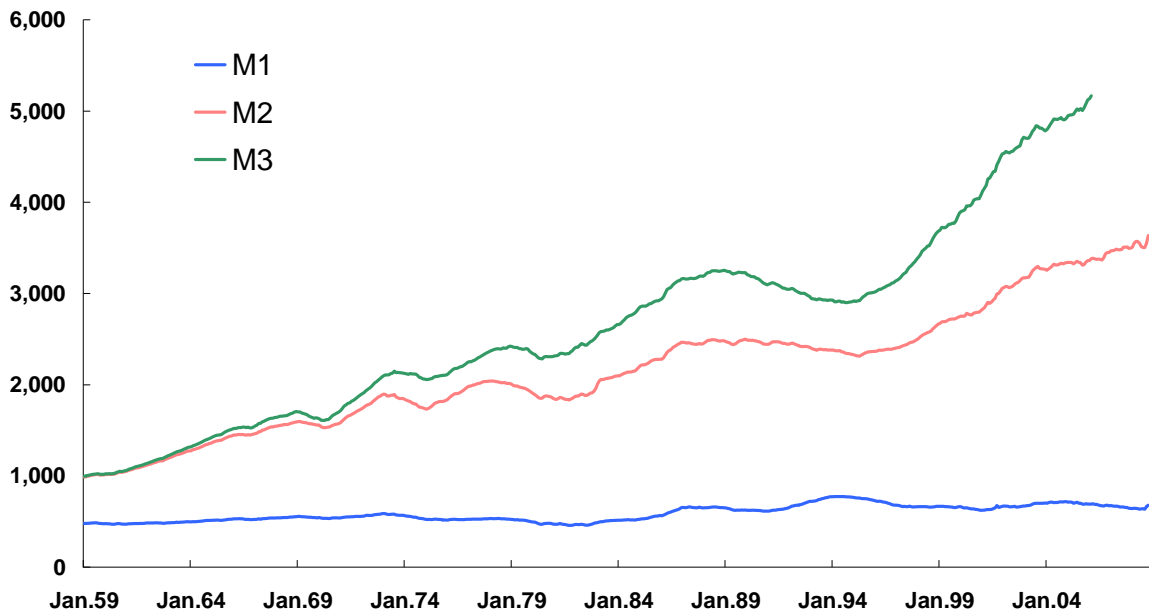
Source: BCRA from Bloomberg data

Graph 6  
**USA: CPI for all urban consumers**

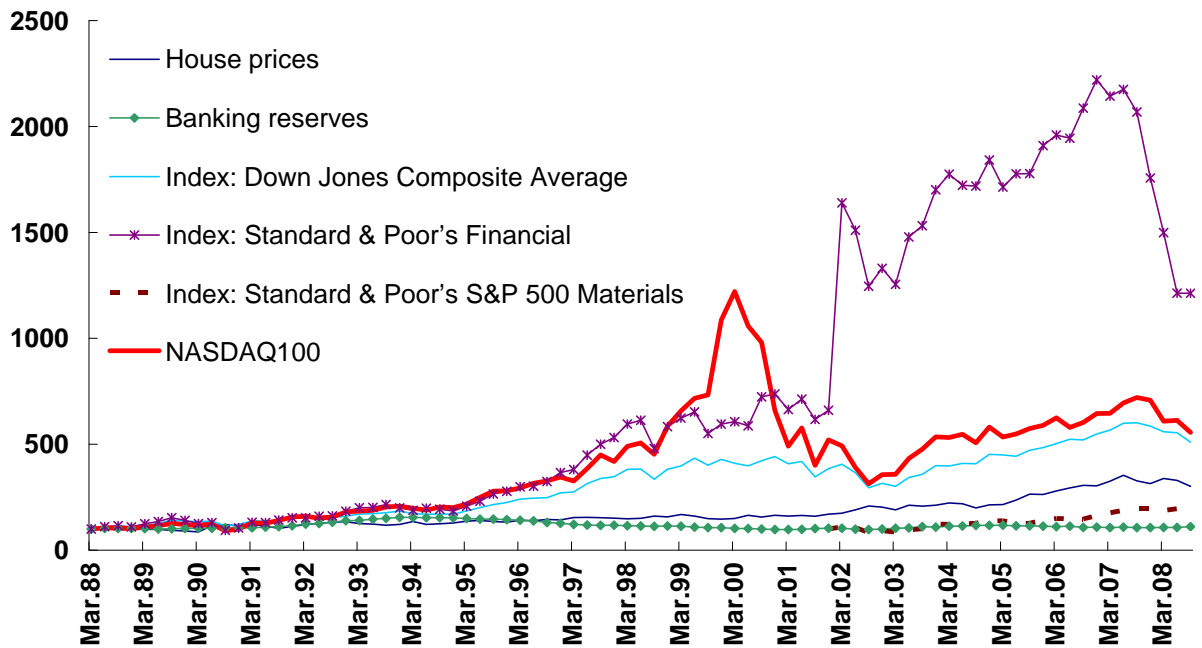


Source: BCRA from Bloomberg data

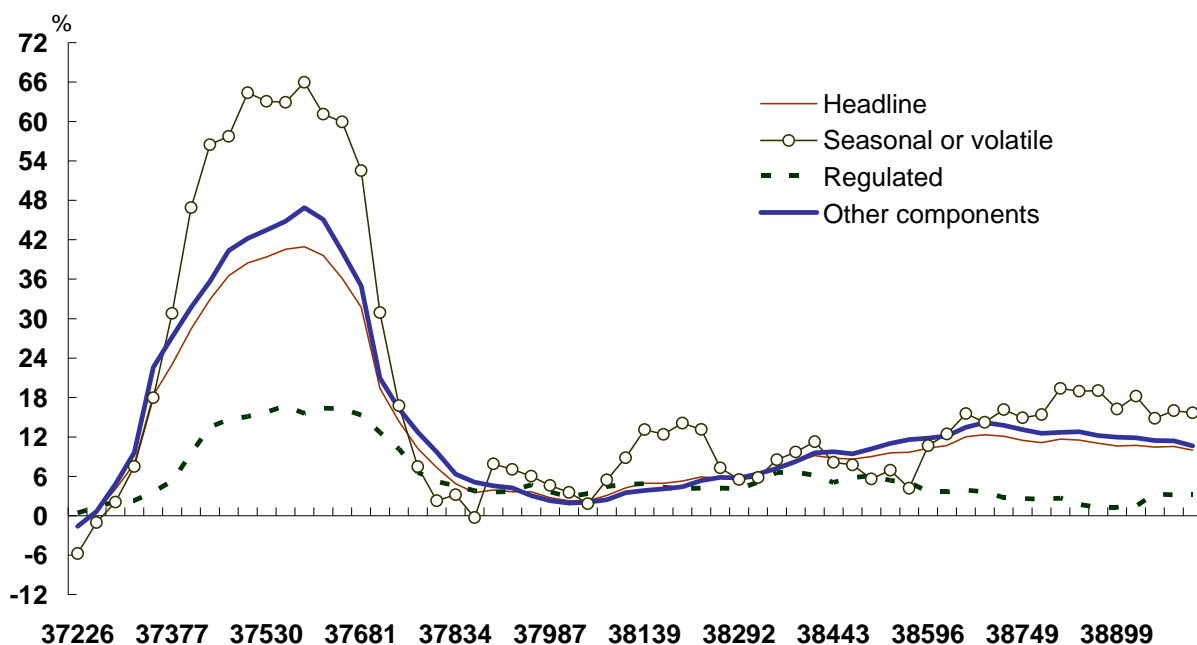
Graph 7  
**USA: real monetary aggregates**  
 M1, M2 and M3



Graph 8  
**Asset prices**  
 Index 1st quarter 1998=100

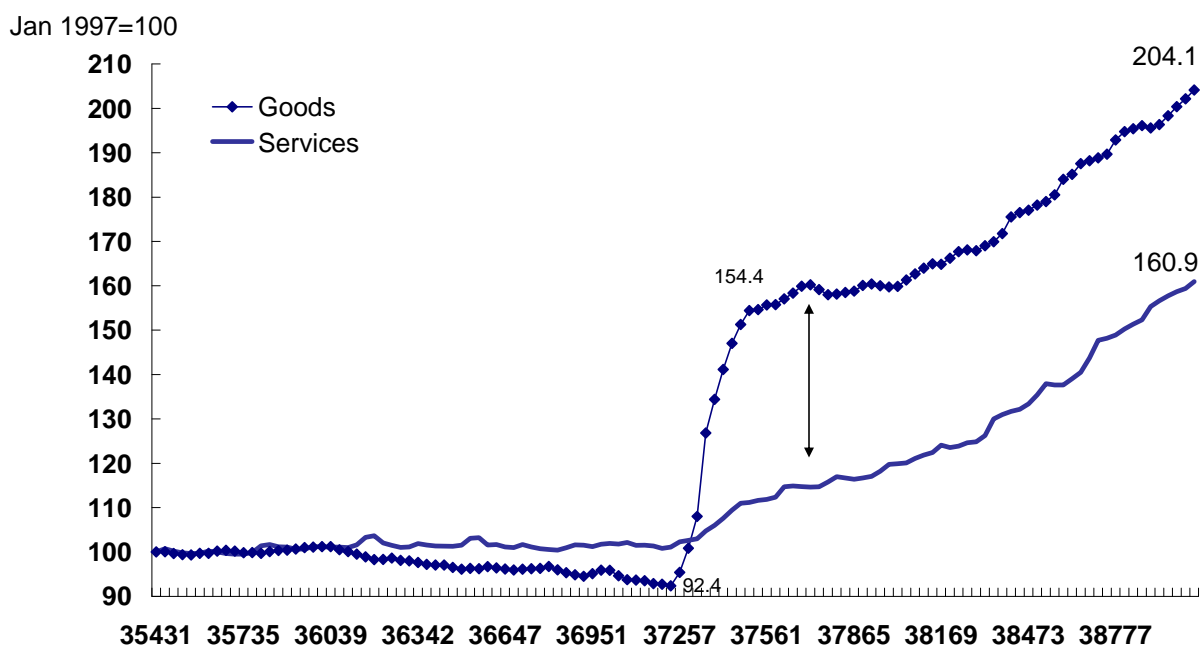


Graph 9  
**Greater Buenos Aires CPI. Components**  
 Y.o.y. change



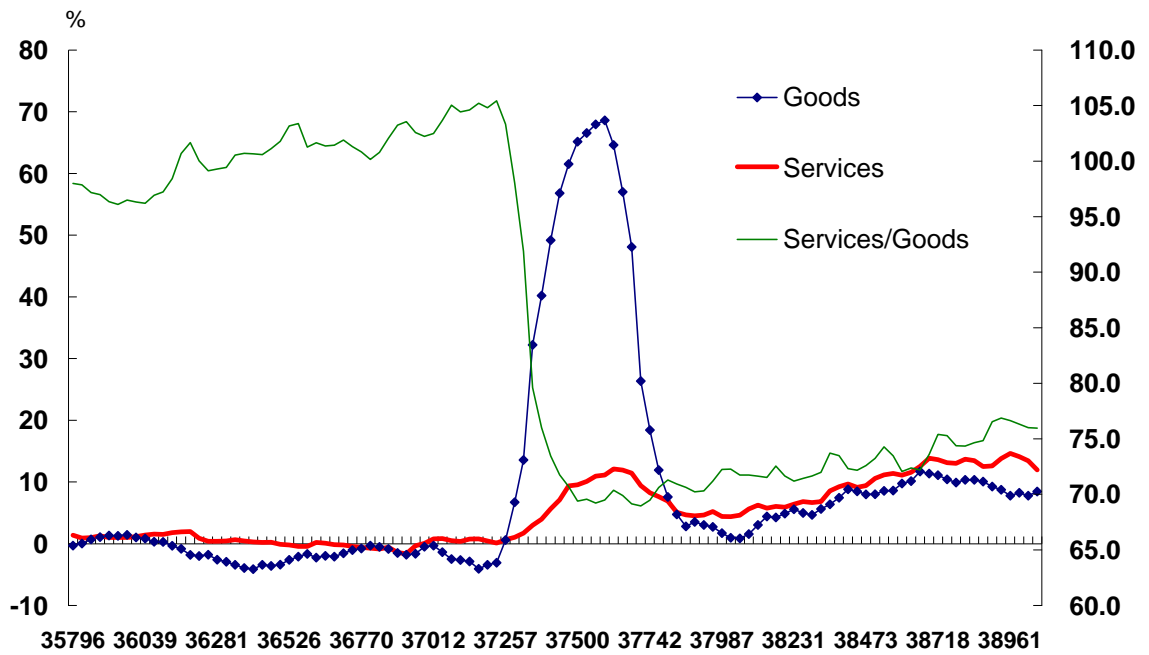
Source: INDEC

Graph 10  
**Greater Buenos Aires CPI. Goods and services**  
 Index Jan. 1997=100



Source: INDEC

Graph 11  
**Greater Buenos Aires CPI. Goods and services**  
 Y.o.y. change and ratio services/goods



Source: INDEC

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# Survey-based inflation expectations in Brazil<sup>1</sup>

Carlos Hamilton V Araujo<sup>2</sup> and Wagner P Gaglianone<sup>3</sup>

## 1. Introduction

Inflation expectations play a fundamental role in the inflation formation process. However, since these variables are in fact latent (and thus, they cannot be directly observed) some proxies are usually adopted by central banks, such as: (i) expectations obtained from financial market data,<sup>4</sup> and (ii) survey-based expectations.

In 1999, the Central Bank of Brazil implemented a daily survey as part of the transition to the inflation targeting system. It was created in order to monitor market expectations of roughly 90 Brazilian banks and non-financial companies, and to improve the inputs for the monetary policy decision-making process.<sup>5</sup>

Because of the importance of the subject to monetary policy, this paper aims to identify the main features of Brazilian survey-based inflation expectations collected by the Central Bank of Brazil, as well as to map the main driving forces behind the expectation formation process.

## 2. Data

Figure 1 depicts the Brazilian CPI headline inflation rate (IPCA), which is the inflation rate adopted in the inflation targeting system, together with the respective survey-based inflation expectations, for several forecast horizons.

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<sup>1</sup> The opinions in this paper are those of the authors and do not necessarily reflect the point of view of the Central Bank of Brazil. Any remaining errors are ours.

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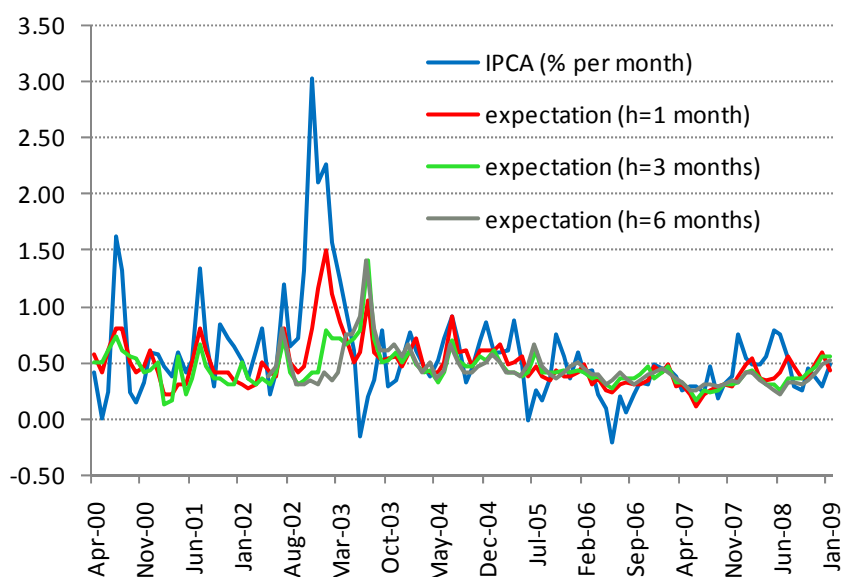
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<sup>4</sup> Inflation expectations extracted from Brazilian financial data might exhibit some problems due to the lack of market liquidity, and also with risk premium issues (eg how to separate expectations from risk premium, which depends on macroeconomic conditions).

<sup>5</sup> Currently, it monitors market expectations for different inflation rates, GDP growth, industrial production growth, the exchange rate, the Selic interest rate, fiscal variables, and external sector variables.

Figure 1

**CPI monthly inflation rate (IPCA)  
and respective survey-based expectations**



**Note:** The expectations represent the median values, across all consulted market institutions, according to the forecast horizon (h).

Table 1 gives some descriptive statistics of the short- and medium-run expectations, in comparison with the respective inflation rate. Similar statistics are presented in Table 2 for long-run expectations. First, note that the average and median values of expectations approach the inflation rate as long as the forecast horizon decreases, which is a natural result since the available information set becomes larger. In addition, the correlation between the inflation rate and the expectations increases, approaching the unit value.

Table 1

**Descriptive statistics (time series in monthly values)**

	IPCA (% p.m.)	Top 5 short h = 1 month	Median h = 1 month	Top 5 medium h = 3 months	Median h = 3 months	Top 5 medium h = 6 months	Median h = 6 months
Mean	0.559	0.509	0.483	0.449	0.439	0.434	0.438
Median	0.460	0.450	0.450	0.400	0.400	0.400	0.400
Maximum	3.020	1.880	1.490	1.720	1.400	1.300	1.400
Minimum	-0.210	0.100	0.100	0.150	0.160	0.200	0.210
Std. deviation	0.489	0.292	0.227	0.209	0.173	0.178	0.176
Correlation with IPCA	1.000	0.782	0.685	0.177	0.196	-0.083	-0.077

**Note:** The "Top 5" expectations represent the median values of the "Top 5" group (short or medium-run), whereas the so-called "median" expectations indicate the median of all consulted institutions for a given period. The sample period covers May 2002–December 2008 (80 observations).

Figure 2  
**CPI inflation rate – IPCA (% 12 months)  
 and (median) inflation expectations**

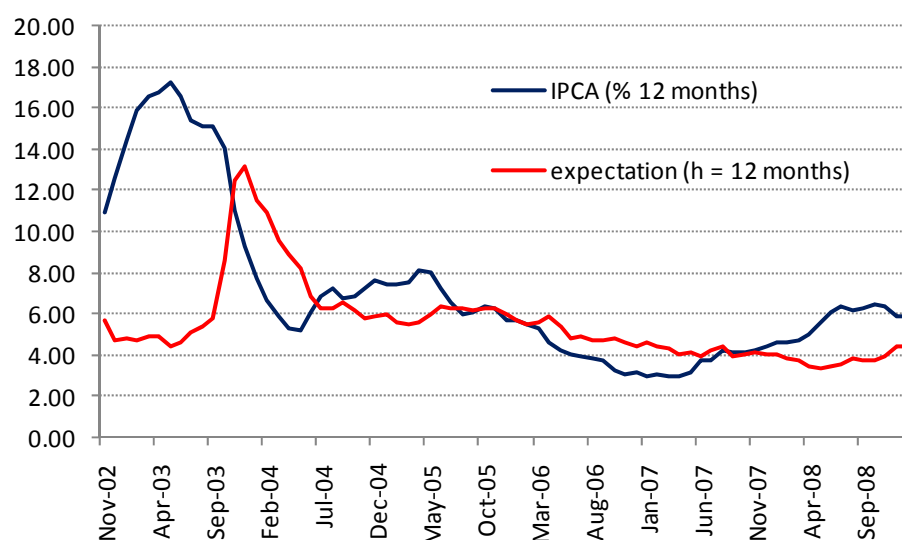


Table 2  
**Descriptive statistics**

	IPCA (% 12 months)	Median (h = 12 months)
Mean	7.092	5.567
Median	6.060	4.920
Maximum	17.240	13.180
Minimum	2.960	3.370
Std. deviation	3.922	2.010
correlation with IPCA	1.000	0.172

**Note:** Sample period November 2002–December 2008.

### 3. Bias investigation

A relevant issue to be investigated regarding any inflation expectations series is the existence of bias. To do so, first consider the following regression:

$$\pi_t = C_1 + C_2 \pi_{t-h}^e + \varepsilon_t, \quad (1)$$

where  $\pi_t$  represents the observed inflation rate,  $\pi_{t-h}^e$  is the respective inflation expectations time series, formed with a forecast horizon of  $h$  periods (ie expectation of the inflation rate for period  $t$ , formed at period  $t-h$ ), and  $\varepsilon_t$  is a random residual.

According to Grant and Thomas (1999), the existence of bias, or a “weak form of rationality”,<sup>6</sup> can be verified through the following null hypothesis  $H_0: (c_1; c_2) = (0; 1)$ <sup>7</sup> Tables 3 and 4 show the results of this “bias existence test” applied to the survey-based inflation expectations in Brazil.

Table 3  
Bias existence test  $H_0: (c_1; c_2) = (0; 1)$

Sample period May 2002– December 2008	Top5short	Median	Top5medium	Median	Top5medium	Median	Median
	h = 1month	h = 1month	h = 3months	h = 3months	h = 6months	h = 6months	h = 12months
$\hat{c}_1$	-0.107	-0.153	0.373	0.316	0.658	0.652	5.224
Std. dev.	0.066	0.128	0.209	0.242	0.224	0.223	1.882
$\hat{c}_2$	1.309	1.474	0.413	0.553	-0.229	-0.213	0.335
Std. dev.	0.169	0.345	0.519	0.608	0.348	0.342	0.234
p-value	0.192	0.360	0.088	0.148	0.001	0.001	0.020

**Note:** The hypothesis test is based on Newey and West's (1987) HAC covariance matrix of residuals. For the median (h = 12 months) regression, the CPI inflation rate (% 12 months) is used as dependent variable, with a sample period November 2002–December 2008.

Table 4  
Bias existence test  $H_0: (c_1; c_2) = (0; 1)$

Sample period January 2004– December 2008	Top5short	Median	Top5medium	Median	Top5medium	Median	Median
	h = 1month	h = 1month	h = 3months	h = 3months	h = 6months	h = 6months	h = 12months
$\hat{c}_1$	0.035	0.041	0.161	0.102	0.157	0.180	3.266
Std. dev.	0.086	0.088	0.117	0.150	0.173	0.195	0.914
$\hat{c}_2$	0.943	0.952	0.704	0.857	0.704	0.651	0.397
Std. dev.	0.156	0.167	0.249	0.349	0.392	0.476	0.146
p-value	0.915	0.770	0.361	0.484	0.548	0.470	0.000

**Note:** The hypothesis test is based on Newey and West's (1987) HAC covariance matrix of residuals. For the median (h = 12 months) regression, in which the CPI inflation rate (% 12 months) is again used as dependent variable, the bias test for a sample period January 2005–December 2008 generates a p-value = 0.563, in sharp contrast to the p-value = 0, obtained from the sample January 2004–December 2008.

Note from Table 3 that the null hypothesis is rejected at a 5% confidence level only for longer horizons (six and 12 months), whereas for one and three months the results suggest the non-existence of a forecast bias. In addition, results with recent samples (see Table 4) indicate that the survey-based expectations might be unbiased in all considered horizons.

<sup>6</sup> According to the authors, the “strong” form of rationality requires the forecast errors to be uncorrelated to any relevant available economic information.

<sup>7</sup> Obstfeld and Rogoff (1996, p 79) argue that rational expectation is a mathematical expectation conditional on the available information set. In other words, the rational expectations hypothesis does not require the forecasts to be strictly correct in all periods but, instead, requires the forecast errors to be unbiased and uncorrelated with any information in which the forecast is conditioned. See also Clements (2005, p 5) for further details.

Therefore, the previous results support a “weak form of rationality” for the Brazilian survey-based inflation expectations, partially reflecting the degree of sophistication of the models and frameworks used by the Brazilian market agents when forming their inflation expectations.<sup>8</sup>

Another feature of expectations usually discussed in the literature is whether forecast errors ( $e_t$ ) are positively correlated to changes in the inflation rate. According to Henzel (2008), this feature would be compatible with the empirical evidence that agents often over-predict inflation during periods of a falling inflation rate, and vice versa. In order to verify this feature in the Brazilian data, consider the following regression:

$$e_t \cong \pi_t - \pi_{t,t-h}^e = \theta_1 + \theta_2 \Delta \pi_t + \epsilon_t \quad (2)$$

Table 5  
Forecast error ( $e_t$ )

Sample period Jan 2004–Dec 2008	Top5short	Median	Top5medium	Median	Top5medium	Median	Median
	h = 1month	h = 1month	h = 3months	h = 3months	h = 6months	h = 6months	h = 12months
$\hat{\theta}_1$	0.013	0.023	0.048	0.048	0.042	0.045	0.143
Std. dev.	0.027	0.027	0.036	0.037	0.038	0.039	0.337
$\hat{\theta}_2$	<b>0.463</b>	<b>0.523</b>	<b>0.494</b>	<b>0.468</b>	<b>0.454</b>	<b>0.486</b>	<b>2.118</b>
Std. dev.	0.067	0.066	0.091	0.084	0.086	0.088	0.633

**Note:** The estimations are based on Newey and West’s (1987) HAC covariance matrix. For the median (h = 12 months) regression, the CPI inflation rate (% 12 months) is used as regressor. In this case, the sample period January 2005–December 2008 produces  $\hat{\theta}_2 = 1.512$ .

Notice from Table 5 that  $\hat{\theta}_2$  is statistically significant, positive, and (except for last column) also less than unit, reflecting a relatively low response of expectations to changes in the inflation rate, corroborating Henzel (2008). This empirical evidence might be linked to results from Tables 1 and 2, which indicate a lower sample standard deviation compared to the inflation rate series itself. Besides that, results from Table 5 are in line with some papers in the literature, such as Ball and Croushore (1995) and Mankiw et al (2003), in which agents seems to react slowly to new information during the formation of inflation expectations.

#### 4. Some driving forces behind the expectation formation process

In this section, some driving factors behind the expectation formation process are presented, in order to reveal some additional features of the Brazilian inflation expectations. In Tables 6 and 7, some specifications of inflation expectations are shown, based on the following regressors: autoregressive term, inflation target (next 12 months), inflation rate (IPCA) and Selic short-term interest rate (both in percentage over 12 months), nominal exchange rate (Reais/USD), industrial production, Embi + Br and industrial capacity utilisation (UCI).<sup>9</sup>

<sup>8</sup> The formation of expectations of some US surveys is analysed by Mankiw et al (2003), in which the authors investigate the hypotheses of adaptive, rational or “sticky-information” expectations.

<sup>9</sup> All variables in log terms, excepting IPCA, Selic, target and expectation, which are used in log (1 + rate/100). None of the regressions has intercept, since inflation target is constant in the adopted sample period.

Table 6

Dependent variable: inflation expectations ( $\pi_{t+12,t}^e$ )

Regressors	I	II	III	IV
Expectation (t + 11,t-1)	<b>0.723</b> (0.000)	<b>0.720</b> (0.000)	<b>0.684</b> (0.000)	<b>0.709</b> (0.000)
Inflation target (t + 12,t)	<b>0.207</b> (0.000)	<b>0.210</b> (0.001)	-0.005 (0.977)	-4.100 (0.229)
IPCA (t)	<b>0.155</b> (0.000)	<b>0.161</b> (0.000)	<b>0.133</b> (0.004)	<b>0.142</b> (0.002)
Selic (t)	<b>-0.071</b> (0.000)	<b>-0.074</b> (0.000)	<b>-0.068</b> (0.000)	<b>-0.051</b> (0.045)
FX rate (t)	<b>0.007</b> (0.043)	<b>0.007</b> (0.032)	0.004 (0.173)	<b>0.008</b> (0.033)
$\Delta$ (ind. production (t))		0.014 (0.130)		
Embi + Br (t)			0.002 (0.211)	
Uci (t)				0.043 (0.208)
R2	0.936	0.939	0.939	0.938
Adjusted R2	0.931	0.933	0.933	0.932
LM residuals autocorrelation				
Test (p-value,4 lags)	0.117	0.094	0.172	0.116

It can be seen from Table 6 that the autoregressive coefficient (around 0.70) indicates quite a significant persistence of inflation expectations. In addition, expectations are positively related to the inflation target, as well as to the current inflation and FX rates. On the other hand, results also suggest a negative coefficient for the Selic short-term interest rate, which reveals a significant reaction of long-term inflation expectations due to changes in monetary policy, also reflecting the credibility of monetary authority, according to market agents.<sup>10</sup>

Table 7 presents the behaviour of inflation expectations, in quarterly rates, with a three-month forecast horizon. First, a lower persistence is obtained in comparison to the previous results, probably due to the higher frequency of the inflation expectation rate. In addition, the coefficient for inflation is again positive, but the responses for the target and Selic seem to be not significant. Nonetheless, results of Table 7 also suggest that past FX rate volatility has a positive impact on short-/medium-term inflation expectations.

<sup>10</sup> Note that we have obtained a different response for the interest rate, in comparison with Minella et al (2003) or Cerisola and Gelos (2005), probably due to the sample period considered in this paper, which covers only the last five years of inflationary dynamics.

Table 7

Dependent variable: inflation expectations  $(\pi_{t+3,t}^e)$ 

Regressors	I	II	III	IV
Expectation (t + 2,t-1)	<b>0.535</b> (0.000)	<b>0.534</b> (0.000)	<b>0.499</b> (0.000)	<b>0.547</b> (0.000)
Inflation target (t + 12,t)	0.033 (0.361)	0.033 (0.366)	-0.059 (0.554)	-3.141 (0.397)
IPCA (t)	<b>0.071</b> (0.015)	<b>0.071</b> (0.016)	0.058 (0.093)	0.053 (0.133)
Selic (t)	0.001 (0.939)	0.001 (0.939)	-0.002 (0.853)	0.019 (0.446)
FX rate volatility (t-2)	<b>0.166</b> (0.001)	<b>0.165</b> (0.028)	<b>0.132</b> (0.003)	<b>0.223</b> (0.016)
$\Delta(\text{ind. production (t)})$		0.000 (0.987)		
Embi + Br (t)			0.001 (0.317)	
Uci (t)				0.031 (0.392)
R2	0.654	0.654	0.660	0.660
Adjusted R2	0.629	0.622	0.629	0.629
LM residuals autocorrelation				
Test (p-value,4 lags)	0.901	0.904	0.514	0.806

**Note:** All regressions are based on Newey and West's (1987) HAC covariance matrix. Sample period is January 2004–December 2008 (60 observations). P-values are shown in parentheses, and the 5% level significant coefficients are presented in bold. In Table 6, inflation expectations (median across all agents) are in percentage over 12 months, with a forecast horizon of  $h = 12$  months. In Table 7, inflation expectations (median of *Top5* medium-term) are in quarterly percentage, with a forecast horizon of  $h = 3$  months. FX rate volatility refers to a 3-month moving average of the volatility of the monthly nominal exchange rate.

## 5. Conclusions

Nowadays, inflation expectations are frequently monitored by the vast majority of central banks, due to its importance on inflation forecasting setups. Departures from rational expectations represent a serious matter of concern to policymakers, since forecasting devices are usually based on a rational expectations hypothesis.

In this paper, we aim to provide a simple investigation of Brazilian survey-based inflation expectations, with respect to statistical properties and bias existence, as well as to identify some driving forces behind the expectation formation process. Empirical exercises indicate that expectations might be unbiased, and that different factors might help explaining short- and long-term inflation expectations in Brazil.

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# Terms of trade, commodity prices and inflation dynamics in Chile<sup>1</sup>

Jorge Desormeaux, Pablo García and Claudio Soto

## 1. Introduction

Commodity prices, terms of trade and real wages play significant roles in shaping the inflationary dynamics and persistence of prices in small open economies. The Chilean economy is a case in point. A small and very open economy, with a structure of production starkly different from the structure of demand, the Chilean economy is subject to the effects of significant shocks to commodity prices.

On the production side, Chile's endowment of copper is sizeable (both in absolute terms and in relation to the world markets), while the rest of the export basket is heavily tilted towards exports of raw or processed natural resources. On the demand side, firms and households import a significant part of their intermediate inputs (particularly fuels), machinery and equipment, and durable goods. The above, coupled with a general policy conducive to free trade and with fairly reduced public intervention in the distribution and retailing of goods and services, imply that shifts in commodity prices are fed through the economy rather rapidly, affecting the allocation of production and demand, as well as changing cost pressures and hence, inflationary dynamics.

This paper presents, in a stylised way, how the Central Bank of Chile has undertaken the task of understanding these different channels. Given the existence of nominal rigidities, changes in the structure of production and demand will have an impact on the economy's degree of slack, and hence will affect inflationary pressures as well as nominal and real wages. Commodity prices, particularly those that affect the local energy prices, will generate supply shocks that ripple through the cost structure of the economy and potentially affect expectations and the inflationary process over and above its direct impact. These changes in relative prices also have a bearing on the real exchange rate, thus potentially dampening the effect on the real economy but itself adding to the cost shifts.

To assess the proper conduct of policy, given the forward-looking character of monetary policy in an inflation targeting framework, as well as the large swings in commodity prices that we have witnessed in the past few years, we need to develop a structural view of the transmission mechanism of commodity prices to inflation dynamics. Small, semi-structural models fall short, requiring the construction and simulation of models that render in richer detail the production and demand structure of the economy.

The rest of the paper is structured as follows. The next section presents a brief description and outline of the structure of production and demand, highlighting the relevant role played by mining and other natural resource sectors. The different dynamics of a set of price deflators are also shown, particularly the differences between CPI inflation and the annual inflation of the GDP deflator. The movements of the real exchange rate and the terms of trade are also shown. The third section brings these issues together in a version of the *Model for Analysis and Simulation* (MAS), a DSGE model of the Chilean economy that is now routinely used in monetary policy discussions. The fourth section subjects this model to a number of shocks, namely oil price and copper price shocks, and the monetary policy

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<sup>1</sup> Prepared for the BIS Annual Meeting of Deputy Governors, 5–6 February 2009.

response to each of them is analysed, conditional on the degree of credibility of the inflation target and the behaviour of the fiscal authority. These exercises help to highlight the transmission mechanism of these different shocks to inflation, taking into account the multi-sectoral nature of the Chilean economy, the role of the real exchange rate, and real wages. The fifth section describes recent developments in the inflationary dynamics in Chile. The final section presents some tentative conclusions.

## 2. Economic structure, relative prices and inflation

Table 1 presents a broad outline of the sectoral structure of the Chilean economy, in current US dollars for the most recent year for which detailed national accounts data are available (2006). Several features are noteworthy. On the production side, the intensity of natural resources is readily apparent. Mining, farming and fisheries, for instance, account for 22% of total domestic supply, without considering the part of manufacturing that is related to natural resources. Imports of mining, farming and fisheries represent only 12% of the total supply (net of markups) of these sectors. Conversely, on the demand side, a large fraction of the demand faced by these sectors is represented by exports: 62% of total demand, and a significant 92% if only exports and final domestic demand are considered.

From this perspective, manufacturing provides an interesting counterpoint. A large fraction of total supply is provided by imports (28%), while only close to one-half (15%) of total demand arises from exports. Note that petroleum and chemical products, a sector where local production is dwarfed by imports, is included within manufacturing.

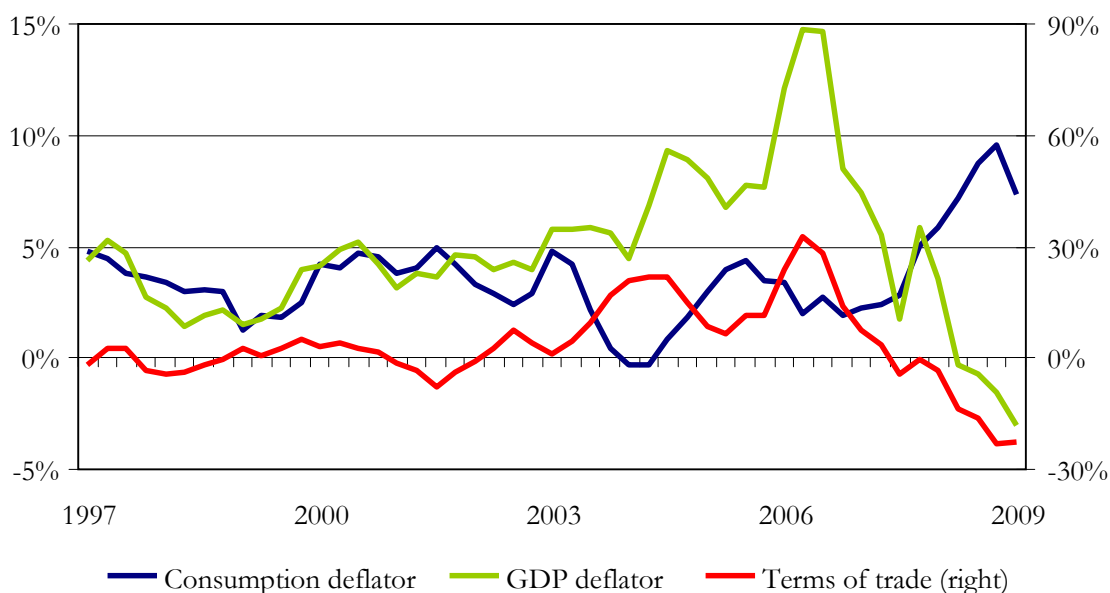
Table 1  
Production and demand structure (US\$ million, 2006)

<b>Farming and fishery</b>		<b>15,549</b>	<b>Farming and fishery</b>	
domestic supply	11,880		7,289	intermediate consumption
imports	733		5,004	exports
markup	2,936		3,257	final domestic demand
<b>Mining</b>		<b>50,576</b>	<b>Mining</b>	
domestic supply	43,348		14,255	intermediate consumption
imports	6,964		36,265	exports
markup	264		56	final domestic demand
<b>Manufacturing</b>		<b>112,779</b>	<b>Manufacturing</b>	
domestic supply	57,079		46,179	intermediate consumption
imports	31,787		17,225	exports
markup	23,912		49,375	final domestic demand
<b>Other sectors</b>		<b>145,220</b>	<b>Other sectors</b>	
domestic supply	133,948		64,896	intermediate consumption
imports	6,757		8,481	exports
markup	4,515		71,843	final domestic demand
<b>Total</b>		<b>324,124</b>	<b>Total</b>	
domestic supply	246,255		132,618	intermediate consumption
imports	46,242		66,975	exports
markup	31,627		124,531	final domestic demand

Other, non-traded sectors share the usual characteristic of being mostly supplied and demanded locally. Overall though, they represent less than half of total demand and supply in the Chilean economy, again underscoring the relevance of primary and tradable sectors, mostly linked to natural resources, in the sectoral structure of the economy.

These structural peculiarities make the one-sector/one-good paradigm particularly limited as a representation of the different linkages and sectoral relationships of the Chilean economy when modelling inflation and output. The fact that the domestic demand bundle differs from the production bundle naturally leads to different – but likely related – price dynamics between the production and consumption baskets. Figure 1 presents the annual change in the GDP deflator, the private consumption deflator, and the terms of trade. As can be seen, the dynamics of the GDP and private consumption deflator differ markedly, due to the large terms of trade swings that affect the Chilean economy, and the small representation of exportable goods in the consumption basket.

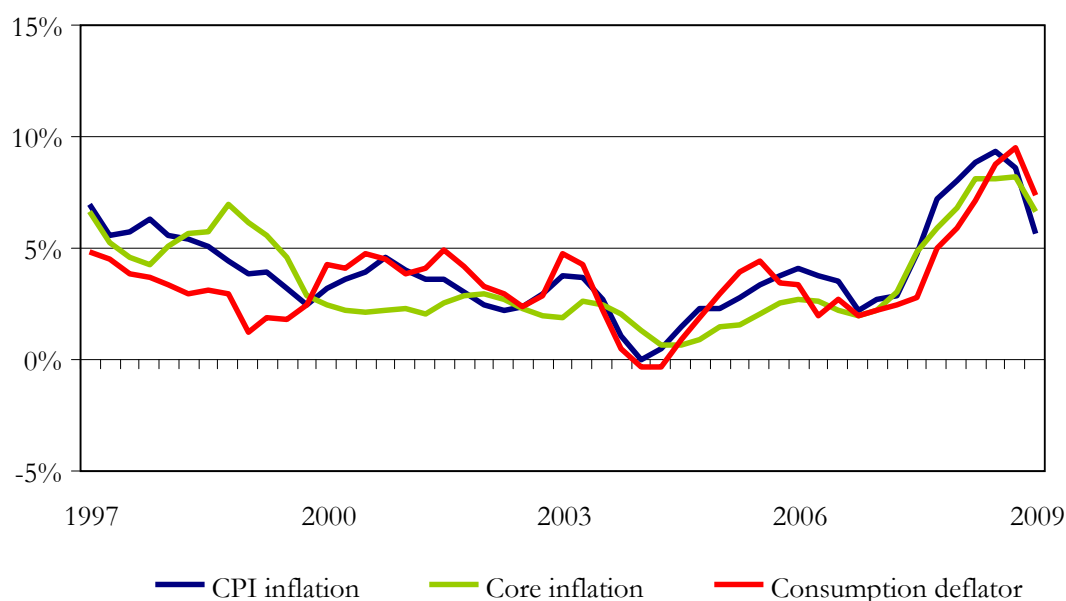
Figure 1  
**GDP and consumption deflators, and terms of trade**  
 (year-on-year percentage change)



From 1997 to early 2003 the annual fluctuations in the terms of trade were rather limited (but not muted), at around +/- 10%. Over that period, it can be seen that private consumption deflator and the GDP deflator fluctuated closely, at or below 5% annually. In contrast, from late 2003 onwards, large swings in the terms of trade led to a sharp dissociation of the consumption deflator and the GDP deflator. The latter followed the swings in the terms of trade, as can be seen in 2006 when the GDP deflator increased 15%, while the terms of trade rose 30%, both on an annual basis.

The private consumption deflator, on the other hand, does not follow the swings of terms of trade, and shows what seems like a countercyclical fluctuation: deceleration at a time of terms of trade gains, and acceleration as the terms of trade moderate. This pattern is more striking from early 2004 onwards, when gains in terms of trade coincided with a deceleration in the private consumption deflator. Figure 2 shows that the evolution of the consumption deflator is similar to the CPI inflation readings, both headline and core.

Figure 2  
**Consumption deflator and CPI inflation**  
 (year-on-year percentage change)

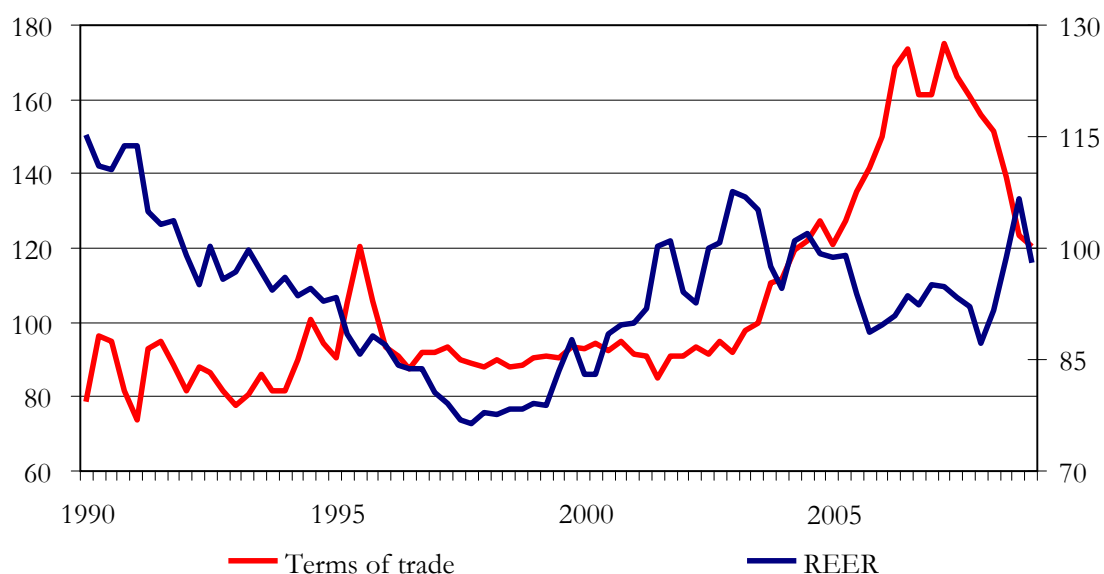


The natural link between consumer price inflation and the terms of trade is, of course, the real exchange rate. As a commodity exporting economy, the linkage between the real exchange rate and the terms of trade has been widely researched and documented.<sup>2</sup> This link, however, seems to have grown weaker over time, thanks to an increased diversification of the export base, and also in response to an enhanced macroeconomic framework, which allowed, for instance, the insulation of fiscal policy from copper income shocks, as well as a floating exchange rate regime that now bears the brunt of the adjustment to changes in external conditions. Thus, although the sensitivity of the overall economy to terms of trade shocks is likely to have diminished, this is not necessarily the case with respect to the exchange rate, particularly given the huge swings that the prices of copper and oil have experienced in the near past.

Figure 3 shows the path followed over the last decade and a half by the real exchange rate and the terms of trade. Although a link is hardly evident, in recent years it appears that swings in the real exchange rate are related to changes in terms of trade. This association would help to explain the gap between terms of trade changes and domestic consumption behaviour.

<sup>2</sup> See Caputo and Nuñez (2008), and Cerda, Donoso and Lema (2005), amongst others.

Figure 3  
**Terms of trade and the real exchange rate**  
(index, sample average = 100)



### 3. A structural model of the Chilean economy

In order to understand from a general equilibrium perspective the impact of commodity price shocks on different macro variables, we analyse the impulse-response functions to commodity price shocks derived from a structural DSGE model for a small open economy.

The model is a small open economy model in the spirit of Christiano, Eichenbaum and Evans (2005), Altig et al (2004), and Smets and Wouters (2003). The economy includes two types of households: Ricardian (optimising, forward-looking) households that make choices about consumption and borrowing, and set wages; non-Ricardian households that consume all their labour income and neither save nor borrow. Production technology uses labour, capital and oil. Both prices and wages are sticky (subject to nominal rigidities à la Calvo), with partial indexation to past inflation. There are adjustment costs to investment, and the pass-through from the exchange rate to the domestic price of imports is imperfect in the short run. The model also includes a commodity sector whose production – based on natural resources – is completely exported. This sector is meant to characterise the copper sector in the Chilean economy. Monetary policy is conducted through a policy rule for the interest rate, while fiscal policy is conducted through a structural balance rule. A brief summary of specific aspects of the different building blocks of the model is given below (for specific details, see Medina and Soto (2007a)).

#### 3.1 Households

The domestic economy is inhabited by a continuum of households. A subset of the households is Ricardian, with full access to capital markets to smooth consumption. These households make consumption and savings decisions that maximise their expected utility. The remaining subset is composed of non-Ricardian households without access to capital markets. These households consume all of their after-tax disposable income in every period. We also assume that all households exhibit habit formation in their preferences. This means

that consumption evolves slowly over time in response to shocks. Each household consumes a basket composed of three types of final goods: domestic goods, foreign goods and oil (fuel). The composition of this basket is determined optimally by minimising its cost.

Each household is also a monopolistic supplier of a differentiated labour service, and sets wages in a staggered way. In each period, each household faces a probability of being able to re-optimize its nominal wage. A household that is able to re-optimize its wage at  $t$  will maximise the expected discounted future stream of labour income net of the disutility from its work effort, subject to labour demand and to an indexation rule in case it cannot re-optimize in the future. This process determines a slow adjustment for nominal wages in response to shocks.

### **3.2 Investment process**

A representative firm rents capital goods to firms producing intermediate goods, and decides how much capital to accumulate each period. The firm may adjust investment each period, but changing the flow of investment is costly. This assumption provides a tractable approach to modelling investment inertia (see Christiano, Eichenbaum and Evans (2005)). The firm chooses the level of investment, and the rental price of capital, to maximise its expected future profits (rental returns on capital net of the cost of investment), subject to the law of motion of the capital stock, which accounts for depreciation and investment adjustment costs.

### **3.3 Domestic production**

Domestic goods are produced by firms with monopoly power over particular varieties of these goods. These firms maximise profits by choosing the price of their differentiated good subject to the demand they face, and the available technology. The technology to produce a particular good is a function that combines capital, labour and oil. Since oil is an imported intermediate good, it does not add to the value added in production. The value added is given by a Cobb-Douglas function with capital and labour. The technology for gross output combines value added and oil with an elasticity of substitution between them that is less than one.

Price setting is assumed to follow a Calvo-type structure. In every period, the probability that a firm is able to adjust its price is fixed, and is the same for all firms, independent of their history. If a firm does not receive a signal, it indexes its price following a simple rule that weights past inflation and the inflation target set by the central bank. Given this pricing structure, the behaviour of inflation is captured by a new-Keynesian Phillips curve with indexation. In its log-linear form, inflation depends on last period's inflation, expected inflation in the next period, and marginal costs.

We also assume that a single firm produces a homogeneous commodity good that is completely exported abroad, e.g. copper. Production requires no labour or capital. Production in this sector can be interpreted as the exogenous evolution of an endowment of natural resources. The price of this commodity is determined in the world market.

### **3.4 Fiscal and monetary policies**

In the baseline case, the model assumes that the government follows a structural balance fiscal rule (see Medina and Soto (2006b)). The purpose of this fiscal rule is to avoid excessive fluctuations in government expenditure stemming from transitory movements in fiscal revenues. Government expenditure can increase if the long-run price of copper rises, or if potential output growth increases. In the case of a transitory rise in fiscal revenues from a copper price increase, the rule implies that the additional fiscal income should mainly be

saved. The same happens with extra revenues collected from a transitory expansion in output beyond potential.

Monetary policy is characterised as a simple feedback rule for the real interest rate. We assume that the Central Bank responds to contemporaneous deviations of core inflation from the target of 3% and also to deviations of output from its trend. In the model, core inflation corresponds to a linear combination of the inflation of domestic goods and the inflation of imported goods, excluding oil. While it is true that the target for the Central Bank is defined in terms of headline CPI inflation, its intermediate objective is to keep expected inflation on target. In the case of open economy DSGE models, it has been shown that expected inflation rules tend to render the model undetermined (see Batini and Pearlman (2002)). In order to avoid such a problem, the model assumes that the Central Bank reacts to contemporaneous deviations of trend inflation – proxied by core inflation – from target.

## 4. Macro responses to commodity price shocks

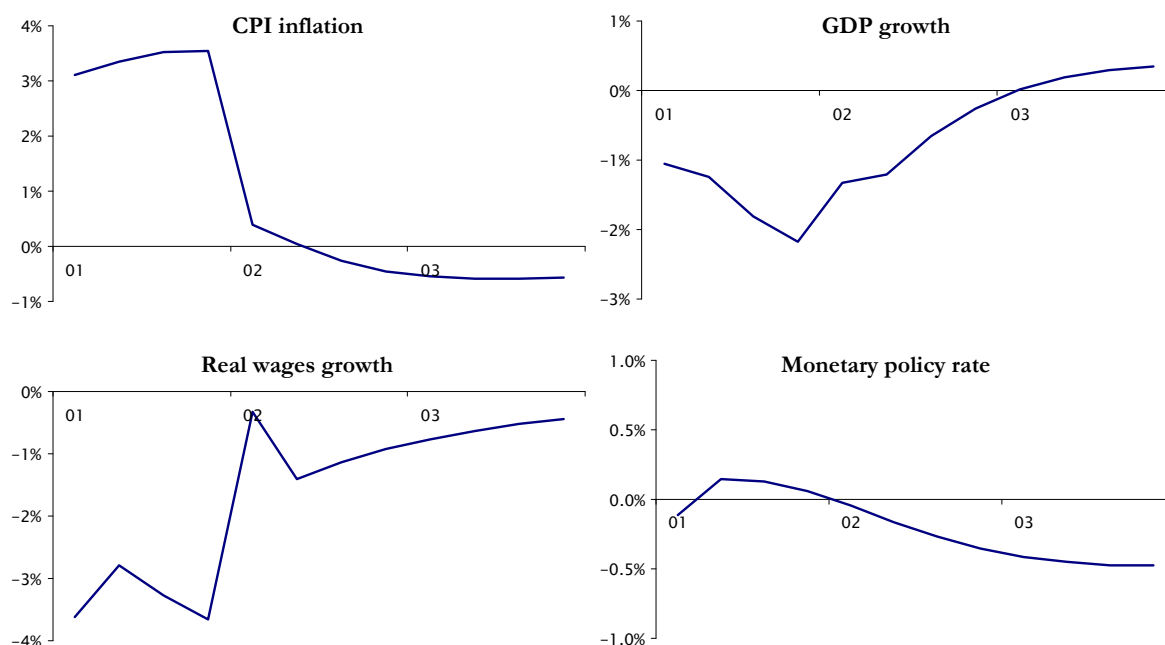
### Oil price shock under perfect credibility

We analyse first the responses to an oil price shock under perfect credibility regarding the target of the monetary policy. The shock corresponds to an increase of 100% in the real price of oil (nominal price of oil in US\$ deflated by the international price level).

Figure 4

### Quarterly impulse response to an oil price shock under perfect credibility

(year-on-year percentage change from steady-state)



Results are depicted in Figure 4. Since oil is part of the consumption basket and thus enters directly into the measure of the price level relevant for consumption, an oil price shock generates an immediate increase in CPI inflation. It also affects inflation indirectly through its impact on marginal cost faced by domestic firms. Since prices are sticky, this increase in

marginal cost is not completely transferred to prices, and markups shrink. This leads to a contraction in activity of almost 2% within a year of the shock.

Notice that the contraction in activity implies a reduction in labour demand, which in turn requires an adjustment in real wages. This variable actually falls in response to the shock and remains below trend for several quarters, even after inflation has converged back to target after a year.

The monetary policy response to the shock is initially an increase in the policy rate, followed after two quarters is by a rate reduction below the neutral rate. The muted increase in the policy rate despite the relatively large increase in CPI inflation is due to the fact that the shock is transitory and that the policy is credible. The subsequent lowering of the policy rate is required in order boost demand so that output returns back to trend.

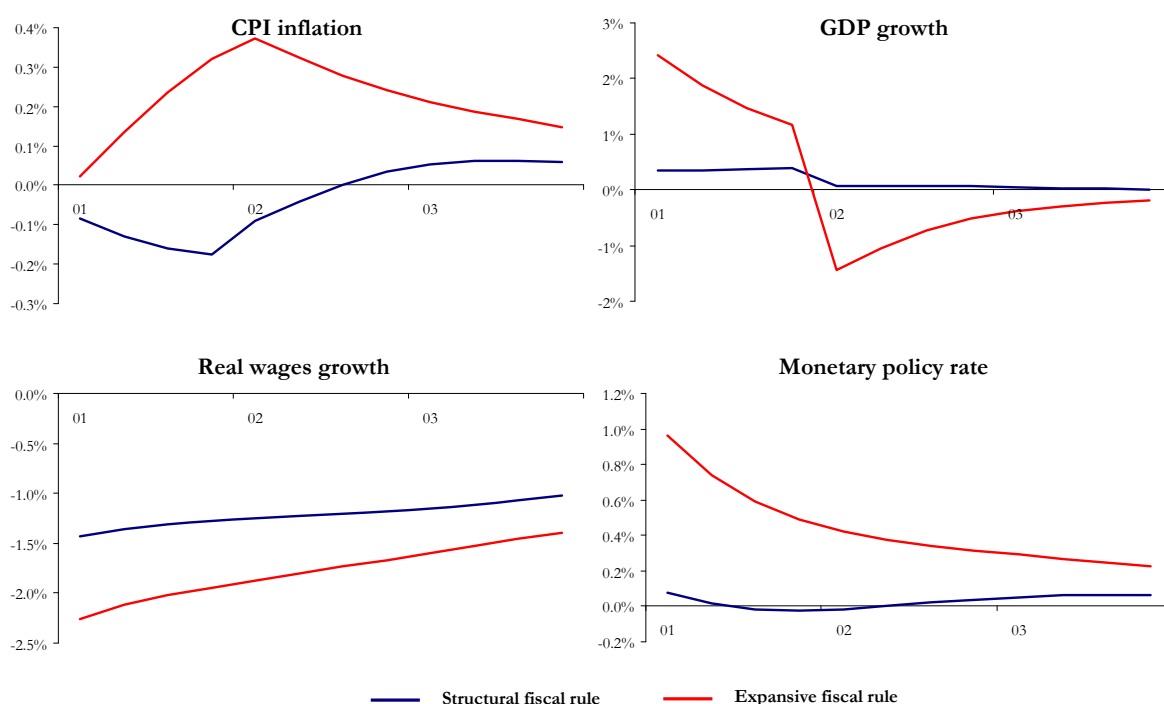
### Copper price shock under alternative fiscal policies

As mentioned above, the baseline case scenario considers a fiscal policy that follows a structural rule, which is intended to replicate the policy rule being followed by the Chilean government since 2001. We use the model to ask ourselves what would have happened in the economy if, instead of following this rule, the government had followed a procyclical pattern, increasing expenditures one to one with a copper price shock.

Figure 5

#### Quarterly impulse response to a copper price shock under alternative fiscal policies

(year-on-year percentage change from steady-state)



The results of this exercise are reported in Figure 5. The most striking difference in the responses of the main macro variables to the copper price shock under alternative fiscal policies is regarding inflation. When the government raises its expenditure in response to the windfall gains from copper, there is a large increase in demand, and output rises. As a result, inflation increases and the real exchange rate appreciates significantly.



When the government follows the structural rule, instead, most of the windfall gain is saved. The currency appreciates since the net foreign asset position of the country improves. The appreciation of the currency leads to a fall in the inflation of imported goods, and total CPI also decreases.

This sharp contrast in the response of inflation to the copper price shock leads to a very muted monetary policy reaction. In the first case, when the government follows a highly expansionary fiscal policy, monetary policy needs to be tightened strongly. In contrast, if the government follows the structural rule, the monetary policy does not need to respond.

### Oil price shock under imperfect credibility

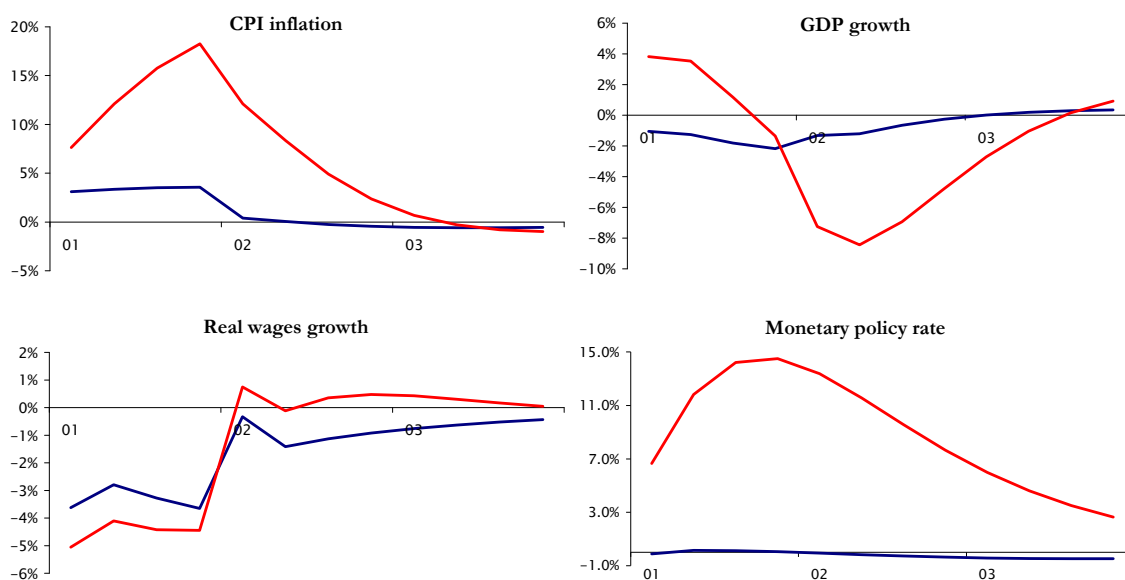
Now we turn to the case of imperfect credibility regarding the objective of monetary policy. In order to analyse this case, we assume that private agents assign certain probability that the Central Bank will transitorily deviate from its target. More precisely, since the oil price shock leads to a temporary increase in inflation, we assume that private agents believe that part of this increase is due to a relaxation of the target by the monetary authority, while in fact it is not.<sup>3</sup>

When the monetary authority lacks credibility, an oil price shock leads to a much larger increase in inflation. Inflation not only rises by more when credibility is imperfect, it is also much more persistent in response to the shock.

Figure 6

### Quarterly impulse response to an oil price shock under perfect and imperfect credibility

(year-on-year percentage change from steady-state)



Note that, initially, output may grow above trend during some quarters. This is due to the fact that the real interest rate (not shown) falls during the first quarters after the shock, because the nominal interest rate has not increased as much as necessary to compensate for the

<sup>3</sup> This exercise is taken from Medina and Soto (2008).

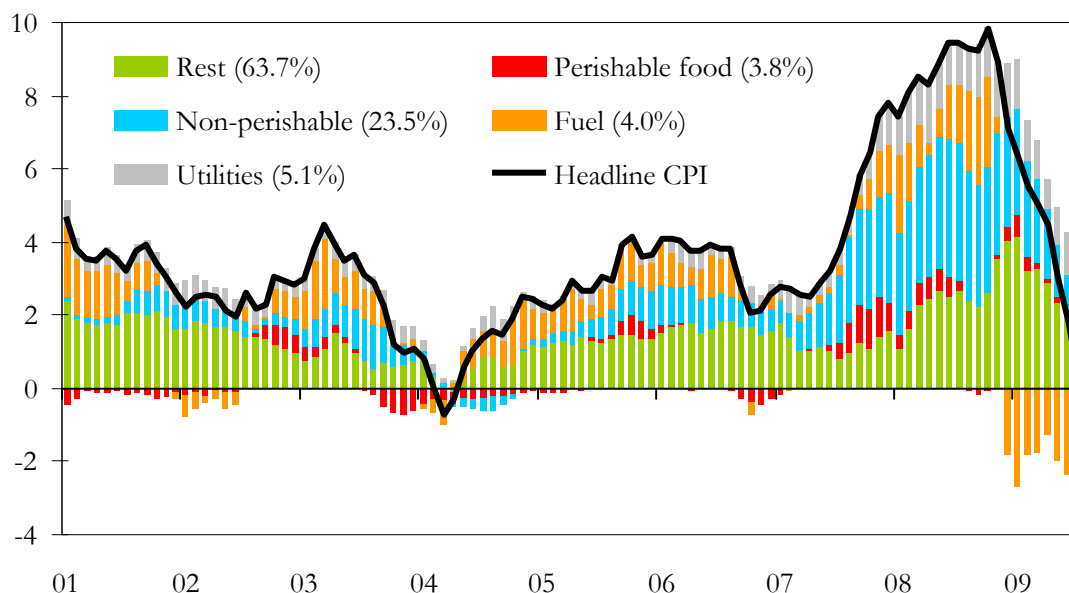
surge in inflation. After a few quarters, the monetary authority tightens even further, and succeeds in inducing an increase in the ex-ante real interest rate above the neutral rate. This creates a contraction in activity that is much stronger than in the case of perfect credibility. This is the only way the Central Bank can bring expectations back in line with the target in order to reduce inflation. In sum, if the monetary authority lacks credibility it will face a more serious trade-off between stabilising output and inflation. As a result, the sacrifice ratio will also be larger.

## 5. Recent inflation trends in Chile

The inflation process in Chile has shown dramatic changes in the past year and a half, thanks to significant swings in the international prices of food and energy, and their various implications on the price setting behaviour of domestic agents. By mid-2007, inflation surprises in energy and foods showed that the pass-through of international prices to local prices was proceeding quickly, and in August 2007 annual inflation breached the high end of the Central Bank's tolerance range (4%) and kept increasing, reaching close to 8% by year-end. This process was further exacerbated by the significant impact of local weather conditions (ice storms in springtime) on the prices of perishable foods, which contributed to a significant hike in non-core inflation. Also, the regulatory environment implied that the higher costs of energy generation, resulting from an increase in the likelihood of a drought in 2008, and hence of a lower contribution of hydroelectric power, along with higher energy prices and the scarcity of imported gas, led to significant increases in residential tariffs.

Figure 7

### Incidence in headline inflation

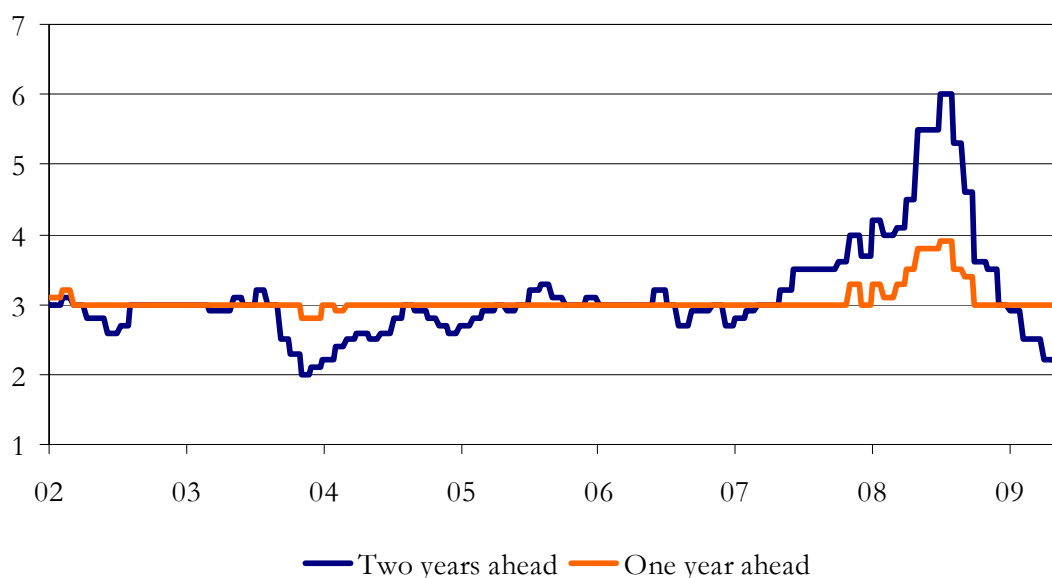


Over this period (late 2007), however, the broadly held view was that the inflation spike was merely a supply side shock derived from higher international prices and specific domestic factors, but where no generalised inflation pressures were evident. The bulk of the argument regarding this point relied on the stability of inflation expectations up to that point. Although one-year-ahead expectations had showed a small increase, they nevertheless implied a very quick convergence to the target over 2008 and early 2009. Moreover, with the exception of perishable foods, energy and tariff components, core measures of inflation had been

remarkably resilient to the sharp spike in headline inflation. The official forecast for inflation presented in the Inflation report of early 2008 considered that by the end of that year inflation would have fallen to slightly below 5%.

Over the first quarter of 2008, the inflation prospects became more uncertain. On the one hand, the incoming data on headline inflation was somewhat reassuring, in that no evidence was available of further large surprises on that front and data on wages and indexed prices did not show an abnormally large response to the higher inflation of 2007, as a propagation on core components of inflation was expected to occur anyway. The significant appreciation of the nominal exchange rate, due to the swings in currency markets over the initial period of the global financial crisis in late 2007 and early 2008, indicated lower inflationary pressures in the medium run. On the other hand, inflation expectations remained stubbornly sticky at levels higher than the official forecasts, and breakeven inflation rates kept on creeping upwards. In this complex macroeconomic environment, the Board of the Central Bank held the policy rate constant and actually initiated a programme of reserve accumulation in April 2008 to increase the insurance against a further deterioration of the global financial environment. The monetary policy report of May 2008 presented forecasts for inflation that still considered a somewhat rapid convergence to the target and thus the bias on the policy stance was starkly neutral.

Figure 8  
Expected inflation – monthly survey

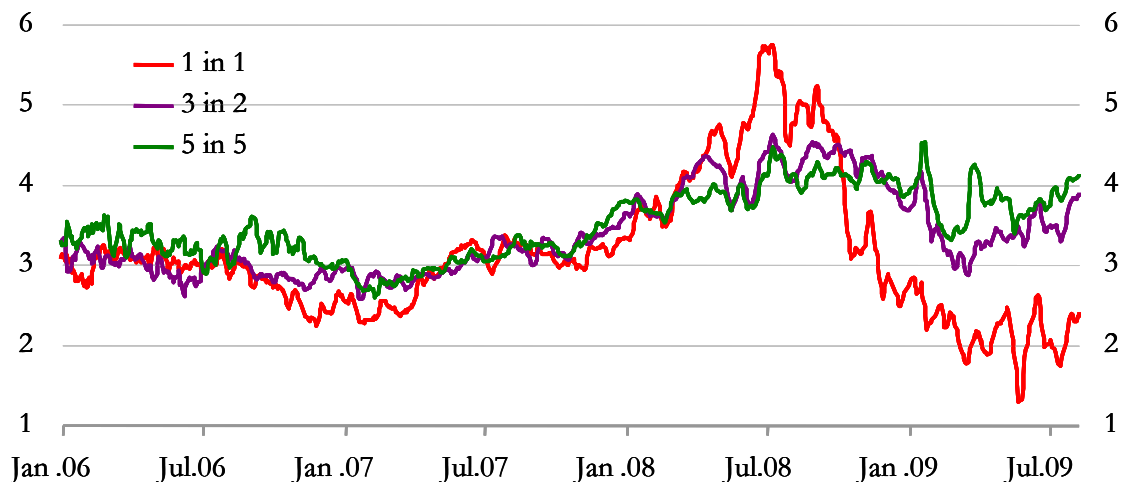


Between April and September the inflation genie got out of the bottle, quickly showing that the inflation forecast had become obsolete. Headline inflation exceeded 9% in June. Although this period also coincided with the significant spike in fuel prices globally, propagation of inflation pressures to core components became increasingly visible: our non-fuel non-energy CPI inflation crept up over 5% and expected inflation shot through the roof, to levels that implied clearly non-convergence to the 3% target over a two-year horizon. Monetary policy moved accordingly to a tighter stance, hiking the policy rate by 50 basis points in June, July, August and September, to 8.25%. The likelihood of double-digit inflation increased significantly. In the Monetary Policy Report presented on 11 September 2008, the Board communicated that a tough stance had to be taken to fight the inflationary tendencies, announcing that further monetary policy rate hikes were in the pipeline, over and above what the market was expecting at the time. The basis of this argument was that global conditions would not help much in the disinflation process and that local growth was actually surprising

us on the upside. Expected GDP growth for 2008 was in the 4.5–5.0% range, and oil price futures pointed to steady prices of around \$109 per barrel. Lehmann Brothers collapsed the following week.

Figure 9

**Inflation break even rates – swap contracts**



Since October 2008, this environment changed yet again in dramatic fashion. Commodity prices collapsed, emerging market exchange rates depreciated markedly, and the impact of the global financial crisis was felt acutely in the domestic front. In our two most recent Monetary Policy Reports (January and May 2009), the Central Bank acknowledged that since the last quarter of 2008 the economy had observed a much weaker performance than expected, weakening the labour market and widening the output gap, and that as a result we now expected the slack of the economy to persist well into 2010. This led the Central Bank in January 2009 to initiate a policy-easing cycle without precedent in our history. Policy rates were cut by 775 basis points, from 8.25% in January 2009 to 0.50% in July of the same year. Thanks to the resilience of our financial system, the markets have accommodated a large depreciation of the exchange rate with actually lower break-even inflation rates going forward, despite the sharp easing of policy rates in the very short term. Just as the previous increase in international prices fed into local fuel prices during the first half of 2008, the dramatic fall in energy prices has been quickly transferred to domestic prices, leading to large negative headline inflation readings in recent months. We expect negative annual inflation rates again, at the end of the third quarter and the beginning of the fourth quarter of 2009. Our May 2009 Monetary Policy Report projects that inflation will reach 0.6% by year-end, and will gradually converge back to 3% within our two-year policy horizon.

**Conclusions**

The Chilean economy is a small and very open economy, with a structure of production that is starkly different from the structure of its demand, and regularly experiences significant commodity price shocks. Commodity prices, terms of trade and real wages play significant roles in shaping the inflationary dynamics and persistence of prices in Chile. In particular, given the competitive nature of its retail sector, commodity prices are fed through the economy rather rapidly, affecting the allocation of production and demand and the dynamics of inflation.

To describe adequately the different channels through which commodity prices affect the cost structure of the economy, and potentially also expectations and the inflationary process,

in this paper we present the results of a stylised DSGE model of the Chilean economy. The model is subjected to two types of commodity price shocks to highlight the transmission mechanism to inflation, taking into account the characteristics of the Chilean economy, in particular the role played by the fiscal policy rule in smoothing copper price shocks, and credibility regarding monetary policy.

An oil price shock generates a direct increase in CPI inflation, and an indirect effect through its impact on the marginal cost faced by domestic firms. Since prices are sticky, this increase in marginal cost is not completely transferred to prices, and markups shrink. This leads to a contraction in activity of almost 2% within a year of the shock. The monetary policy response to the shock is initially a small increase in the policy rate, which is followed by a small reduction below the neutral rate. The muted reaction of the policy rate, despite the relatively large increase in CPI inflation, is due to the fact that the shock is transitory and that policy is credible. We show that if monetary policy lacks credibility then an oil price shock leads to a much larger and persistent increase in inflation. In this context, the monetary authority needs to tighten further, which creates a contraction in activity that is much stronger than in the case of perfect credibility.

We also analyse the impact of a copper price shock in the context of a fiscal policy that follows a procyclical pattern, where fiscal expenditures increase one to one with terms of trade gains. The results are contrasted with those obtained assuming a fiscal policy that follows a structural balance rule, which intends to replicate the policy rule that Chile has followed since 2001. The most important difference between the two scenarios analysed is the impact on inflation. When the government raises its expenditure in response to the windfall gains from copper, there is a large increase in demand, and output rises. As a result, inflation increases and the real exchange rate appreciates. When the government follows the structural balance rule, instead, most of the windfall gain is saved, and there is only a mild increase in inflation. The monetary policy reaction is different in the two cases. In the first case, when the government follows a procyclical fiscal policy, monetary policy needs to be tightened strongly. When the government follows the structural balance rule, on the other hand, monetary policy does not need to respond.

In sum, a procyclical fiscal policy and imperfect credibility of monetary policy significantly increase the real cost of stabilising inflation in response to commodity price shocks.

These exercises help us understand some recent developments of the inflationary dynamics in Chile, in particular the upsurge in inflation that developed between 2007 and the third quarter of 2008, the rapid disinflation that followed thereafter, and the policy response to it.

During 2007, supply shocks derived from higher international prices of energy and food, together with specific domestic factors, led to an acceleration of domestic inflation. Despite this, both the monetary authority and the market believed that this spike in inflation did not warrant a strong reaction of monetary policy, as a rapid convergence to the target was forecast. However, between April and October, CPI inflation rapidly accelerated, reaching a peak of 9.9% on an annual basis in October 2008, partly as a result of yet another spike in international fuel prices, but also due to the propagation of past inflationary shocks towards core components of inflation.

Expected inflation increased to levels that were no longer consistent with a convergence toward 3% within a two-year horizon. As a result, monetary policy initiated a rapid tightening cycle, and the monetary authority announced, in its September Monetary Policy Report, that further rate increases were to come, as global conditions, though weaker, were not sufficient to cool the economy and guarantee the required disinflation.

This view would start to change in dramatic fashion only a week later, as the world economy plunged into a recession following the fall of Lehman Brothers. Just as the increases in international prices fed into local fuel prices at a rapid pace during the first half of 2008, the dramatic drop in energy and food prices since the last quarter of 2008 was quickly transferred to domestic prices, leading to a rapid disinflation process. As a result, monetary

policy initiated an aggressive easing cycle in June 2009, which reduced policy rates from 8.25% in January 2009 to 0.50% in July 2009.

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# Assessing inflationary pressures in Colombia

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José Vicente Romero and Luis Eduardo Rojas

## 1. Introduction

After the deep recession of 1999 and the financial crisis of 1998–99, the Colombian economy experienced a protracted period of low growth and declining inflation (2000–03). The effect of the crisis on the balance sheet positions of households and firms hindered the expansion of consumption and investment expenditure. Also, external shocks, like the growth slowdown of Colombia's main trading partners between 2001 and 2002, or the large increases of sovereign risk premia in 2002, had an impact on aggregate demand and on the costs of imported inputs and capital goods. The economy generally worked below capacity throughout this period and, with the exception of a brief span between 2002 and 2003, inflation continued to decrease. Accordingly, monetary policy was relatively loose at the time, with real short-term interest rates well below their historical average. Only in the first half of 2003 were policy rates adjusted upwards to offset the pass-through effects of the great depreciation of the currency that occurred in the second semester of 2002, after the jump in sovereign risk premia.

Since 2004 domestic and external conditions has favored a recovery of growth and induced an appreciation of the currency. Risk premia declined rapidly, growth rates of the main trading partners accelerated, terms of trade rose with the increases in world commodity prices, and improved internal security bolstered consumer and investor confidence, leading to large FDI inflows and high rates of growth in consumption and investment. Monetary policy then had a “honeymoon” period, in which growth rose while inflation fell due to the appreciation of the currency and the existing unused capacity. In fact, policy interest rates were reduced throughout 2004 and 2005.

In 2006 the central bank faced its first real challenge in years, when a number of variables signaled a possible overheating of the economy, and yet inflation kept falling. The quick pace of fixed investment and the perceived increases in productivity raised the possibility that the enhanced production capacity contained the inflationary effects of the rapidly expanding aggregate demand. Nevertheless, the central bank tightened policy. Time has shown that this move was opportune and adequate.

More recently, the large and persistent increases in the prices of food and energy have posed another challenge for the central bank. In an economy where inflation has not converged with its long-run target and the credibility of monetary policy is far from perfect, the size and length of these “supply shocks” were a serious concern. Not only did they have various effects on disposable income (Colombia exports and imports many of these commodities), but they were also transmitted to core inflation through indexation and expectations channels. Hence, the monetary authorities found themselves in a difficult situation in 2008. On the one hand, growth was abruptly slowing down because of the effects of previous monetary policy and the impact of supply shocks on costs, income and output. On the other hand, the shocks increased inflation and caused large deviations from the central bank's target in 2007 and 2008, threatening to spread to other prices and wages. In this context, policy rates were increased in July 2008.

This paper describes these challenges and explains the reaction of the central bank. In the case of the 2006 episode, emphasis is placed on the information provided by productivity and unit labor costs statistics in detecting inflationary pressures. It is apparent that the cyclical components embedded in these series limit their usefulness and, in the absence of models that allow us to understand their behavior, they must be examined within a wider array of macroeconomic and financial variables.

For the 2007–08 episode, the discussion focuses on the role of core inflation measures, some of which are evaluated according to the standard criteria. No particular measure seems to be clearly superior to the others, a result similar to that found by Rich and Steindel (2007), who explain this as a reflection of the varying nature of the transitory shocks hitting inflation. Consequently, we argue that the monitoring of core inflation measures must be complemented with an assessment of the nature of the inflation shocks and an analysis of the transmission of the transitory shocks to macroeconomic inflation. We explore this transmission in the final part of the paper by examining the determination of inflation expectations, the effects of transitory inflation shocks on inflation expectations and the impact of shocks to subsets of the consumer price index (CPI) basket on other subsets and the overall CPI.

## 2. 2006: detecting an overheating economy

The improved external and domestic conditions after 2004 produced an appreciation of the currency and an acceleration of aggregate expenditure and output (Table 1 and Graphs 1 and 2). Inflation fell almost continually from the beginning of 2003 to mid-2006, along the targets established by the central bank (Graph 3). For most of this period, monetary authorities were confident in the expected future decline of inflation, given the appreciation and the large, negative output gap inherited from the recession and the financial crisis of 1998–99 (Graph 4). This gap was believed to close slowly thanks to the rapid growth of investment and the expansion of total factor productivity (TFP). The fixed investment ratio rose from 11.7% of GDP in December 1999 to 24.7% in June 2008 (Graph 5), producing acceleration in the growth rate of the stock of capital (Graph 6). Similarly, TFP annual growth rates, as approximated by the Solow residual, rose from around 0% in 2000–03 to about 2% from 2004 (Graph 7).<sup>1</sup>

Policy interest rates were reduced accordingly, from 7.5% in the beginning of 2004 to 6% in the fourth quarter of 2005. Real ex-post interest rates remained stable because of the fall in inflation (Graph 8). However, by the second quarter of 2006, the cumulative differences between domestic demand and output growth raised the question of whether the excess capacity in the economy was being exhausted. Some skeptics pointed to the fact that inflation was still falling (CPI annual inflation reached a historical minimum of 4% in June 2006 – Graph 3). In addition, investment growth was strong (Table 1) and both total

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<sup>1</sup> Calculation of the Solow residual series controlled for delays in installation and the degree of utilization of the capital stock, as well as for variations in the global participation rates and the rate of unemployment of the labor input:

$$A_t = Y_t / (L_t^{1-a} K_t^e), \text{ where}$$

$L$  = Working age population x global participation rate x (1 – unemployment rate), and

$K^e$  = Lagged capital stock (one-year) x capacity utilization index.

Source: DPI, Banco de la República



productivity and labor productivity kept increasing for the economy as a whole (Graph 9).<sup>2</sup> Filtered total factor productivity indicators were edging up, suggesting a change in trend TFP growth, while there were no large deviations of estimated TFP from this trend (Graph 10).<sup>3</sup>

Labor productivity indicators in manufacturing industry, the sector with the most complete information, also showed continuous improvement (Graphs 11 and 12). Both output per worker and output per hour kept increasing at a pace similar to the one observed in previous years. There was no evidence of large excesses when comparing the productivity series with their filtered counterparts, while the latter suggested an increase in trend growth. A similar picture emerged from the unit labor cost (ULC) indicators for the manufacturing and retail industries (Graphs 13 and 14). Thus, there were no indications of inflationary pressures stemming from rising marginal costs that could push up prices.

This was, however, a misleading conclusion. Other indicators, such as capacity utilization indices derived from surveys, showed a rapidly decreasing slack in the economy, even as investment and productivity kept growing (Graph 15). Consumer confidence indicators, which had shown a close relationship with consumption growth, pointed to a strong performance in the immediate future (Graph 16). Credit growth was recovering fast, after years of stagnation following the financial crisis (Graph 17), especially in the segments of consumer and commercial loans.

Based on this and other evidence, the central bank decided to start a tightening cycle in April 2006, despite the fact that headline CPI inflation and the core measures in use were still declining. Time showed that this was a wise decision. Soon after, core inflation measures started to rise, while the financial intermediaries produced a great shock to the credit supply, as they shifted their asset portfolio away from public bonds and into loans to the private sector. The average of the five core inflation measures monitored in the central bank went from 3.5% (year on year) in April 2006 to 4.8% in April 2007. Real growth of bank loans went from 10% in December 2005 to 27% in December 2006. Aggregate expenditure growth accelerated, as reflected by the widening of the current account deficit of the balance of payments, from 1.8% of GDP in the second half of 2006 to 3.6% of GDP in the first semester of 2007.

Graphs 10 through 14 show that in the second half of 2006 and in 2007 there were significant deviations of productivity and ULC indicators from trend, confirming the excesses illustrated with other variables. Thus, not all the increase in observed productivity was finally attributable to trend TFP growth or to sustainable capital accumulation. Based on these indicators alone, policymakers were not able to distinguish short-term “demand” pressures from long-term “supply” movements. There may be several explanations for this, most notably the effects of labor hoarding. In any case, one lesson derived from this episode was that, in the absence of models that help us understand the dynamics of measured productivity, the information provided by these indicators must be examined within a wider array of macroeconomic and financial variables.

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<sup>2</sup> Both TFP and labor productivity measures are adjusted by variations in participation rates, unemployment rates and capacity utilization (see footnote 1).

<sup>3</sup> The calculation of TFP controlled for variations in participation and unemployment rates, as well as for the degree capacity utilization of the capital stock (see footnote 1).

### 3. 2007–08: dealing with supply shocks

In 2007 and 2008 the Colombian economy was hit by several shocks that produced large increases in food and regulated prices.<sup>4</sup> These shocks differed in their persistence and origin, but occurred at a time when aggregate demand pressures were still present. Hence, they complicated monetary policy by blurring the assessment of long-term inflationary pressures. What part of the observed rise in inflation was due to transitory price level shocks? How persistent were some of these supply shocks? To what extent were inflation expectations and core inflation affected by the shocks? These were some of the questions that have bewildered policymakers throughout the past two years.

To further complicate the matter, both relative regulated and food prices have exhibited an increasing trend over the last decade (Graph 18), partly due, in the case of regulated prices, to the gradual elimination of subsidies (fuel and public utilities). The existence of such a trend made it difficult to isolate the size and the effect of the shocks. For example, CPI ex food and regulated prices is sometimes used as a measure of core inflation. While this is a useful concept for analyzing the transmission mechanisms of monetary policy,<sup>5</sup> it significantly underestimates CPI inflation over a long period of time.

Supply shocks during 2007–08 came from three sources. One was related to climate events (a drought in 2007 due to the El Niño phenomenon, and subsequent periods of excessive rainfall), which have affected prices of unprocessed food. A second source was the rise in world commodity prices, which has had direct and indirect effects on the CPI. Among the direct effects are the increases in the prices of fuel, transportation, energy and foodstuffs related to bio-fuel production (cereals, sugar, etc). Indirect effects have been reflected in fast growing costs of production, as raw materials became more expensive. Finally, a third source of shocks was connected to the second one and had to do with the rapidly expanding demand for Colombian exports to Venezuela (an oil exporter and Colombia's second main trading partner), which put strong pressure on the prices of some food items, such as meat in 2007.

Table 2 shows the behavior of the prices most affected by the aforementioned shocks. Unprocessed food price inflation moved up and down with the climate events, while meat prices increased above CPI inflation throughout 2007, reflecting the one-time effect of the rising demand from Venezuela. On the other hand, the relative prices of energy and the food items related to energy production exhibited a more sustained trend, following world prices. However, the pass-through of international food prices to domestic food prices was mitigated in 2007 thanks to the appreciation of the peso, as Gómez has shown (2008). Raw materials cost pressures were significant in 2008 despite the appreciation of the currency, as indicated by producer price index (PPI) inflation (Graph 19).

During 2007 these shocks reinforced the rationale for tightening monetary policy, since demand pressures were being complicated by relative price movements that could spread to inflation expectations and other prices and wages. In 2008, however, signs of an economic slowdown were clear. In fact, the deceleration was faster than expected due to the impact of the shocks on the costs of production and real disposable income, among other things (Graphs 19 and 20).

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<sup>4</sup> Food accounts for 29.1% of the 1999 CPI basket and includes unprocessed foodstuff (potatoes, vegetables and fruits), processed food and food away from home. Regulated prices represent 9.04% of the 1999 CPI basket, and include electricity, natural gas, water, sewage and garbage collection, urban public transportation, inter-municipal public transportation, and fuel (gasoline and diesel).

<sup>5</sup> In fact, the core macroeconomic forecast/simulation model used in the central bank breaks down CPI into four components: food prices, regulated prices, tradable goods and services ex food and regulated prices, and non-tradable goods and services ex food and regulated prices.

Nonetheless, the monetary authorities were reluctant to start loosening policy. The uncertainty about the persistence and effects of the shocks, as well as the augmented likelihood of missing the inflation target for a second, consecutive year, troubled policymakers. At the same time, the uncertainty about the unfolding of the international financial crisis clouded the forecast of demand inflationary pressures. It was not clear whether the pace of the economic slowdown was compatible with the resumption of the disinflation process in the context of an economy hit by supply shocks. The presence of a still positive “output gap” and the size of the shocks themselves tilted the balance toward the inflation risk. Consequently, policy rates were increased by 25 bps in July.

Not surprisingly, part of the policy discussions during this period focused on the nature and persistence of the shocks, and on the adequate measure of macroeconomic inflation. The five core inflation indicators regularly followed at the central bank sent different messages regarding macroeconomic inflationary pressures (Graph 21). In general, the measures that exclude food and energy prices, or food and regulated prices, showed stable core inflation, within the central bank’s range target. Other indicators with different exclusion criteria<sup>6</sup> captured the increasing trend of headline CPI inflation to different degrees. Thus, there was no clear signal from these measures and the question on which ones were the most reliable arose naturally.

### 3.1 An evaluation of core inflation measures

To answer this question, the five core inflation indicators monitored at the central bank are evaluated along with other commonly used core inflation measures, according to the standard criteria:<sup>7</sup> (i) bias with respect to CPI inflation over a long period; (ii) volatility with respect a long-run trend; (iii) ability to forecast future inflation; (iv) ability to track the long-run component of CPI inflation; (v) relationship with macroeconomic determinants of inflation (output gap); and (vi) ease of interpretation/communication and absence of frequent revisions. An ideal core inflation indicator is unbiased, has low volatility, is useful to forecast inflation, tracks closely the long-run component of CPI inflation, displays a close relationship with the macroeconomic determinants of inflation, is easy to follow by the public, and is subject to few revisions. The technical details of the criteria used in the evaluation are explained in the Appendix.

The sample is made up by monthly observations of 12-month core inflation indicators between December 1999 and November 2008. This period corresponds to a “low inflation regime” (Betancourt et al, (2009)) and is characterized by a homogeneous CPI series (December 1998 = 100). The evaluation is conducted for 12-month core inflation because this is the measure most generally followed and understood in Colombia, and because it partially corrects the seasonality present in the CPI measure. The indicators considered are the following:

- Inflation excluding food (X-food)
- Inflation excluding food and regulated prices (X-food-reg)
- Inflation excluding unprocessed food, fuel and public utilities (X-“noise”)
- Inflation excluding food (ex beverages), energy, gas and fuel (X-food-ener)

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<sup>6</sup> CPI excluding food, CPI excluding unprocessed food (ex beverages), fuel and public utilities, and CPI excluding the most volatile items (1990–99) accounting for 20% of the basket.

<sup>7</sup> See for example Rich and Steindel (2007) and Cecchetti (2007).

- Inflation trimming the most volatile items (1990–99) accounting for 20% of the CPI basket (TMV20-9099)
- Inflation trimming the most volatile items (1999–2008) accounting for 5% and 20% of the CPI basket, respectively (TMV5-9908 and TMV20-9908).
- Inflation trimming the most volatile items (1999–2008), where the trimmed percentage of the basket (2.68%) was chosen to track as closely as possible the long-run component of headline CPI inflation<sup>8</sup> (TMVop).
- The median and 5%, 10% and 20% symmetric trimmed CPI inflation means.

The main results of the evaluation may be summarized as follows:

- Bias:** Table 3 shows that only the TMV indicators yield unbiased gauges of inflation. The measures that exclude food or regulated prices are generally biased downwards, a result related to the upward trend of the relative prices of these items in the sample (Graph 18).
- Volatility:** Table 4 shows that, in general, core inflation indicators are smoother than headline CPI, with the notable exception of the median and the trimmed means.
- Ability to forecast future headline inflation:** From Table 7 it is apparent that the core measures that exclude food and some or all regulated prices help forecast future headline inflation (in-sample) better than other core inflation gauges at horizons greater than three months. Trimmed means and TMV indicators do badly in this regard. Out of sample RMSEs suggest a similar pattern, although TMV measures are now included among the indicators that better help forecast future inflation at different horizons (Table 8).
- Ability to track the long-run component of inflation:** By construction, TMVop tracks long-run inflation best (Table 5). Other TMV measures also follow long-run inflation reasonably well, although no RMSE is significantly equal to or lower than that of TMVop according to the Diebold-Mariano test (Table 5). Measures that exclude food and some or all regulated prices fare poorly in this context, a result that is related to the bias they present.<sup>9</sup> On the other hand, Graph 22 and Table 6 indicate that deviations of inflation without food from the inflation target closely track a diffusion index of inflationary pressures.<sup>10</sup> The corresponding RMSE is significantly lower than that of other core inflation measures, as shown by the Diebold-Mariano test.
- Relationship with macroeconomic determinants of inflation:** Based on estimated open economy Phillips Curves,<sup>11</sup> it follows that the industrial production output gap Granger-causes the core inflation measures that exclude food and some or all regulated prices (Table 9). There is evidence of weaker causality regarding TMV indicators and the 5% trimmed mean. In most cases, the in-sample fit of the Phillips Curves (the adjusted R<sup>2</sup>) was high (Table 10), but the best out-of-sample fit

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<sup>8</sup> The long-run component of CPI headline inflation was computed by means of a Kalman filter (see the Appendix, section A.4)

<sup>9</sup> If the bias were constant, these core inflation indicators could still capture turning points of “macroeconomic” inflation. However, this does not seem to be the case for the last part of the sample (Graph 21).

<sup>10</sup> The “diffusion index” captures the percentage of the CPI basket whose price changes are above the inflation target. The higher the value of the diffusion index, the more widespread inflationary pressures are. In this sense, the deviation of a good core inflation indicator from the target should closely correlate with the diffusion index.

<sup>11</sup> See the Appendix, section A.5.

was obtained for the models of inflation that exclude food and all regulated prices (Table 11). Other measures of core inflation that present good out-of-sample fit are those that exclude food and some regulated prices, as well as some of the TMV indicators.

In sum, there is no single core inflation indicator that clearly satisfies all the criteria for a good measure of core inflation. TMV indicators are unbiased and smooth, and track long-term headline inflation reasonably well. However, they are beaten by other measures at forecasting future headline inflation, and their relationship with macroeconomic determinants of inflation is weaker. Inflation excluding food and all or some regulated prices are smooth, help predict future inflation and show a stronger relationship with the output gap. Nonetheless, they are biased over the nine-year period considered and, for the same reason, fail to track the estimated long-term component of inflation, although deviations of inflation without food from the inflation targets closely followed a diffusion index of inflationary pressures.

The median and the trimmed means seem to be the poorest measures. They are biased, no less volatile than headline inflation, and do not excel in tracking long-run inflation, forecasting headline inflation, or in terms of their relationship with macro determinants. Further, they are more difficult to calculate and interpret, since the components that are excluded from the basket change frequently.

The result that no particular measure appears to be clearly superior to the others is similar to that found by Rich and Steindel (2007), who explain this as a reflection of the varying nature of the transitory shocks hitting inflation. This implies that the assessment of inflationary pressures should not rely only on one or few core inflation indicators, since some signals could be picked by some measures and not by others. More importantly, it means that the analysis of core inflation measures must be complemented with a careful examination of the persistence of the shocks and a close monitoring of their impact on inflation expectations.

For example, in Colombia conventional core inflation measures have risen moderately in the past two years, relative to other Latin American countries (BBVA (2008)) and, in the extreme case, inflation excluding food and all regulated prices has remained stable throughout the period. In a sense, this is reassuring because it provides evidence of a low pass-through of the shocks to core prices. However, it does not guarantee that macroeconomic inflation could not rise in the face of persistent increases in world commodity prices, given the lag with which they are transmitted domestically, their impact on inflation expectations and the existence of indexation mechanisms and practices. In fact, it is indicative that even as the output gap came down, non-tradable core inflation remained virtually constant in 2008 (Table 2).

### **3.2 The transmission of inflation shocks to core inflation and inflation expectations**

As an initial exploration of the interaction between movements of the different components of the CPI, a simple VAR for monthly price changes was estimated. The objective was to see how shocks originating in different CPI components are dynamically transmitted to inflation, and what the links are between the different components. The items of the CPI were grouped into four categories, following the classification traditionally used for the analysis of inflation at the central bank: food (processed and unprocessed), goods and services with regulated prices, tradable goods, and non-tradable goods and services. These four components account for 29%, 9%, 25% and 37% of the CPI basket, respectively. The VAR included the

monthly changes of the prices of those groups plus the change in total CPI, and was estimated for the period January 1999—November 2008.<sup>12</sup>

An inspection of the impulse-response functions derived from this model (Graph 23) reveals the following facts:

- Food and regulated price inflation shocks are the most volatile among the components examined.
- Shocks to the headline CPI monthly inflation show some persistence (two to three months), which means added persistence to annual inflation. The shocks to tradable prices have the highest persistence (eight months), and those to food prices also exhibit some persistence (two months).
- A shock to headline CPI inflation has significant, positive effects on the inflation of its components. We could interpret them as responses to an innovation in macroeconomic inflation. The effect (on impact) on food prices doubles the size of the shock itself; conversely, the responses of tradable and non-tradable prices are about half the size of the shock, while the effect on regulated prices is of a similar magnitude. The responses of tradable and regulated price inflation are the most persistent. These results suggest different degrees of nominal rigidities or indexation.
- The shocks to the sub-baskets of the CPI have significant, positive effects on headline monthly inflation on impact. The responses of CPI inflation to shocks to tradable and food price inflation tend to persist (up to four months). The magnitude of the response to a tradable price inflation shock (on impact) doubles the effect accounted for the size of the shock and their share of the CPI basket. The response to a shock to regulated price inflation also seems higher than the effect expected only on the basis of their share of the CPI basket.
- Non-tradable price inflation does not display significant responses to shocks to tradable and food price inflation. There seems to be a significant, lagged, positive response to a regulated price inflation shock.
- Tradable price inflation does not respond to a non-tradable price inflation shock. In contrast, it reacts positively in the face of food and regulated price inflation shocks, a result that may reflect the existence of a common source of the shocks (eg the exchange rate).
- Food price inflation does not respond to non-tradable or regulated price inflation shocks. It responds positively to a tradable price inflation shock, again a result that may reflect the existence of a common source of the shocks (eg the exchange rate).
- Regulated price inflation does not respond to a food price inflation shock. However, it reacts positively to a tradable price inflation shock and, with a lag, to a non-tradable price inflation shock.

In sum, consumer price inflation in Colombia exhibits some persistence, mostly related to the persistence of tradable and food price inflation shocks, and to the lasting responses of tradable and regulated price inflation to overall inflation shocks. Tradable and regulated price inflation shocks seem to have a relatively large impact on headline inflation. Non-tradable and tradable prices appear to be the most rigid, while food prices react strongly to overall

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<sup>12</sup> A VAR(1) was estimated. The order of the VAR was chosen according to the analysis of different information criteria (SIC, HQ, AIC, FPE). To account for seasonality, centered dummy variables were included. A similar model has been proposed by Maureira and Leyva (2008).

inflation innovations. The transmission of shocks between the CPI components considered is rather weak, and the impacts found possibly reflect the effect of a common shock. These results suggest some diffusion of relative price or supply shocks to core inflation, but do not indicate the existence of unanchored inflation or of a fast transmission of the shocks.

There may be several explanations for these features. We will focus on indexation and the impact of the inflation shocks on inflation expectations. Indexation is a relevant factor in the transmission of supply shocks to core inflation in Colombia. First, a ruling of the Constitutional Court suggested that the purchasing power of the minimum wage should be sustained,<sup>13</sup> which means that in practice its annual adjustment is unlikely to be lower than CPI inflation in the previous year. This is important, since the minimum wage in Colombia is relatively high and about a third of the workers in the formal sector earned it in 2006 (Arango and Posada (2007)). Furthermore, it is commonly believed that the minimum wage adjustment influences the increase in wages close the minimum. If this is true, the relevance of the minimum wage is much higher, given that 73% of the formal sector workers received less than two minimum wages in 2006 (Arango and Posada (2007)).<sup>14</sup> Moreover, the fact that indexed contracts last for a year implies that a transitory shock may have large effects on labor costs, and that the reversion of the shock is not easily transmitted to prices. Thus, a significant channel of transmission of supply shocks to core inflation may be working through the labor cost component of several sectors in the economy.<sup>15</sup>

A second source of indexation in Colombia comes from regulated prices. In particular, the rates of electricity, gas and water/sewage are linked to past CPI or PPI. In the case of electricity and gas, the adjustments are monthly, while the changes in water/sewage prices are irregular (López, (2008)). Other regulated prices (fuel and transportation) are not automatically linked to past inflation, but are set by the regulators according to the evolution of costs.<sup>16</sup> Interestingly, López (2008) found that regulated price inflation is less persistent than overall inflation, and specifically, less persistent than services price inflation, a result that draws attention back to wage indexation. In addition to wage and regulated price indexation, there are other informal indexation practices that may help explain why inflation persistence remains high in Colombia, despite a reduction after the fall of inflation and the adoption of an inflation targeting regime (Vargas, 2007).

In addition to indexation, the credibility of monetary policy may determine the extent to which supply shocks are transmitted to core inflation. González and Hamann (2006) argue that the high degree of persistence of inflation in Colombia has to do with imperfect credibility. The latter in turn is associated with the fact that the long-run inflation target has not been reached, which implies a slow process of learning about the “permanent” component of the inflation target. Indeed, the evidence presented in Gómez and Hamann (2006) favors this explanation over a simple ad hoc indexation hypothesis. Thus, an examination of the determinants of inflation expectations is warranted.

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<sup>13</sup> Corte Constitucional del Colombia, Sentencia (ruling) C-815/99.

<sup>14</sup> Nevertheless, Arango and Posada (2006) found that there is no long-run (co-integration) relationship between the real minimum wage and a real private sector wage obtained from household surveys. According to these authors, the correlation coefficient between changes of the real minimum wage and the real private sector wage was just 0.252 between 1984 and 2005. On the other hand, negotiations between trade unions and firms that result in labor contracts with wage increases for more than one year usually index the second or third year increases to observed CPI inflation. However, the fraction of the labor force covered by such contracts is very low.

<sup>15</sup> The minimum wage is also used to index fines and some pensions.

<sup>16</sup> In the case of fuel, the determination of the producer and consumer prices is rather complex, since it involves taxes and subsidies at different government levels (Rincón (2008)).

In Colombia the central bank conducts two surveys of inflation expectations: a monthly survey (since 2003) directed mostly to financial and banking sector analysts, and a quarterly survey (since 2000) with a broader coverage (businessmen, unions and academia among others). Furthermore, *break-even inflation expectations* implicit in the public debt market have been constructed since 2003. Monthly survey and break-even annual inflation expectations seem to be unbiased (with respect to future inflation) for the period without the large relative price shocks (2001–06, Table 12). In contrast, quarterly survey annual inflation expectations tend to exceed future inflation for the same time-span (Table 12). As expected, there are great forecast errors in the years of the relative price shocks (2007–08, Table 12). All inflation expectations indicators were as volatile as headline inflation throughout the 2000–08 sample, a feature that may be interpreted as evidence of imperfect credibility of monetary policy (imperfect anchoring of inflation expectations) during this period (Table 13).

However, Graph 24 shows that annual/annualized inflation expectations have not increased as much as inflation after the recent supply shocks. In the case of one-year-ahead 12-month inflation expectations, this means that the shocks were perceived as transitory (though persistent) events and that the credibility of monetary policy (the inflation target) may be playing a role. However, the fact that the five- and 10-year break-even inflation expectations rose by almost 200 bps imply that longer-term inflation expectations are far from being anchored.<sup>17</sup> Below, two questions regarding the determination of inflation expectations are given a preliminary answer: (i) how are inflation expectations formed? And, in particular, what is the role of past inflation and the inflation targets? (ii) how do inflation expectations respond to supply shocks?

- i. **The formation of inflation expectations:** In order to explore what the impact of inflation and the inflation target on inflation expectations is, two reduced form equations for the inflation expectations were estimated. The models were fitted to the data coming from the monthly and quarterly surveys described earlier.<sup>18</sup>

$$\pi_{t,t+12}^{e,m} = \beta_1 + \beta_2 \pi_{t-1,t+11}^{e,m} + \beta_3 \pi_{t-1}^m + \beta_4 \bar{\pi}_{t+12}^m$$

$$\pi_{t,t+4}^{e,q} = \gamma_1 + \gamma_2 \pi_{t-1,t+3}^{e,q} + \gamma_3 \pi_t^q + \gamma_4 \bar{\pi}_{t+4}^q$$

$\pi_{t,t+12}^e$  and  $\pi_{t,t+4}^e$  represent the one-year-ahead 12-month inflation expectations obtained in period  $t$  from the monthly and quarterly surveys, respectively;  $\pi_{t-1,t+11}^{e,m}$  and  $\pi_{t-1,t+3}^{e,q}$  represent one lag autoregressive term,  $\pi_{t-1}^m$  and  $\pi_t^q$  represent the relevant inflation rate observed when the respective survey is collected and  $\bar{\pi}_{t+12}^m$  and  $\bar{\pi}_{t+4}^q$  represent the inflation target set by the central bank. The superscripts  $m$  and  $q$  indicate the monthly and quarterly frequency of the data. The following are the results of the estimation.<sup>19</sup>

<sup>17</sup> This conclusion must be qualified though, since the inflation risk premia may be experiencing large movements.

<sup>18</sup> The timing of the monthly survey is as follows: At time  $t$ , when respondents report their 12-month inflation expectations for  $t+12$  ( $\pi_{t,t+12}^{e,m}$ ), they have not observed current annual inflation ( $\pi_t^m$ ), but they had observed inflation in  $t-1$  ( $\pi_{t-1}^m$ ). That is why current inflation is excluded from the regression and the one period lagged inflation is the “*relevant*” variable to analyze the impact of past inflation on expectations. In the case of the quarterly survey, the respondent observes annual inflation of quarter  $t$  before he/she projects annual inflation one year (four quarters,  $t+4$  periods) ahead. That is why annual inflation in  $t$  is the “*relevant*” measure to capture the effect of past inflation on expectations.

<sup>19</sup> For both estimated equations, residuals have a normal distribution and do not display serial correlation.



Equation	Results (p-values in parentheses)
Estimated equation for monthly data	$\pi_{t,t+12}^{e,m} = 0.0 + 0.34 \pi_{t-1,t+11}^{e,m} + 0.17 \pi_{t-1}^m + 0.47 \bar{\pi}_{t+12}^m$ (0.579) (0.065) (0.000) (0.007)
Estimated equation for quarterly data	$\pi_{t,t+4}^{e,q} = 0.0 + 0.36 \pi_{t-1,t+3}^{e,q} + 0.37 \pi_t^q + 0.29 \bar{\pi}_{t+4}^q$ (0.810) (0.000) (0.009) (0.057)

It is clear that inflation expectations have some persistence: in both equations the autoregressive term is greater than 0.3 and is statistically significant. Past inflation is also a significant determinant and has a greater impact on the quarterly survey expectations than on the monthly survey data. Conversely, the inflation target has a greater impact on the monthly survey expectations than on quarterly data. This suggests that the inflation target is more relevant for the analysts from the financial sector (who follow closely monetary policy) than for the public at large. Anyway, in both cases the inflation target set by the central bank has a significant effect on inflation expectations.

Henao (2008) used data from the central bank's quarterly survey to assess the reaction of the deviations of expected inflation from target to deviations of observed inflation from target. Interestingly, she examined inflation expectations by sector (transportation and communication, academics and consultants, labor unions, financial intermediaries, mining and industry, and big retail chains) to check for differences in the behavior of expectations of different agents. More precisely, ordinary least squares (OLS) estimates of the following equation were obtained:

$$(\pi_t^e - \pi_t^T)_j = \alpha + \beta_j (\pi_t - \pi_t^T) + \varepsilon_t$$

$(\pi_t^e - \pi_t^T)_j$  and  $(\pi_t - \pi_t^T)$  represent, respectively, the deviations of inflation expectations from target for sector  $j$  and the deviation of observed inflation from target. Only the transportation and communication and labor union sectors exhibited a significant, positive response of inflation expectations to deviations of inflation expectation from target. For the other sectors, inflation expectations seemed to be "anchored".

On the other hand, Henao (2008) constructed an index of the credibility of the inflation target<sup>20</sup> and found that the behavior of this index depends on whether the inflation target of the previous year was met. She also found that the distribution of the inflation expectations at the beginning of a year is conditioned by the fulfillment of the previous year target: it is centered and concentrated around the current target when the previous year target was met, while it is more disperse and centered above the target when the previous year target was missed. These pieces of evidence indicate the presence of an adaptive component in the formation of inflation expectations.

Finally, González et al (2009) propose an exercise that follows the spirit of a growing number of studies that incorporate *learning mechanisms* (Evans and Honkapohja (2002) and Woodford (2003)). Using recursive least squares, they estimate a learning model of survey inflation expectations of the following form:

$$Expect_{t,h} = \phi_t Infl_{t-1} + \beta_t [Infl_{t-1} - Expect_{t-1-h,h}] + \alpha_t Shock_{t-1}$$

<sup>20</sup> The credibility index is defined as the percentage of respondents whose inflation expectations at the beginning of one year were inside the range target set for the end of that year.

where  $Expect_{t,h}$  represents the inflation expectations at time  $t$  for horizon  $h$ ,  $Infla_{t-1}$  represents the corresponding lagged inflation rate  $[Infla_{t-1} - Expect_{t-1-h}, h]$  corresponds to a forecasting error that reflects the learning process and  $Shock_{t-1}$  represents unexpected monetary policy shocks.<sup>21</sup> They found that the largest parameter estimate was  $\phi_t$ , which happened to be relatively constant and close to 1, reflecting the important impact that observed inflation has on expectations. The learning parameter,  $\beta_t$ , and the parameter that reflects the unanticipated policy shock,  $\alpha_t$ , were relatively small, suggesting a slow learning rate.

Based on the previous evidence, it is clear that survey inflation expectations are strongly affected by past inflation, so that persistent “supply” or “demand” shocks may have long-lasting effects on core inflation, if price/wage formation is influenced by these expectations. However, there is also evidence of an impact of the inflation targets on survey inflation expectations and of some anchoring of the expectations of some sectors of the economy. Hence, shocks are not fully transmitted and monetary policy credibility seems to play a relevant role.

- ii. **The response of inflation expectations to supply shocks:** To assess the response of inflation expectations to supply shocks, two empirical exercises were carried out. First, estimates of the supply shocks were computed as the difference between annual CPI headline inflation and several measures of core inflation.<sup>22</sup> The deviations of inflation expectations (obtained from surveys or break-even inflation) from headline inflation were then regressed against the estimated supply shocks in order to gauge the response of expectations to the shocks:

$$\left(\pi_{t+h}^{e_i} - \pi_{t+h}\right) = \alpha + \beta_{ij}^h \left(\pi_t - \pi_t^{c_j}\right) + \sum_{k=1}^p \gamma_{ij} \left(\pi_{t-k}^{e_i} - \pi_{t-k}\right) + \varepsilon_t$$

for core inflation indicator  $j$  and inflation expectations  $i$  at horizon  $t+h$ .  $\beta_{ij}^0$  measures the contemporaneous effect of a supply shock on the deviations of inflation expectations with respect to inflation. The value of this parameter can be associated with the credibility of the inflation regime. For instance, if  $\beta_{ij}^0$  equals  $-1$ , then a transitory supply shock does not affect expectations, implying a perfectly credible monetary regime. On the contrary, if  $\beta_{ij}^0$  equals 0, then a transitory supply shock affects inflation expectations as much as it affects inflation itself.

Since a supply shock is likely to have persistent effects, we estimated  $\beta_{ij}^h$  for a set of regressions where the dependent variable is leading the independent variable by  $h$  periods. That is, Graphs 25 to 29 present the sequence of  $\beta_{ij}^h$  for several values of  $h$ . In general, one can see from the graphs that inflation expectations are partially anchored and that supply shocks do not affect one-to-one inflation expectations. In fact, for most of the cases the estimated impact was negative, though greater than  $-1$ , ie transitory supply shocks are not entirely transmitted to inflation expectations, but there is no evidence of a perfectly credible regime.

There are some drawbacks to this approach, since the estimated equation is a reduced form of a system that may involve both demand and supply shocks with

<sup>21</sup> These shocks were constructed as the difference between actual and expected policy interest rates, where the latter were obtained from a Bloomberg survey.

<sup>22</sup> See Section 3.1

different degrees persistence, hitting the economy under varying monetary policy credibility. Hence, the estimates may be biased for several reasons.<sup>23</sup>

In a second exercise we measured the impact of inflation “surprises” on the dynamics of quarterly survey inflation expectations. The objective was to estimate the extent to which inflation expectations are adjusted following an inflation surprise. More precisely:

$$A_{t|t+i} = \alpha_i S_{t-1}^t + \varepsilon_t$$

where:

$$A_{t|t+i} \equiv E_t \pi_{t+i} - E_{t-1} \pi_{t+i}$$

$$S_{t-1}^t \equiv \pi_t - E_{t-1} \pi_t$$

$A_{t|t+i}$  represents the adjustment of the inflation expectations (at a fixed horizon) and  $S_{t-1}^t$  proxies the inflation surprises. The coefficient  $\alpha_i$  gauges the impact of the latter on the expectations adjustment. If expectations were not anchored, a transitory inflation surprise would be totally transmitted to the expectations ( $\alpha_i$  close to one). The results of the estimation are presented in Graph 30. It is clear that the impact of inflation surprises on the expectation adjustment is significantly positive, less than one and decreasing with the expectation horizon. This can be interpreted as evidence of partial and declining transmission of inflation surprises to expectations. However, to obtain more robust results and reduce the probability of bias, this exercise could be improved to distinguish between demand and supply shocks, or persistent and short-lived shocks.

In another version of this exercise, the inflation surprise was redefined as:

$$S_{t-1}^t \equiv \pi_t^a - E_{t-1} \pi_t$$

that is, as the difference between food price inflation and the past expectation of current inflation. To eliminate predictable, low frequency movements of the relative price of food, the deviations of  $S_{t-1}^t$  with respect to its long-run trend (Hodrick-Prescott) were used in the estimation. The idea was to identify the effects of short-lived supply shocks, as approximated by short-run food price movements. Graph 31 indicates again a positive impact of the shocks on the expectations adjustment, but of significantly lower magnitude.

## 4. Conclusion

The assessment of inflationary pressures in Colombia has faced two important challenges in the present decade. The first occurred in 2006 and consisted of detecting an overheating economy in the midst of fast-growing investment and increasing measured productivity. These phenomena suggested a large, possibly permanent supply shock that did not imply a risk to the achievement of the inflation target. In fact, at the time inflation reached a historical minimum. However, the central bank raised the policy interest rates anticipating a strong

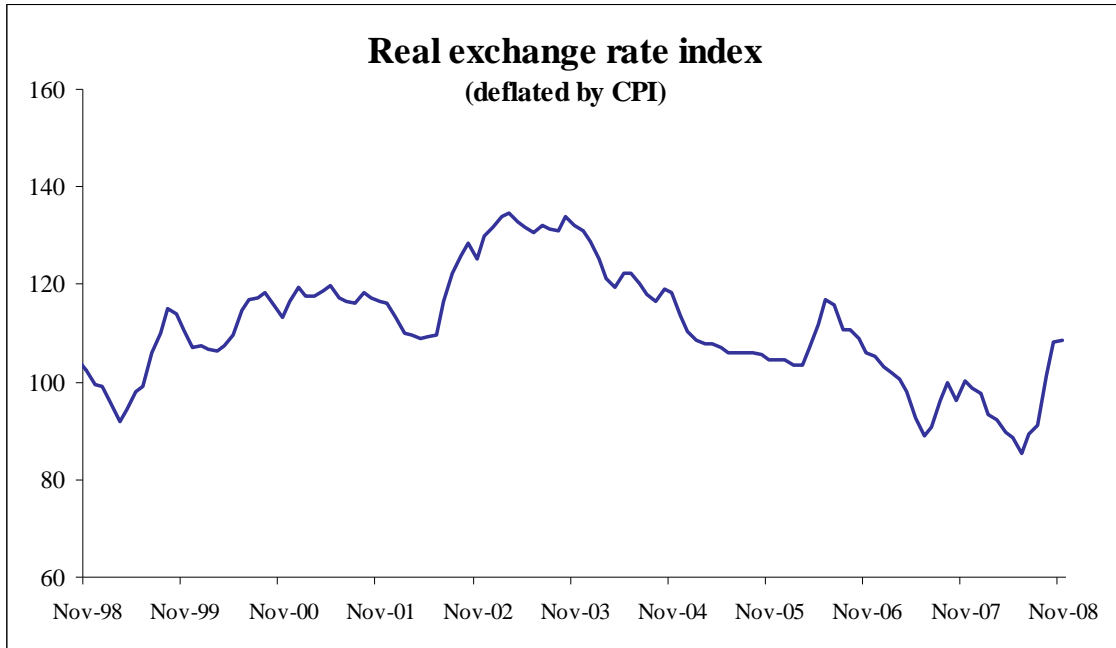
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<sup>23</sup> One that is particularly important for the purpose of this paper is a situation in which monetary policy is not fully credible, inflation falls faster than expected inflation, following a permanent demand shock, but the economy is also hit by a myriad of supply shocks. In this case, a negative value of beta may emerge that does not imply a credible monetary policy regime. Nonetheless, an inspection of the scatter plots indicates that this situation has low probability, since significant portions of the data are located in an area that clearly suggests the presence of credibility in the sample.

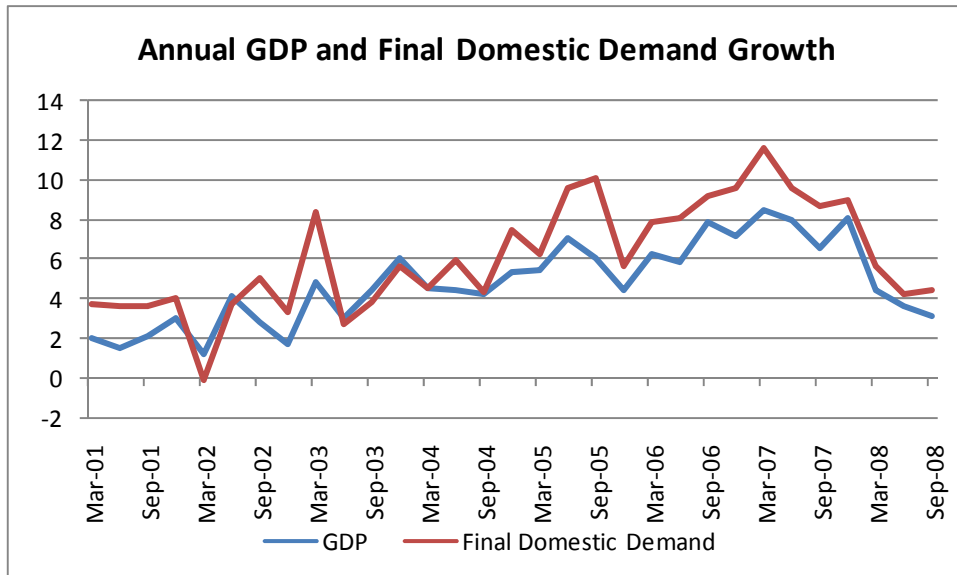
demand pressure on the basis of other indicators, a decision that proved to be timely. Traditional indicators of productivity and unit labor costs were not sufficient to identify “supply” and “demand” movements, so the policymakers had to rely on a wider array of variables to gauge the state of the economy.

The second challenge took place in 2007–08, when the economy was hit by a number of supply shocks and core inflation indicators sent diverging signals about the transmission of those shocks to macroeconomic inflation. An evaluation of the core inflation indicators according to standard criteria suggests that no particular measure seems to be clearly superior to the others, a result similar to that found by Rich and Steindel (2007), who explain this as a reflection of the varying nature of the transitory shocks hitting inflation. This implies that the assessment of inflationary pressures should not rely only on a single or few core inflation indicators, since some signals could be picked by some measures and not by others. More importantly, it means that the analysis of core inflation measures must be complemented with a careful examination of the persistence of the shocks and a close monitoring of their impact on inflation expectations. In fact, core inflation measures are used to derive estimates of the supply shocks hitting the economy to assess their impact on inflation expectations. It was found that the latter are formed on the basis of past inflation, but that the inflation target also plays a role. Moreover, inflation expectations *partially* move with supply shocks, an outcome that reflects a degree of credibility of monetary policy.

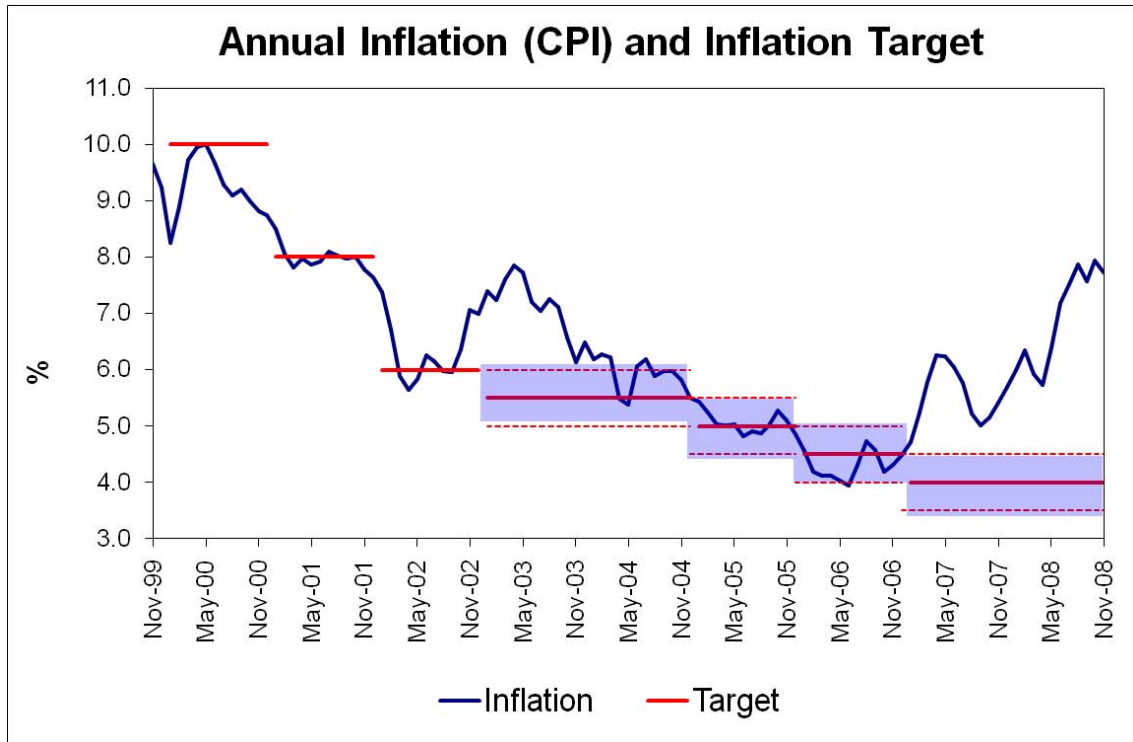
Graph 1  
Real exchange rate



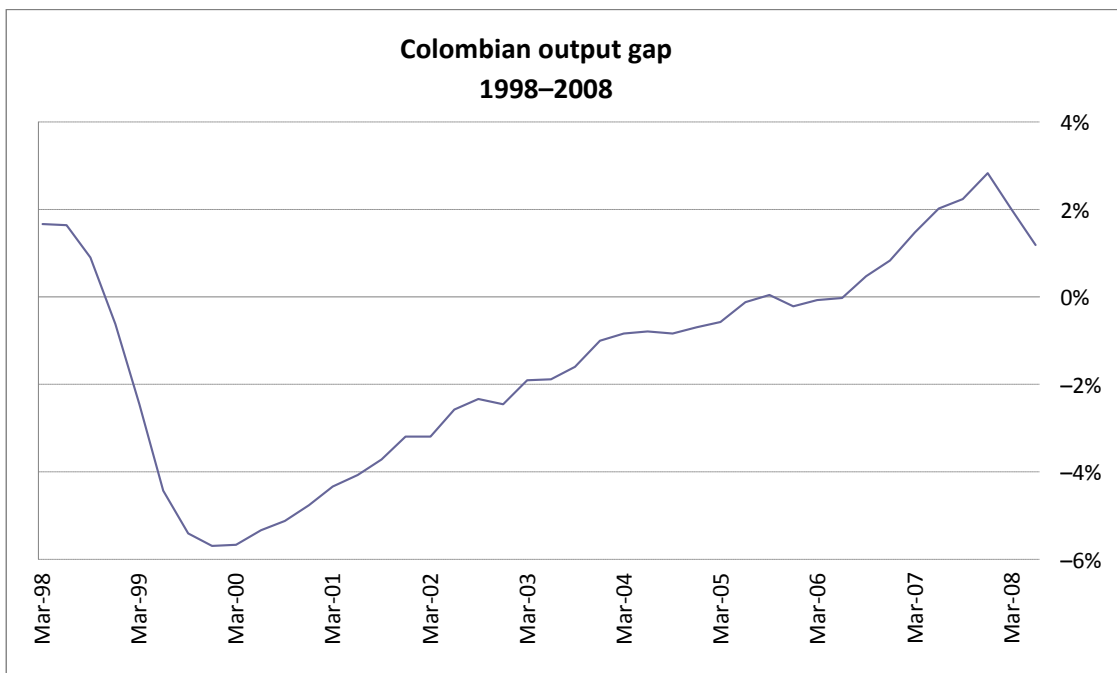
Graph 2  
Aggregate domestic demand and GDP real growth



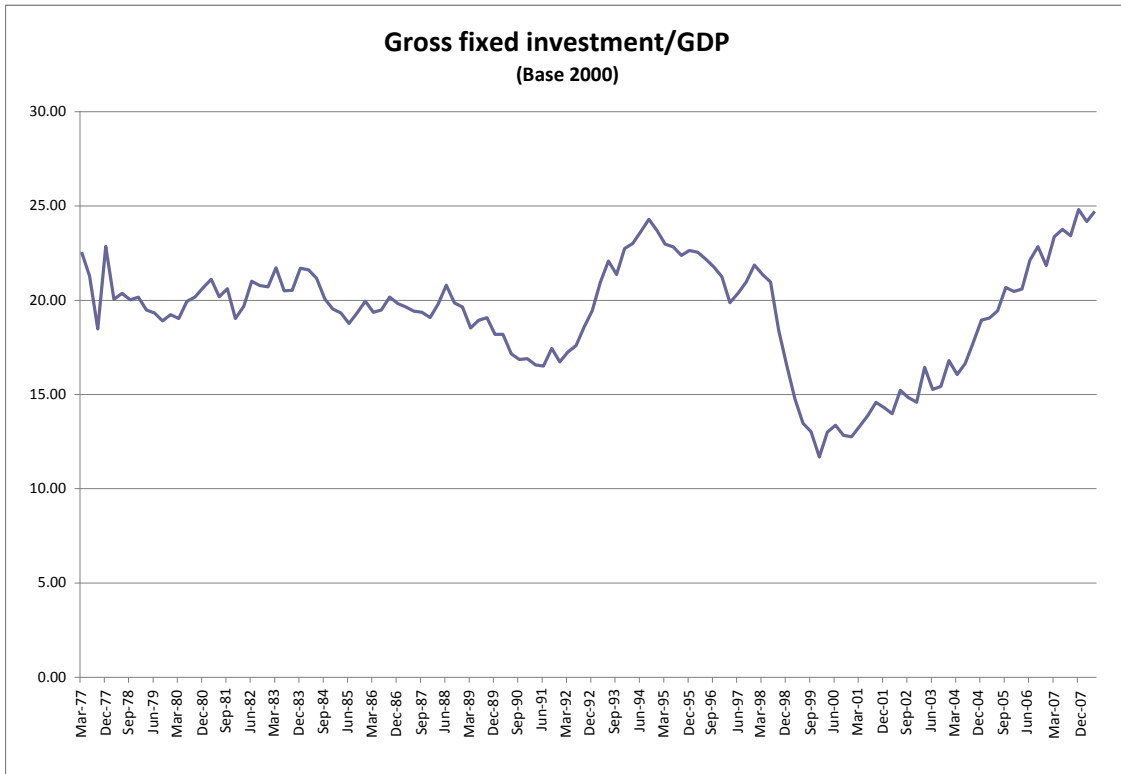
Graph 3  
CPI inflation and targets



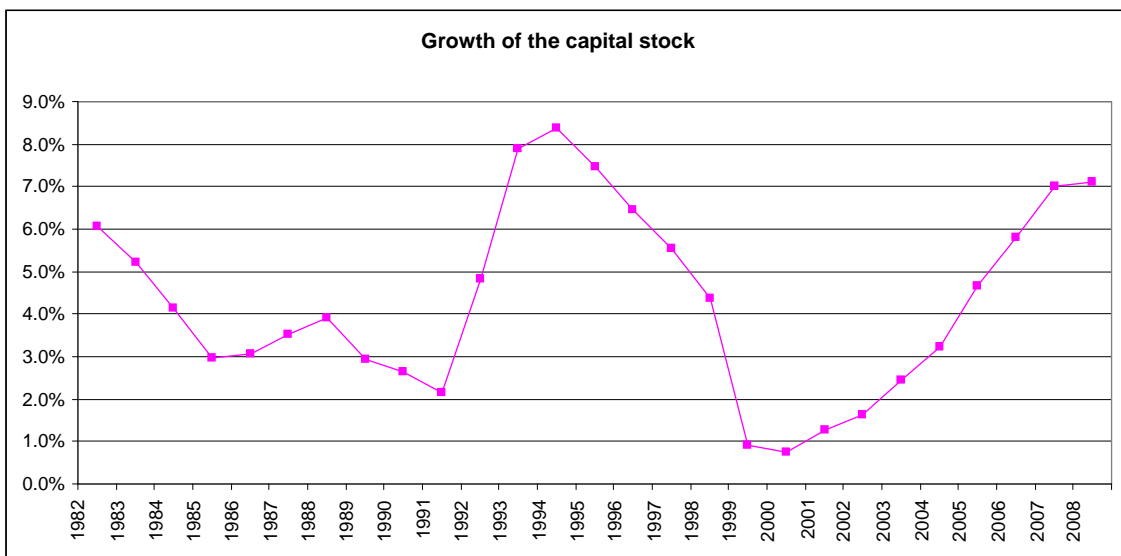
Graph 4  
Output gap



Graph 5  
Investment ratio

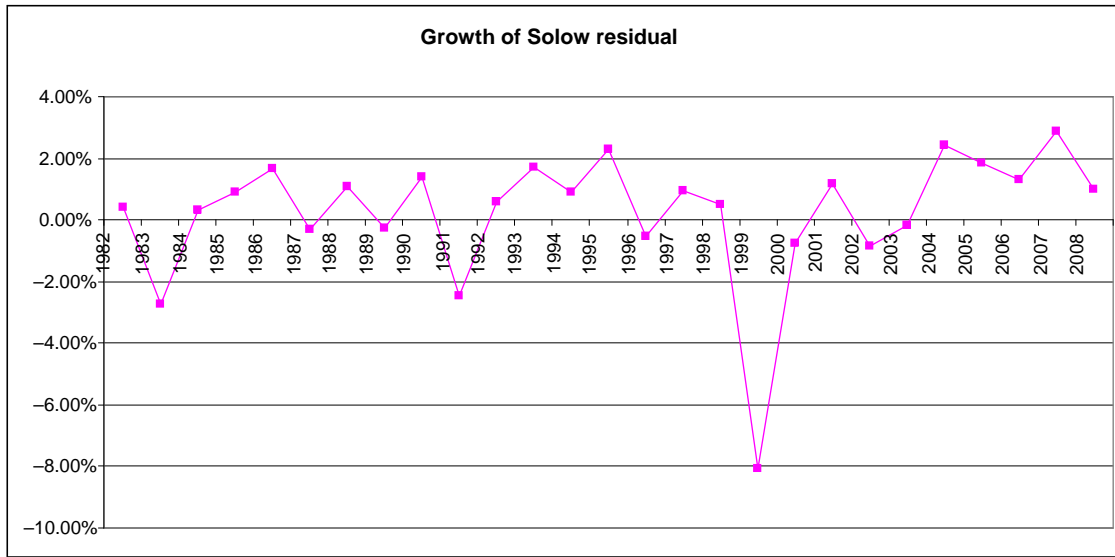


Graph 6  
Growth of the capital stock



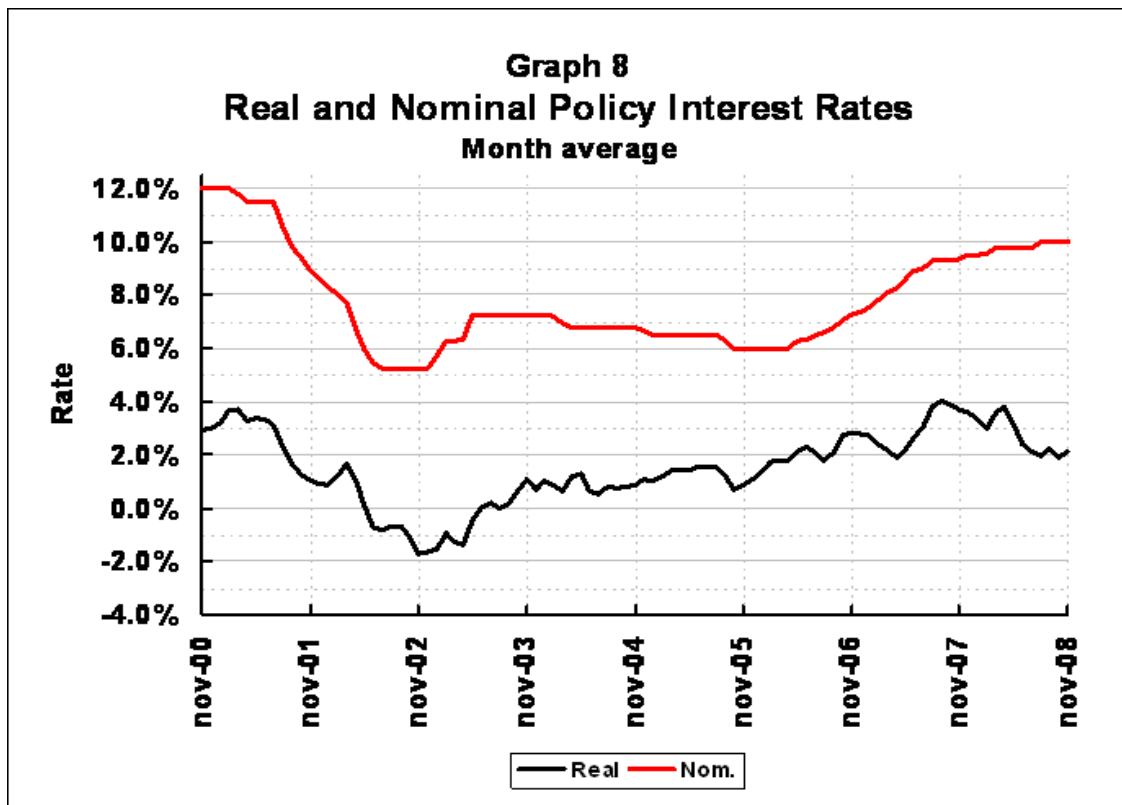
Source: DPI, Banco de la República

Graph 7  
Growth of Solow residual



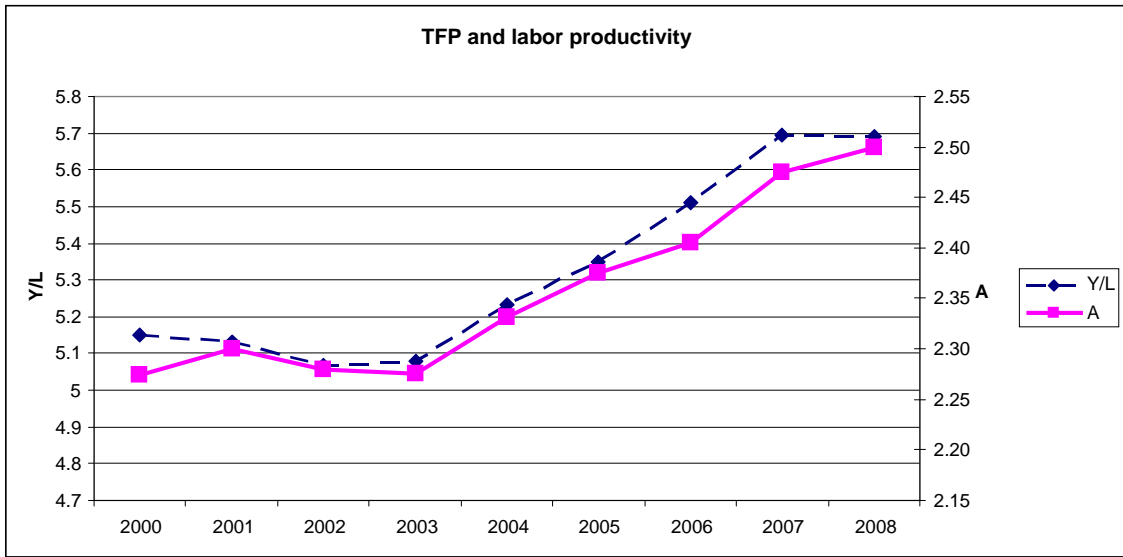
Source: DPI, Banco de la República

Graph 8  
Real and nominal policy interest rates





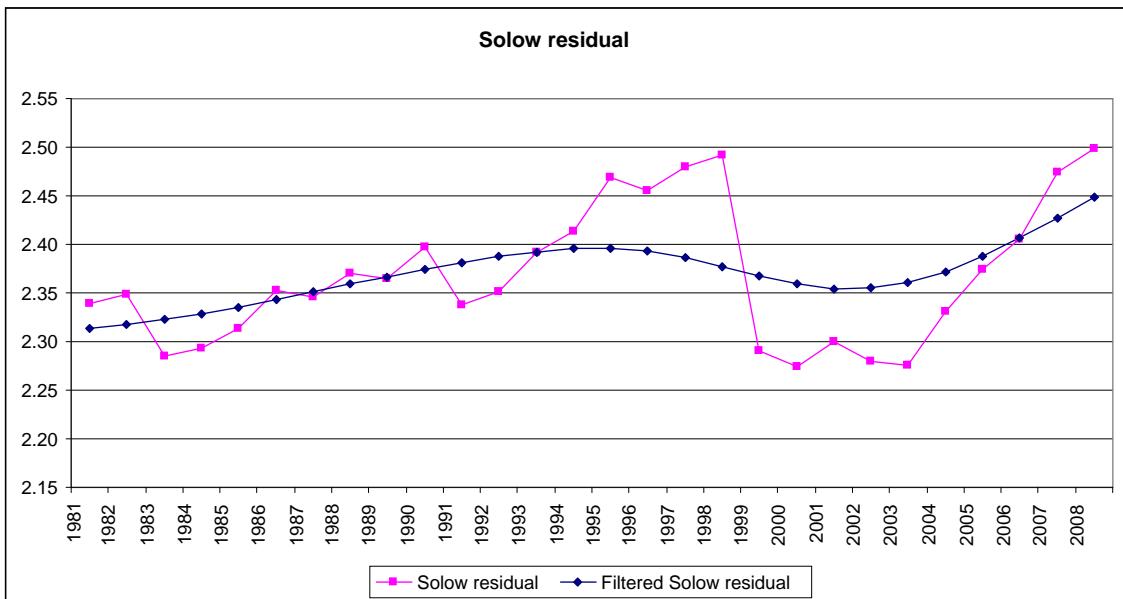
Graph 9  
**Total factor productivity and labor productivity**



Y/L = GDP/adjusted employment  
 A = Solow residual  
 See footnote 1

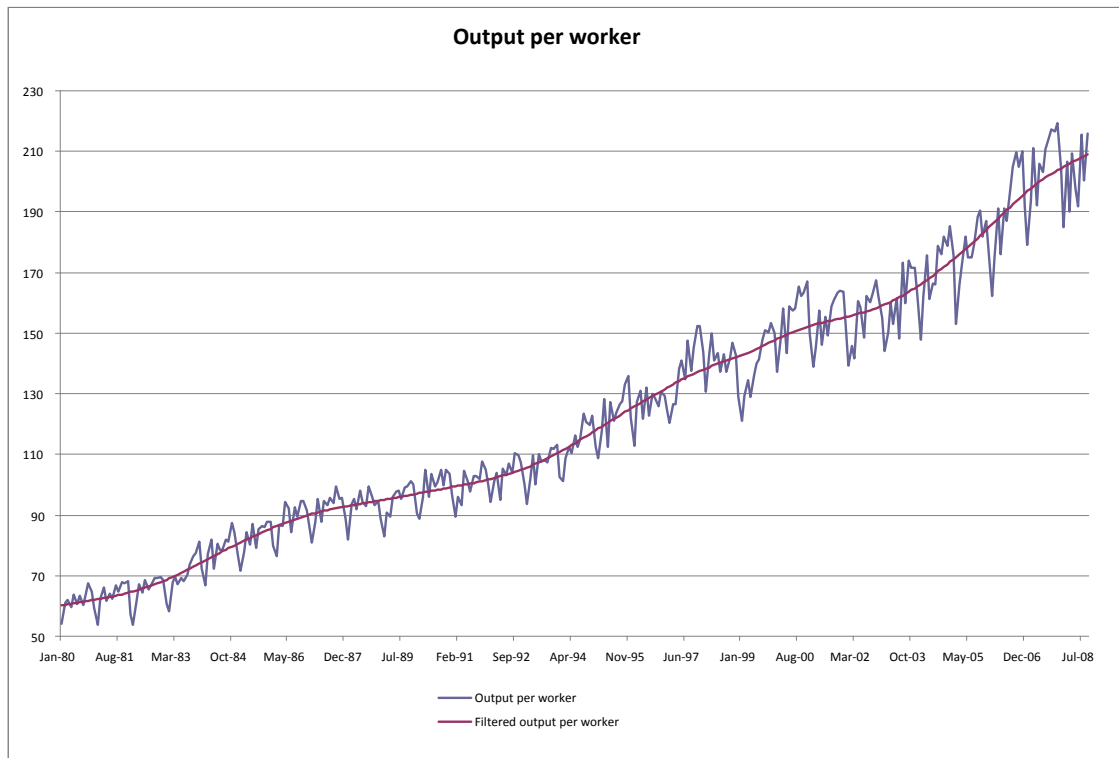
Source: DPI, Banco de la República

Graph 10  
**TFP and TFP trend**



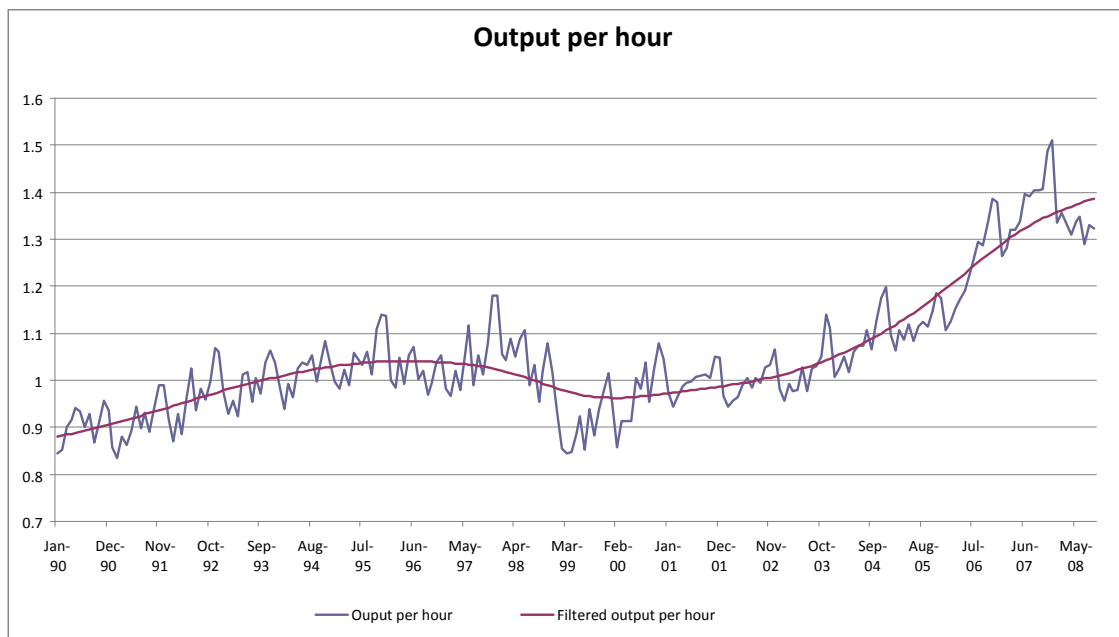
Source: DPI, Banco de la República

Graph 11  
**Labor productivity in the manufacturing industry**  
 Output per worker



Source: DANE, calculations from DPI, Banco de la República

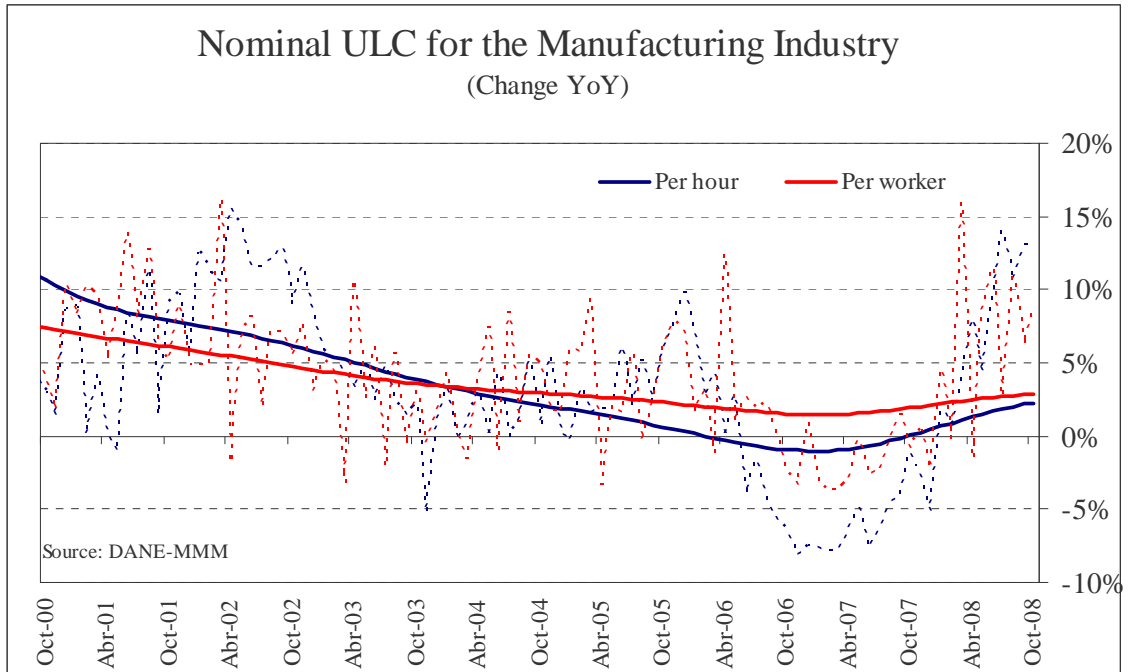
Graph 12  
**Labor productivity in the manufacturing industry**  
 Output per hour



Source: DANE, calculations from DPI, Banco de la República

Graph 13

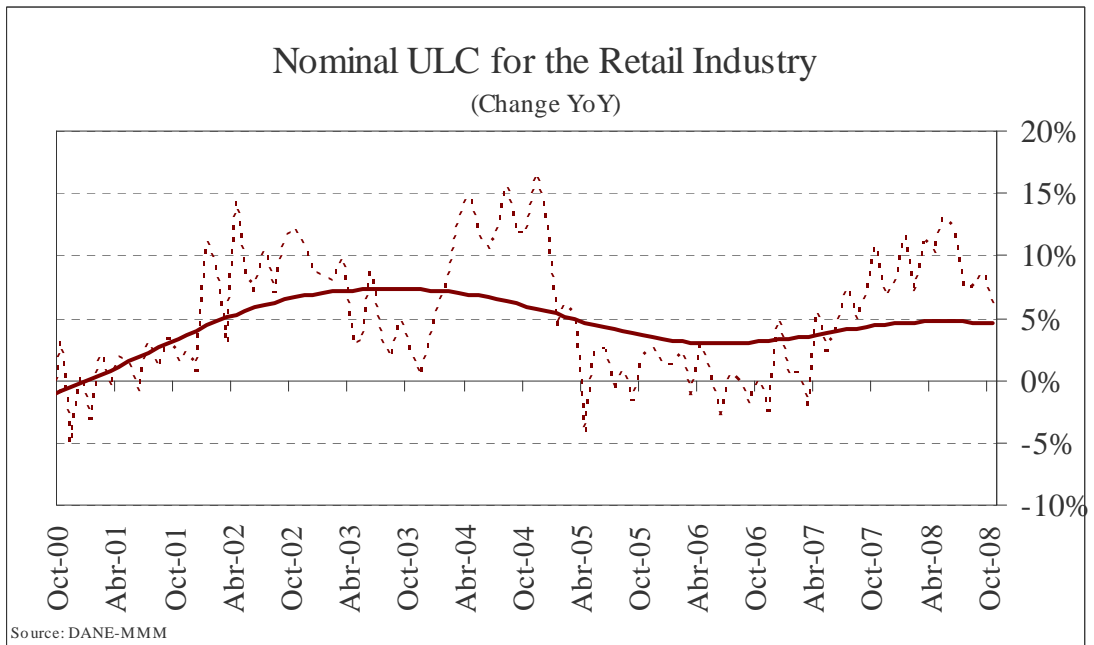
**Unit labor costs for the manufacturing industry**



Source: DANE, calculations from DPI, Banco de la República

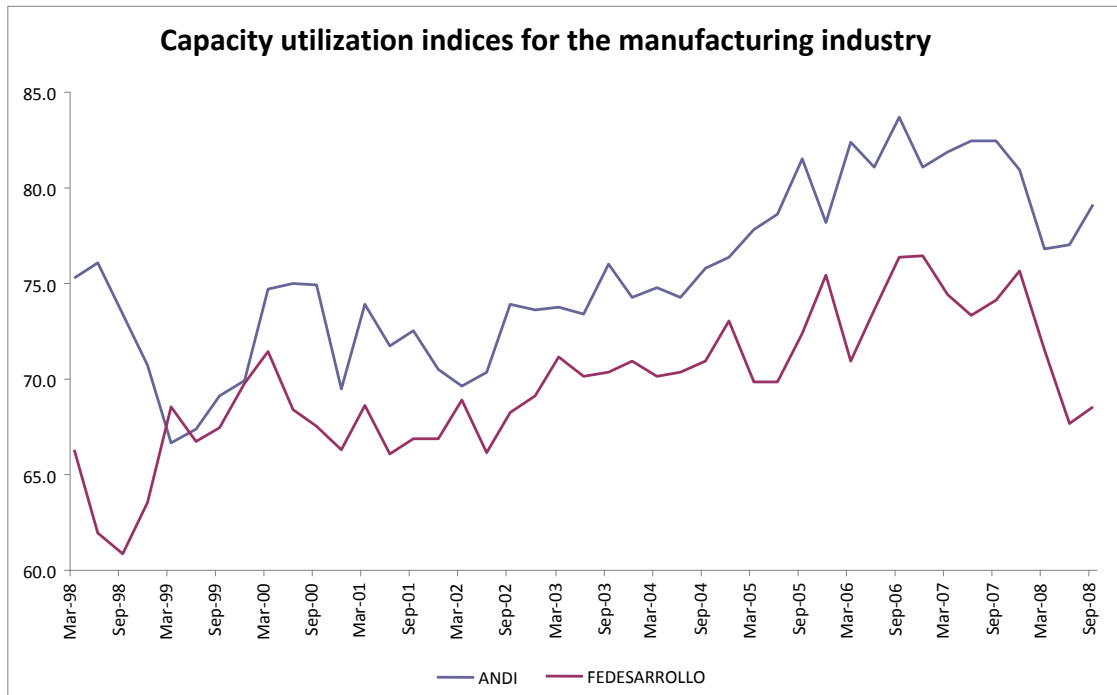
Graph 14

**Unit labor costs for retail industry**



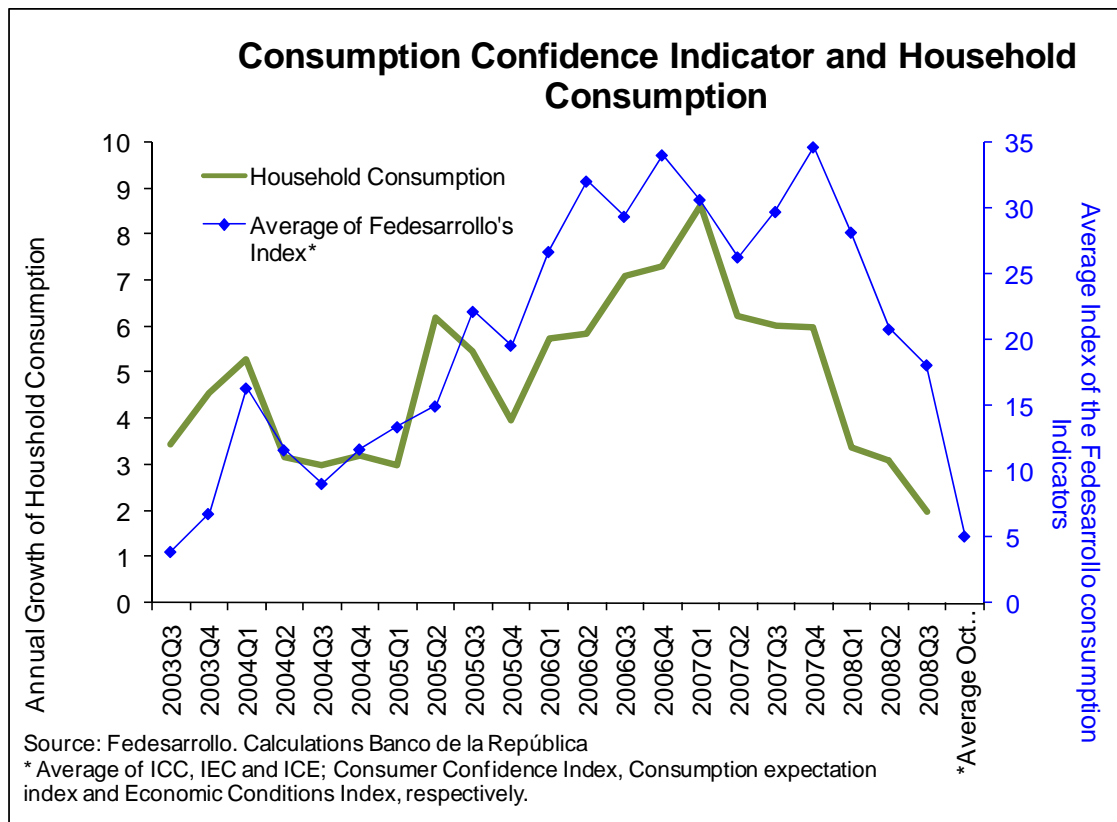
Source: DANE, calculations from DPI, Banco de la República

Graph 15  
**Capacity utilization indices for the manufacturing industry**  
 DANE-ANDI



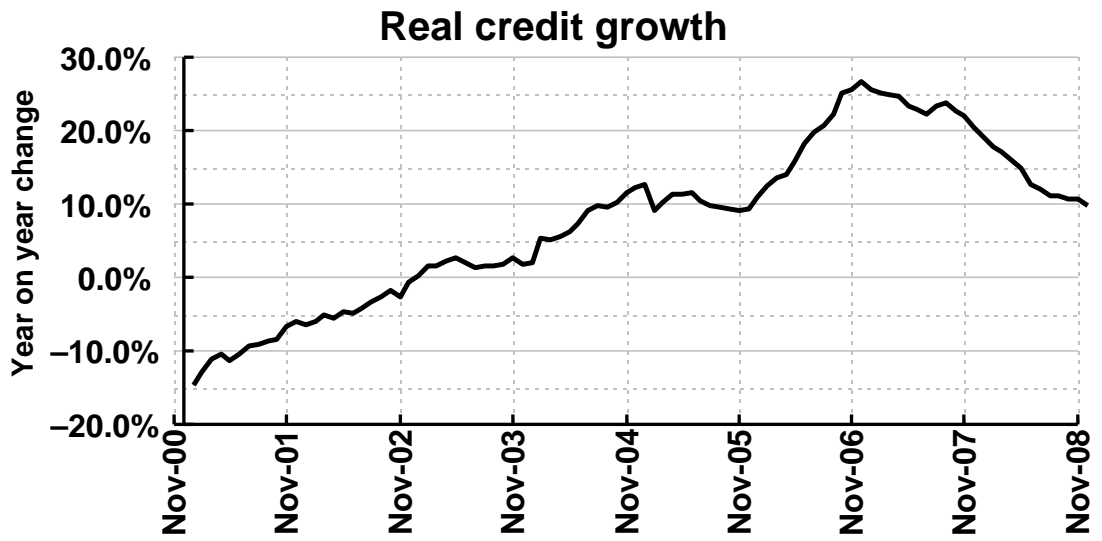
Source: DANE and Fedesarrollo

Graph 16  
**Consumer confidence indicator and consumption growth**

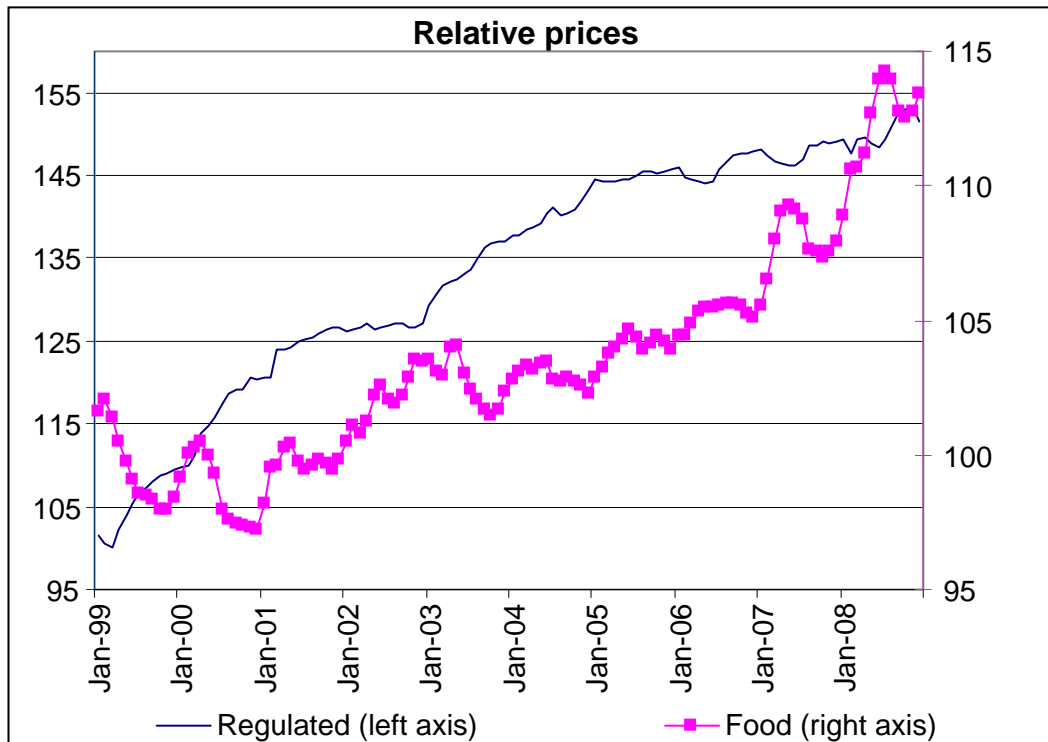


Source: Fedesarrollo. Calculations Banco de la República  
 \* Average of ICC, IEC and ICE; Consumer Confidence Index, Consumption expectation index and Economic Conditions Index, respectively.

Graph 17  
Real credit growth



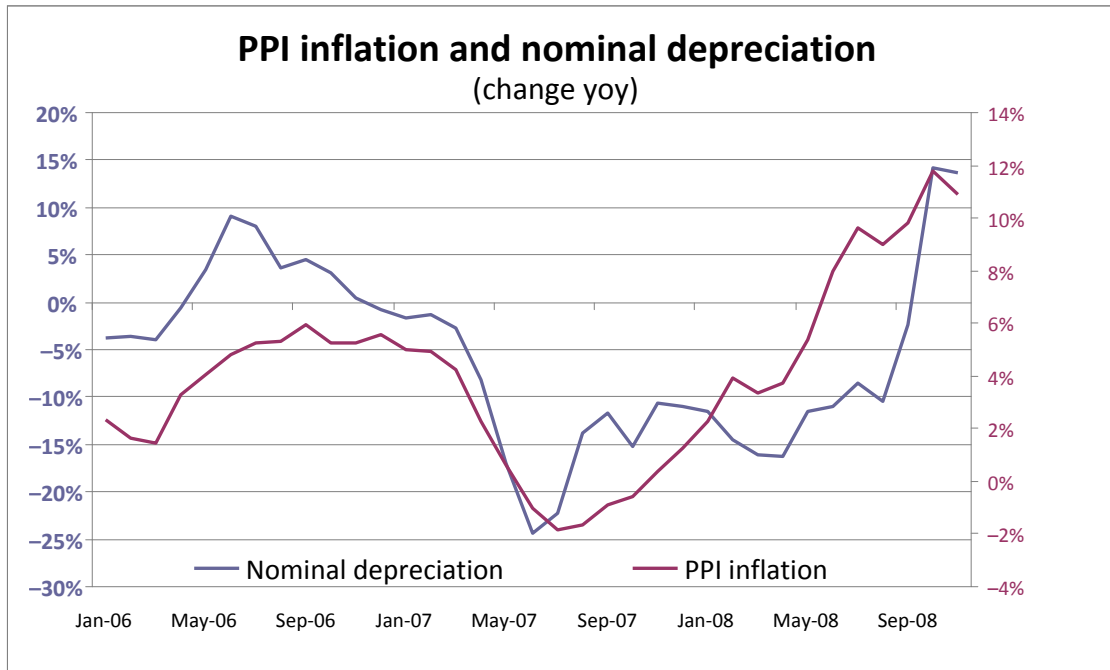
Graph 18  
Relative food and regulated prices\*



\*CPI regulated and food prices / Headline CPI

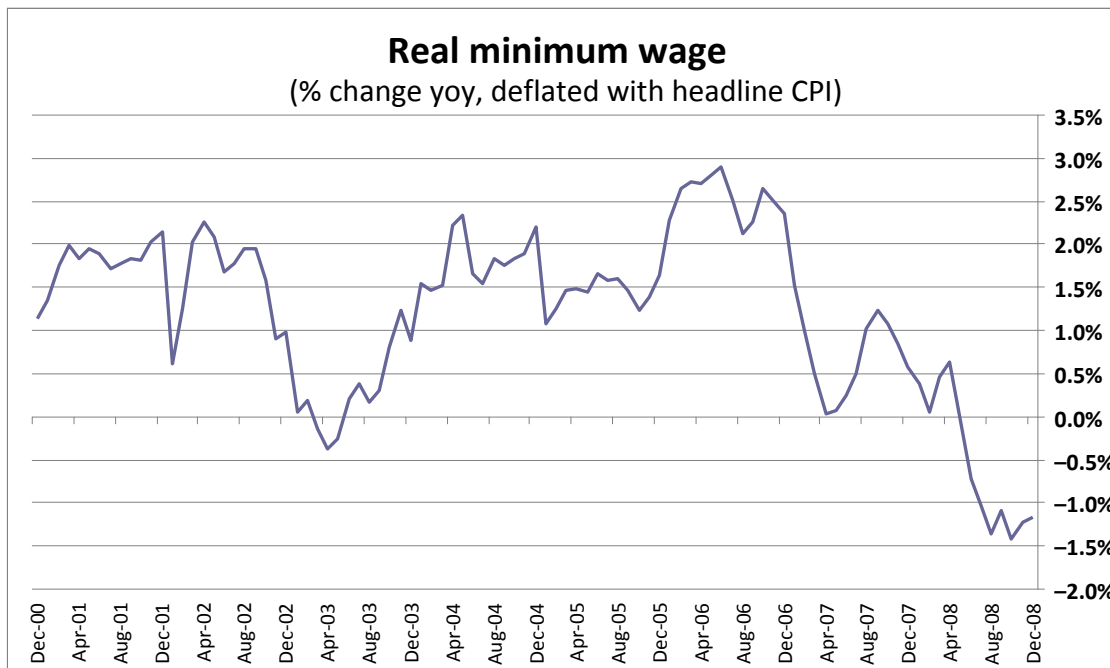
Graph 19

**PPI inflation and the nominal depreciation of the COP**



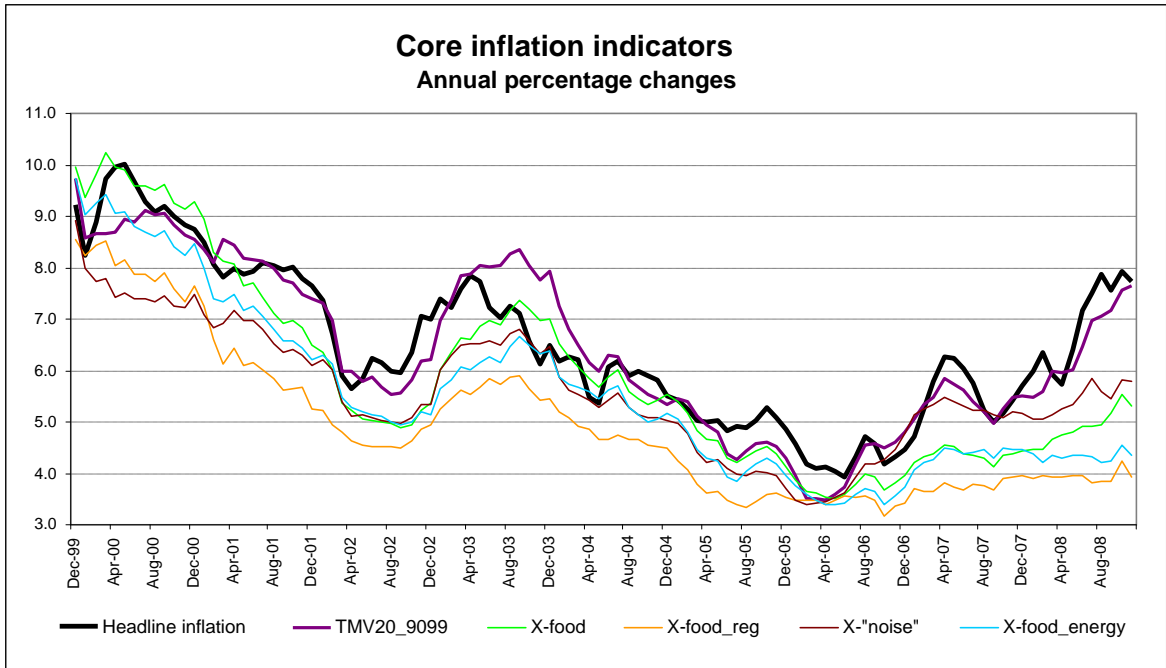
Graph 20

**Impact of price shocks on real disposable income**



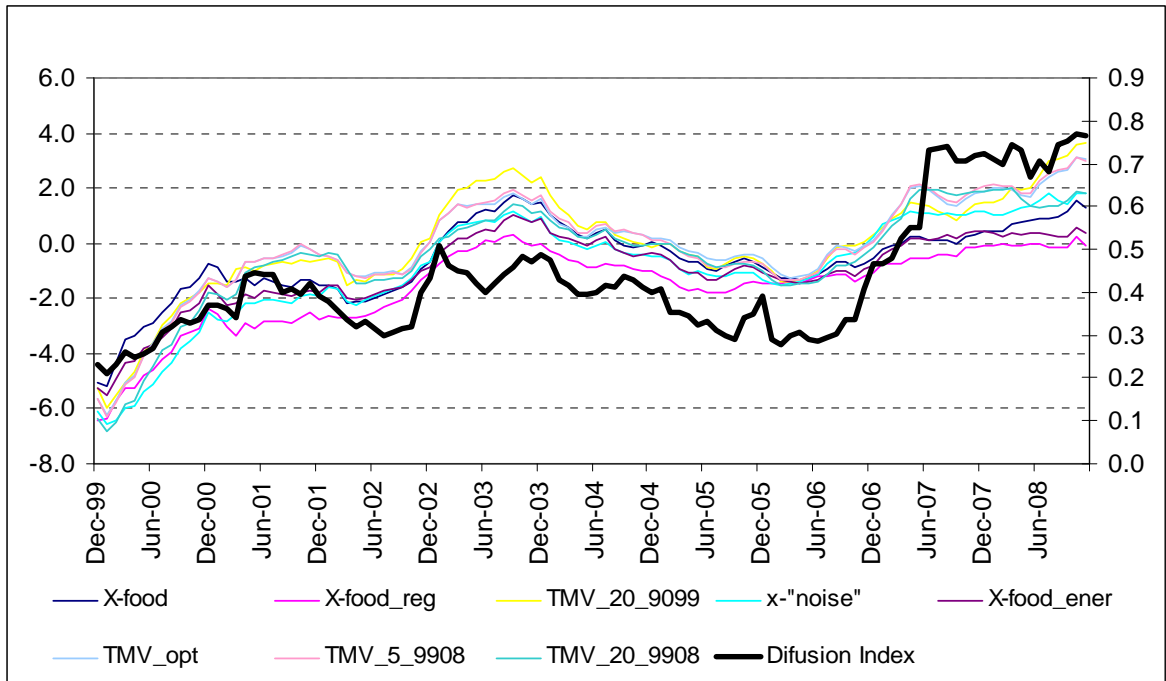
Graph 21

Headline CPI inflation and core inflation measures



Graph 22

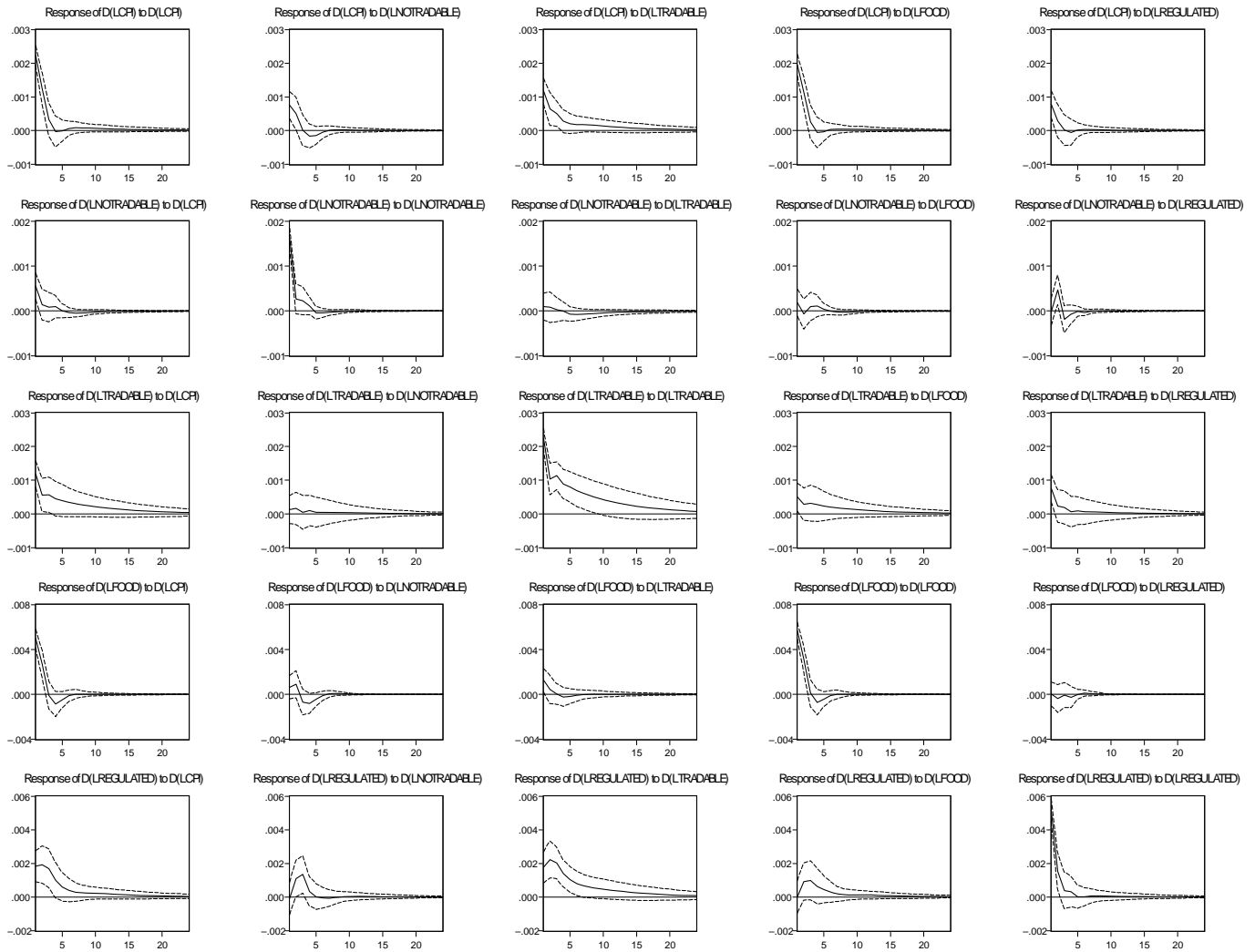
Deviations of core inflation measures from target and the diffusion index



### Graph 23

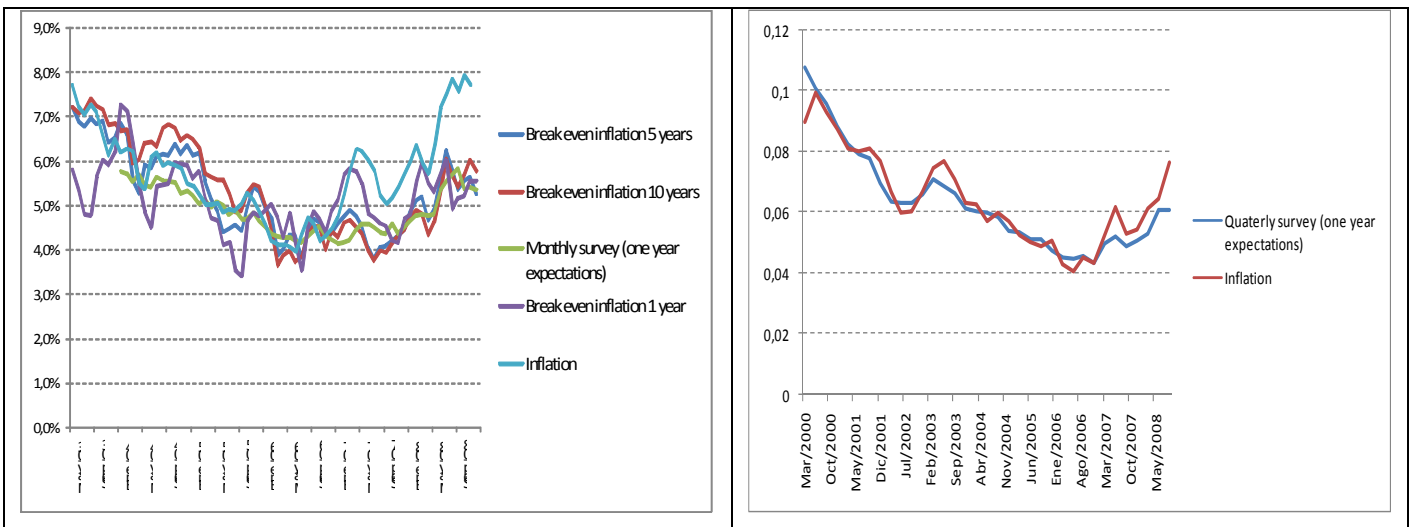
## Impulse response functions of a VAR for the monthly changes of the CPI and its components

Response to generalized one S.D. innovations  $\pm 2$  S.E.





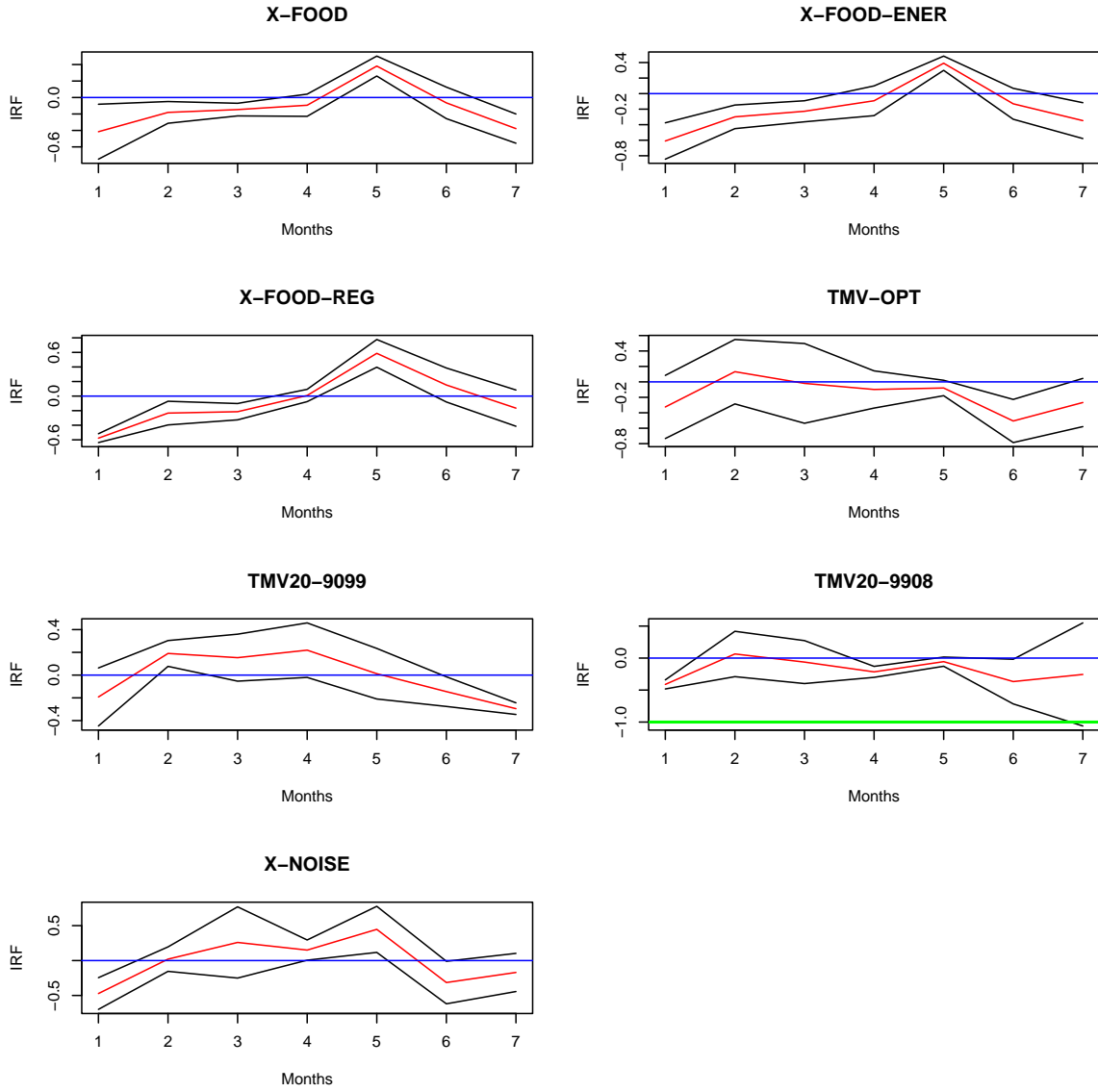
Graph 24  
**CPI inflation and inflation expectations**



Graph 25

**Response of inflation expectations to supply shocks**

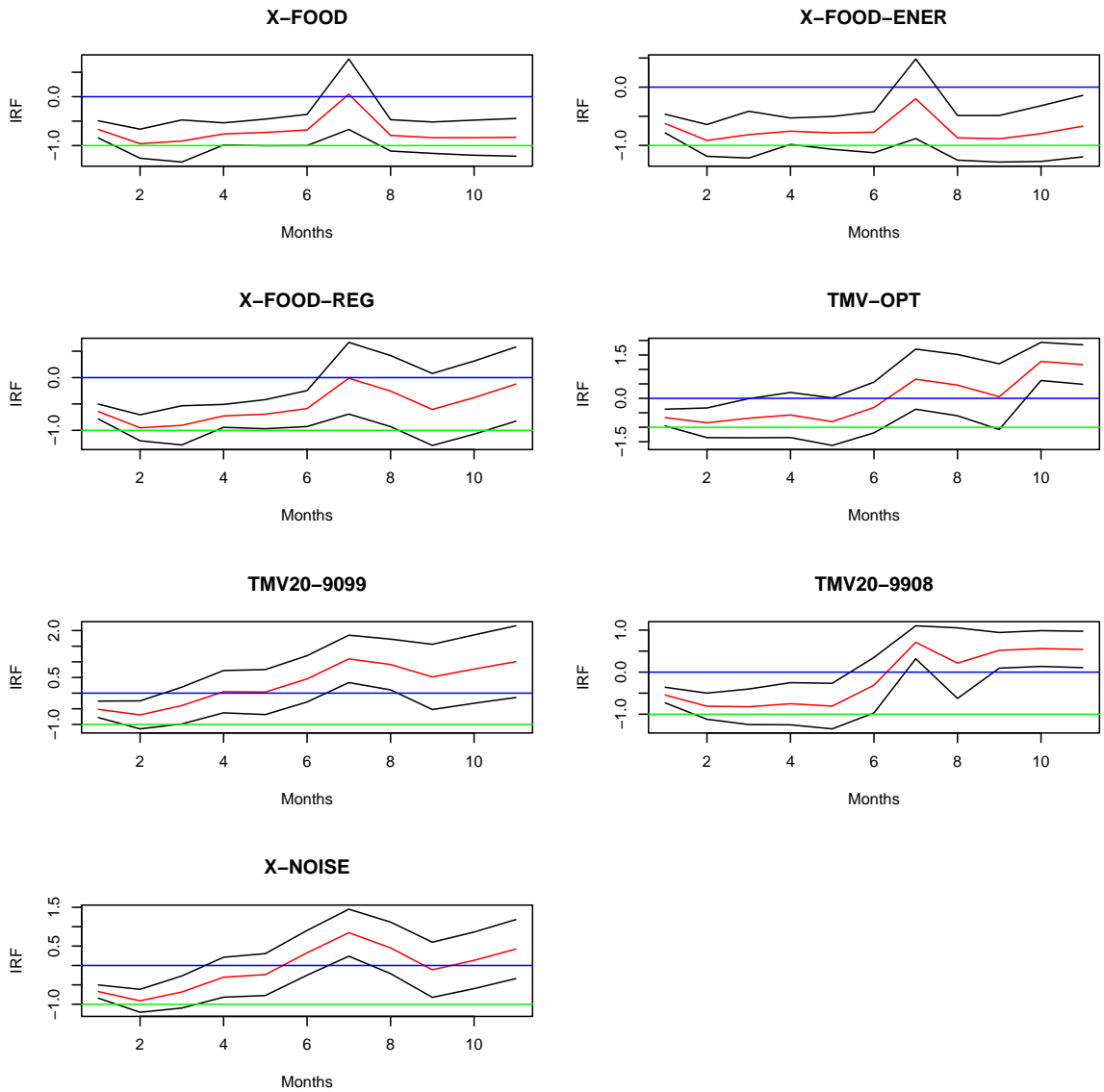
Quarterly survey expectations



Graph 26

**Response of inflation expectations to supply shocks**

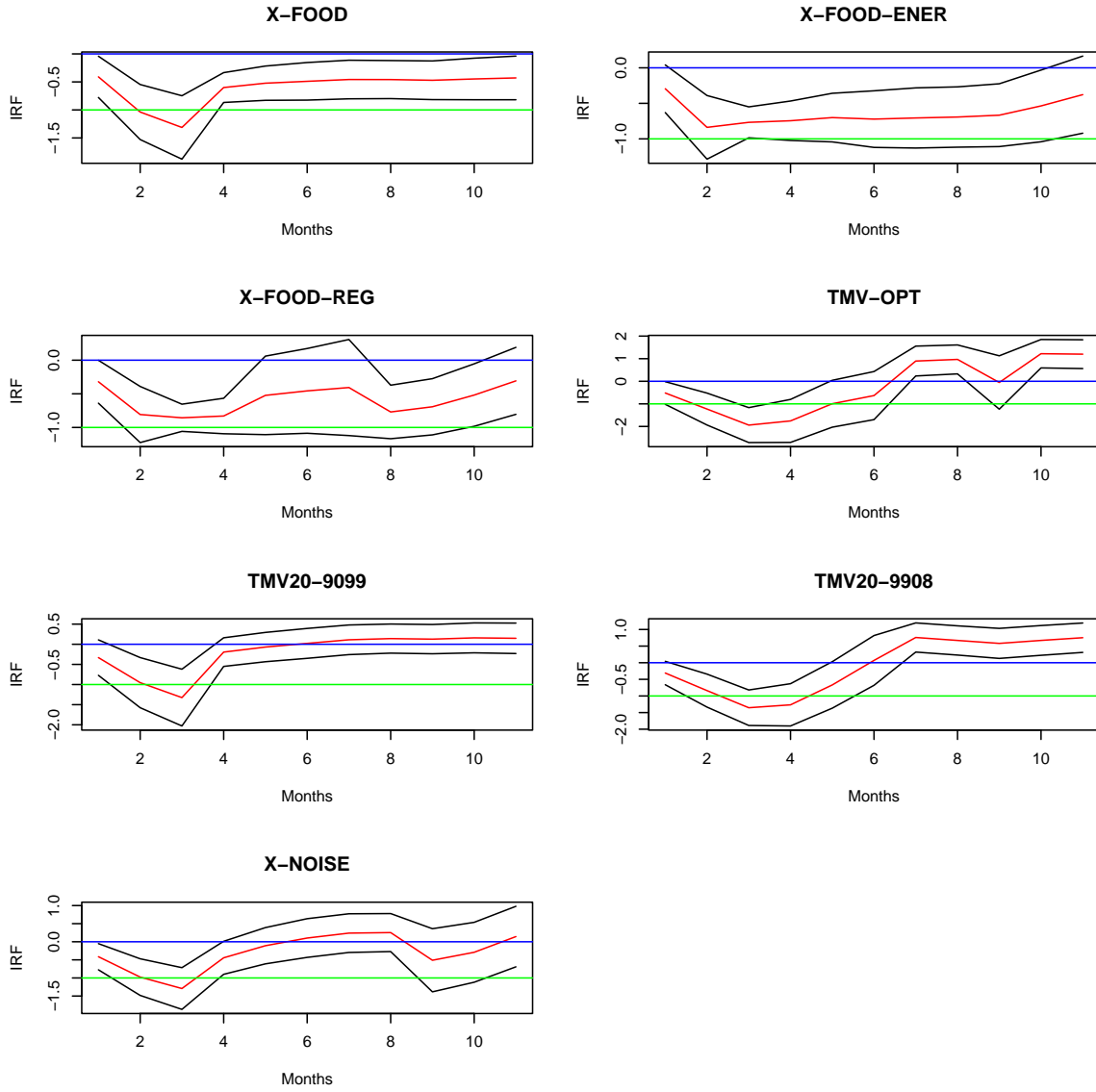
Monthly survey expectations



Graph 27

**Response of inflation expectations to supply shocks**

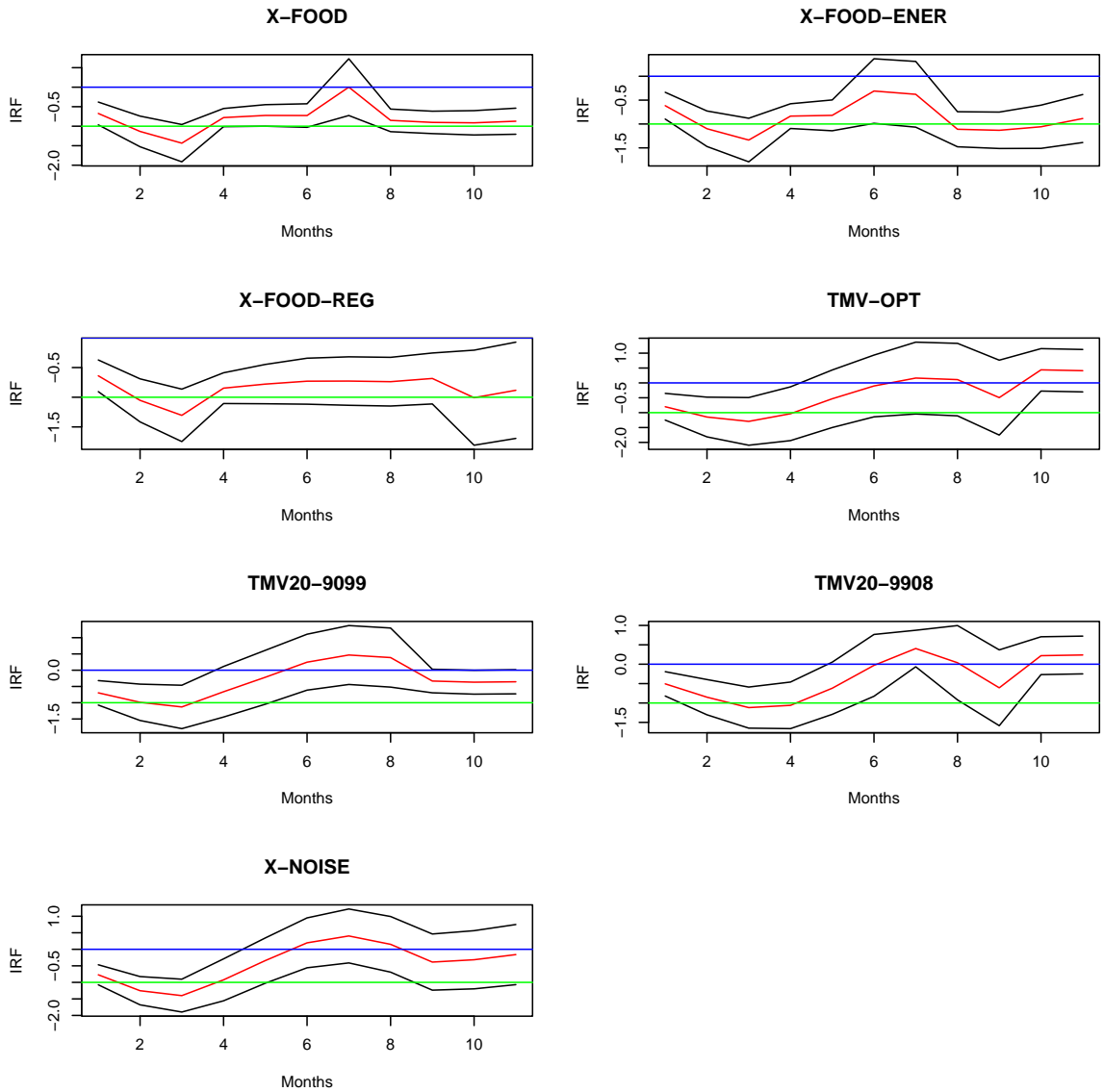
one-year break-even inflation expectations



Graph 28

**Response of inflation expectations to supply shocks**

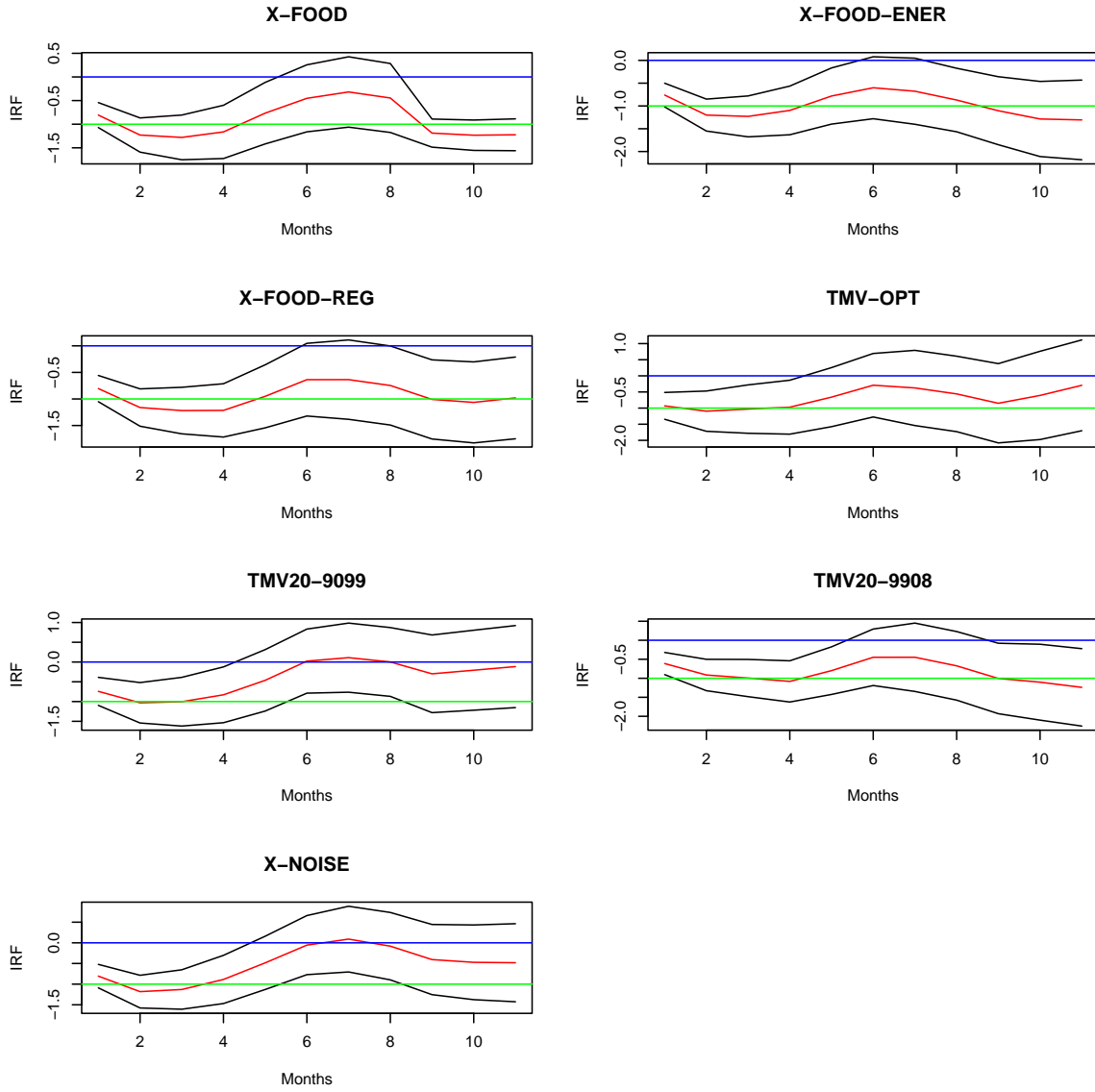
Five-year break-even inflation expectations



Graph 29

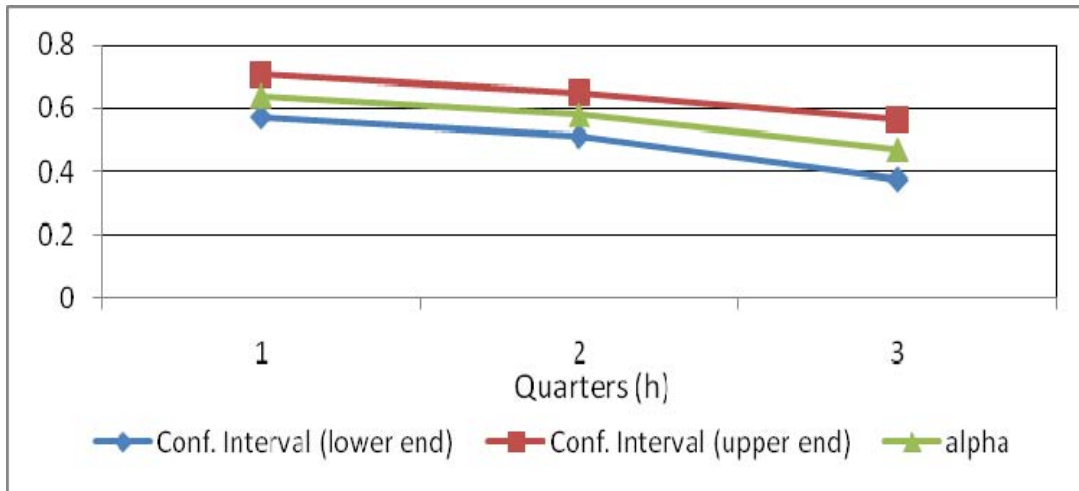
**Response of inflation expectations to supply shocks**

10-year break-even inflation expectations



Graph 30

**Response of the expectations adjustment to an inflation surprise**



Graph 31

**Response of the expectations adjustment to a food price inflation surprise**

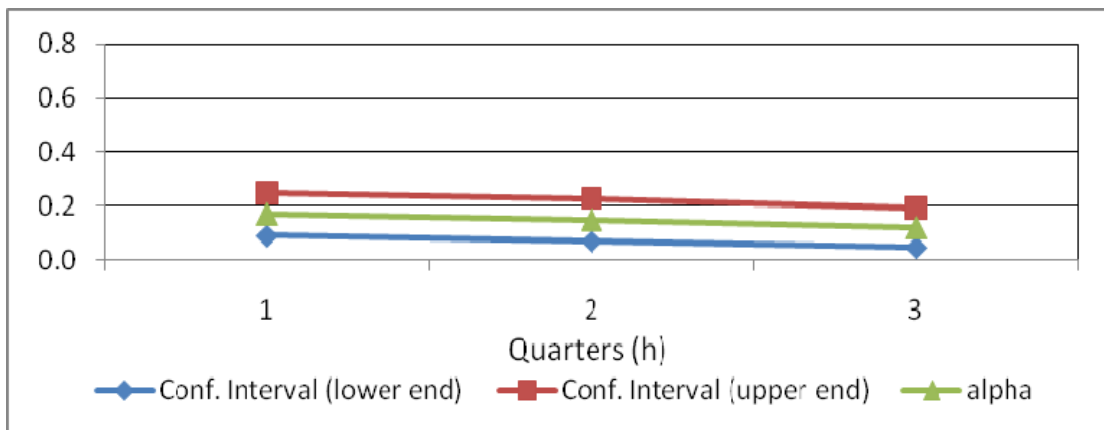


Table 1  
GDP and aggregate demand growth (2000–08)

GDP annual growth by components of the demand

	2001	2002	2003	2004	2005	2006	2007	Mar-08	Jun-08	Sep-08
Final consumption	2.9	3.3	3.5	3.9	5.1	6.0	6.5	3.3	2.8	2.0
Private consumption	2.7	3.2	3.5	3.7	4.7	6.5	6.7	3.4	3.1	2.0
Public consumption	3.7	3.9	3.4	4.6	6.4	4.2	5.9	3.1	1.7	1.9
Gross capital formation	8.5	1.2	14.0	13.7	20.3	19.2	20.6	13.1	8.4	12.0
Fixed gross capital formation	10.4	7.0	14.1	13.7	21.2	17.2	17.5	8.1	7.8	9.4
Agriculture	11.0	91.2	-14.3	-9.7	-4.6	-2.3	2.6	-2.4	0.7	0.4
Equipment and machinery	6.5	-1.9	20.8	18.0	40.7	18.8	22.5	18.9	22.0	9.9
Transport equipment	74.1	8.4	16.0	8.7	22.6	25.5	25.4	3.0	-6.4	-22.9
Construction	4.0	32.8	11.0	33.1	4.4	14.1	1.3	25.5	25.9	27.5
Civil engineering	4.1	-7.3	16.0	0.8	20.7	16.7	23.3	-14.6	-13.8	10.3
Services	25.9	5.5	8.1	7.5	6.5	17.2	9.1	1.9	4.3	2.5
Change in private inventory	-0.8	-30.8	13.4	13.5	12.6	37.0	45.0	48.1	11.7	n.a.
<b>Final domestic demand</b>	<b>3.7</b>	<b>3.0</b>	<b>5.1</b>	<b>5.6</b>	<b>7.9</b>	<b>8.7</b>	<b>9.7</b>	<b>5.7</b>	<b>4.2</b>	<b>4.4</b>
Exports	-0.9	-1.4	3.1	10.3	7.7	7.5	11.9	14.1	11.6	1.4
Imports	8.4	2.1	6.3	14.0	18.2	16.2	19.0	15.4	10.5	7.0
<b>GDP</b>	<b>2.2</b>	<b>2.5</b>	<b>4.6</b>	<b>4.7</b>	<b>5.7</b>	<b>6.8</b>	<b>7.7</b>	<b>4.5</b>	<b>3.7</b>	<b>3.1</b>

Table 2

Shocks to CPI inflation (yoy % changes)

	Dec-06	Mar-07	Jun-07	Sep-07	Dec-07	Mar-08	Jun-08	Sep-08	Dec-08
<b>CPI inflation</b>	<b>4.48</b>	<b>5.78</b>	<b>6.03</b>	<b>5.01</b>	<b>5.69</b>	<b>5.93</b>	<b>7.18</b>	<b>7.57</b>	<b>7.67</b>
Food stuffs	5.68	8.90	9.69	6.96	8.51	8.61	11.98	12.77	13.17
Fruits, vegetables, potato and dairy	2.79	9.45	7.06	1.35	6.66	6.59	22.22	23.72	21.94
Cereals, bakery, oils, and others	9.62	11.04	9.22	6.61	9.12	11.13	15.71	16.54	19.02
Beef	6.27	10.55	21.70	18.09	17.27	13.66	2.84	4.24	4.27
Poultry, fish and eggs	5.27	5.15	5.97	5.55	3.83	8.49	4.78	6.45	9.36
Food away from home and others	5.83	7.74	8.56	8.10	7.65	6.77	7.01	7.07	7.27
Public utilities	3.51	5.80	5.71	2.30	3.77	6.83	9.19	13.89	11.64
Gas	11.82	12.09	7.24	2.52	5.46	6.53	10.84	18.30	4.22
Energy	3.34	4.16	3.63	-0.04	2.14	6.72	10.99	16.28	18.39
Water, sewage and garbage collection	0.24	4.44	6.88	4.30	4.42	7.07	6.87	9.83	9.28
Gasoline	10.42	10.46	9.80	7.05	7.64	10.09	12.05	15.82	11.89
Public transportation	6.62	7.69	7.83	8.33	7.94	7.50	7.26	6.11	7.00
The remainder of the basket									
Tradables	1.71	1.97	1.76	1.19	2.28	2.37	2.18	2.16	2.37
Non-tradables	4.75	4.93	5.12	5.55	5.19	5.09	5.27	5.08	5.25



Table 3

**Bias test for core inflation measures**

	Average	Standard deviation	T- stat	P-value
Total CPI inflation	6.51	2.34		
Core Inflation indicators				
X-food	5.90	3.37	-2.672	0.009
X-food_reg	4.92	2.09	-7.853	0.000
X-"noise"	5.60	1.40	-4.874	0.000
X-food_ener	5.53	2.69	-4.537	0.000
TMV_20_9099	6.43	2.55	-0.372	0.710
Median	5.08	0.87	-8.295	0.000
Trimm_5	6.09	2.18	-2.047	0.043
Trimm_10	5.91	1.88	-3.060	0.003
Trimm_20	5.48	0.94	-5.910	0.000
TMV_opt	6.39	2.19	-0.586	0.559
TMV_5_9908	6.38	2.29	-0.619	0.537
TMV_20_9908	6.02	1.94	-2.458	0.016

Table 4

**Volatility of the core inflation measures****Test for equal variances**

	Deviation from trend	F-stat	P-value
Total CPI inflation	0.313		
Core inflation indicators			
X-food	0.174	3.238	0.000
X-food_reg	0.130	5.750	0.000
X-"noise"	0.164	3.656	0.000
X-food_ener	0.157	3.980	0.000
TMV_20_9099	0.225	1.931	0.000
Median	0.344	0.828	0.834
Trimm_5	0.336	0.867	0.769
Trimm_10	0.295	1.124	0.274
Trimm_20	0.285	1.205	0.168
TMV_opt	0.232	1.815	0.001
TMV_5_9908	0.231	1.832	0.001
TMV_20_9908	0.193	2.617	0.000

Table 5

### Deviation from long-run inflation

Core inflation indicators	RMSE	P-value DM test
X-food	0.717	0.000
X-food_reg	2.711	0.000
TMV_20_9099	0.244	0.000
X-"noise"	1.084	0.000
X-food_ener	1.203	0.025
Median	3.283	0.000
Trimm_5	0.457	0.000
Trimm_10	0.595	0.000
Trimm_20	1.534	0.000
TMV_opt	0.181	0.000
TMV_5_9908	0.207	0.000
TMV_20_9908	0.533	0.000

Diebold & Mariano test:

H0: RMSE of model TMV\_opt = RMSE model in row i

H1: RMSE of model TMV\_opt <> RMSE model in row i

Table 6

### Deviations of core inflation measures from target and the diffusion index

#### Distance from diffusion index

Core inflation indicators	RMSE	P-value DM test
X-food	1.630	0.000
X-food_reg	2.444	0.000
X-"noise"	2.270	0.000
X-food_ener	1.884	0.000
TMV_20_9099	1.873	0.002
Median	2.933	0.000
Trimm_5	1.968	0.014
Trimm_10	2.078	0.004
Trimm_20	2.506	0.000
TMV_opt	1.792	0.038
TMV_5_9908	1.845	0.011
TMV_20_9908	2.021	0.003

Table 7

**In-sample forecast ability of core inflation measures****Forecast ability of core inflation indicators**

In-sample fit: Adj\_R2

Core inflation indicators	Forecast horizon						
	1	3	6	9	12	15	18
X-food	0.046	0.189	0.397	0.346	0.176	0.109	0.353
X-food_reg	0.061	0.249	0.427	0.343	0.353	0.164	0.441
X-"noise"	0.137	0.303	0.417	0.237	0.215	0.216	0.393
X-food_ener	0.080	0.261	0.444	0.343	0.205	0.203	0.426
TMV_20_9099	0.013	0.171	0.426	0.271	0.096	0.121	0.345
Median	0.141	-0.028	0.020	-0.011	-0.016	-0.027	0.031
Trimm_5	0.040	0.010	0.169	0.146	0.002	-0.005	0.167
Trimm_10	0.010	-0.016	0.114	0.013	-0.027	-0.023	0.090
Trimm_20	-0.025	-0.002	0.213	0.035	-0.034	-0.005	0.194
TMV_opt	0.070	0.164	0.312	0.161	0.129	0.106	0.307
TMV_5_9908	0.058	0.140	0.301	0.132	0.116	0.082	0.292
TMV_20_9908	0.087	0.245	0.359	0.325	0.203	0.189	0.370

Table 8

**Out-of-sample forecast ability of core inflation measures****Forecast ability of core inflation indicators**

Out-sample fit: RMSE

Core inflation indicators	Forecast horizon						
	1	3	6	9	12	15	18
X-food	0.34	0.51*	0.53	0.56*	0.37*	0.62*	0.78*
X-food_reg	0.35	0.51*	0.55*	0.56*	0.34*	0.61*	0.75*
X-"noise"	0.32	0.49	0.54*	0.58*	0.33	0.59*	0.74*
X-food_ener	0.34*	0.51*	0.55*	0.57*	0.35	0.62*	0.78*
TMV_20_9099	0.36	0.58*	0.62*	0.57	0.38*	0.62*	0.67*
Median	0.35*	0.68	0.82	0.66	0.38*	0.68	0.85
Trimm_5	0.38	0.66	0.78	0.59	0.38*	0.65*	0.79
Trimm_10	0.37	0.67	0.77	0.65	0.38*	0.66	0.82
Trimm_20	0.38	0.66	0.73	0.63	0.37*	0.65	0.8*
TMV_opt	0.35*	0.58	0.62*	0.59	0.37*	0.62	0.65*
TMV_5_9908	0.35*	0.58	0.62*	0.60	0.37	0.63	0.68*
TMV_20_9908	0.33*	0.51	0.58	0.54	0.34*	0.57	0.63

\*: The null hypothesis of equal RMSE is not rejected at 10% significance. The reference indicator is the one with the smallest RMSE for each forecast horizon (shaded).

Table 9

**Causality tests: industrial production and core inflation measures**

P-values

Core inflation indicators	Forecast horizon						
	1	3	6	9	12	15	18
X-food	0.004	0.012	0.067	0.711	0.187	0.662	0.504
X-food_reg	0.018	0.067	0.295	0.454	0.090	0.007	0.412
X-"noise"	0.012	0.027	0.094	0.892	0.014	0.035	0.919
X-food_ener	0.012	0.009	0.032	0.521	0.243	0.098	0.565
TMV_20_9099	0.012	0.143	0.287	0.859	0.034	0.845	0.518
Median	0.315	0.520	0.896	0.840	0.462	0.918	0.384
Trimm_5	0.042	0.548	0.707	0.711	0.242	0.880	0.040
Trimm_10	0.234	0.554	0.805	0.973	0.659	0.994	0.839
Trimm_20	0.194	0.609	0.936	0.680	0.699	0.501	0.814
TMV_opt	0.019	0.082	0.533	0.935	0.179	0.461	0.929
TMV_5_9908	0.023	0.090	0.489	0.848	0.229	0.509	0.970
TMV_20_9908	0.076	0.022	0.181	0.450	0.918	0.471	0.158

The shaded cells are the cases in which the null hypothesis: industrial production GAP does not cause inflation is rejected at 10% level of significance.

Table 10  
In-sample fit of Phillip curves

Phillips curve fit

Adjusted R2

Core inflation indicators	Forecast horizon						
	1	3	6	9	12	15	18
X-food	<b>0.60</b>	<b>0.85</b>	<b>0.87</b>	0.83	0.13	<b>0.79</b>	0.84
X-food_reg	<b>0.68</b>	<b>0.89</b>	0.90	0.87	0.15	<b>0.88</b>	0.87
X-"noise"	<b>0.61</b>	<b>0.86</b>	<b>0.87</b>	0.84	0.14	<b>0.87</b>	0.86
X-food_ener	<b>0.62</b>	<b>0.86</b>	<b>0.89</b>	0.84	0.19	<b>0.83</b>	0.86
TMV_20_9099	<b>0.53</b>	0.78	0.80	0.76	0.19	0.80	0.82
Median	0.97	0.98	0.98	0.98	<b>-0.04</b>	0.96	0.96
Trimm_5	<b>0.89</b>	0.90	0.92	0.91	-0.09	0.85	<b>0.91</b>
Trimm_10	0.96	0.93	0.95	0.94	-0.06	0.92	0.93
Trimm_20	0.97	0.95	0.96	0.96	-0.18	0.92	0.92
TMV_opt	<b>0.60</b>	0.83	0.85	0.81	0.09	<b>0.79</b>	0.81
TMV_5_9908	<b>0.61</b>	0.83	0.84	0.81	0.06	0.80	0.79
TMV_20_9908	<b>0.55</b>	0.82	0.85	0.79	0.14	0.83	0.88

In yellow, adjusted R2 at least 80%.

In bold, industrial production gap contributes significantly to explain core inflation (according to F-test of significance of all parameters of industrial production gap).

Table 11  
Out-of-sample fit of Phillip curves

Forecast ability – Phillips curve

Out-of-sample fit: RMSE

Core inflation indicators	Forecast horizon						
	1	3	6	9	12	15	18
X-food	0.26*	0.30	0.30	0.21*	0.2*	0.54*	0.45*
X-food_reg	0.25*	<b>0.23</b>	<b>0.22</b>	<b>0.18</b>	<b>0.18</b>	0.33*	<b>0.34</b>
X-"noise"	0.26*	0.28	0.26*	0.23	0.23	<b>0.29</b>	0.36*
X-food_ener	0.25*	0.24*	0.24	0.19	0.19	0.3*	0.36*
TMV_20_9099	0.25*	0.36	0.37	0.33	0.29	0.42*	0.47
Median	0.33	0.33	0.33	0.30	0.27*	0.45	0.60
Trimm_5	0.62	0.56	0.48	0.46	0.45*	0.76	0.95
Trimm_10	0.47	0.34	0.36	0.33	0.31*	0.65	0.81
Trimm_20	0.45	0.38	0.34	0.29	0.29*	1.11	1.15
TMV_opt	0.29*	0.35*	0.36	0.32*	0.32	0.48*	0.47
TMV_5_9908	0.29	0.37	0.37	0.33*	0.32	0.48*	0.52
TMV_20_9908	<b>0.21</b>	0.3*	0.31	0.28	0.29	0.35*	0.35*

\*: The null hypothesis of equal RMSE is not rejected at 10% significance. The reference indicator is the one with the smallest RMSE for each forecast horizon (shaded).

Table 12  
Inflation expectations bias

Survey	Forecasting Horizon	Unbiasedness test		Conclusion
		alpha=0	P-value	
Quarterly	4 quarters	1.013	0.319	Biased
Monthly	12 months	-1.640	0.108	Biased
Break-even inflation 1 year	12 months	-2.706	0.009	Unbiased

Expected inflation-headline inflation = alpha + error

Survey	Forecasting horizon	Unbiasedness test						Conclusion
		alpha=0	P-value	dummy=0	P-value	F-test	P-value	
Quarterly	4 quarters	2.692	0.012	-4.271	0.000	18.244	0.000	Biased
Monthly	12 months	-0.069	0.945	-9.404	0.000	88.440	0.000	Unbiased
Break-even inflation 1 year	12 months	-0.103	0.918	-5.811	0.000	33.767	0.000	Unbiased

Expected inflation-headline inflation = alpha + beta\*dummy + error  
dummy = 1 for t >= Jan/2007; 0 otherwise

Table 13  
Volatility of inflation and inflation expectations

Inflation and inflation expectations	Sample	Standard deviation	F-test	P-value
Quarterly survey	2000:1 - 2008:2	1.642	1.062	0.303
Headline inflation		1.546	-	-
Monthly survey	2003:9 - 2008:6	0.570	0.718	0.397
Headline inflation		0.795	-	-
Break-even inflation 1 year	2003:5 - 2008:6	0.776	0.859	0.354
Break-even inflation 5 years		0.971	1.075	0.300
Break-even inflation 10 years		1.152	1.275	0.259
Headline inflation		0.904	-	-

## Appendix: Criteria for the evaluation of core inflation measures

### A.1 Bias:

A good core inflation measure must not present a bias with respect to headline inflation over a long period of time. The idea is that core inflation should filter only *transitory* movements in headline inflation that are produced by short-lived supply shocks, tax adjustments or large relative price shocks (in the presence of nominal rigidities). Hence, on average core inflation must be close to headline inflation. The absence of a bias is evaluated by means of a standard means difference test:

$$t: \frac{\bar{\pi}_b - \bar{\pi}_{IPC}}{\sigma}$$

$$\sigma^2 = \left( \frac{1}{n_1} + \frac{1}{n_2} \right) \left( \frac{(n_1 - 1)\sigma_b^2 + (n_2 - 1)\sigma_{IPC}^2}{n_1 + n_2 - 2} \right)$$

### A.2 Volatility:

A good core inflation measure must not be highly volatile. It should be less volatile than headline inflation, since it is supposed to filter transitory shocks. Volatility in this context is understood as the variance of inflation around its long-term trend. To evaluate volatility, a hypothesis test for equal variances of core and total inflation is performed. The variance measure is the root mean square deviation of each core inflation indicator with respect to its trend. The trend is obtained using the Hodrick-Prescott filter of the corresponding core inflation indicator:

$$F: \frac{\sigma_b^2}{\sigma_{IPC}^2}$$

### A.3 Ability to forecast future inflation:

Assuming that core inflation is stable, its current level must help forecast future headline inflation, since transitory shocks are filtered.<sup>24</sup> The following model was estimated and recursive forecasts were obtained to check in-sample and out-of-sample fit. Recursive forecasts for the period January 2005–November 2008 were obtained. The in-sample fit measure is the Adjusted – R2. The out of sample fit measure is the RMSE of the recursive forecasts for different horizons of  $h = 1, 3, 6, 9, 12, 15$  and 18 months:

$$\pi_{t+h} - \pi_t = \alpha_0^h + \beta^h (\pi_t - \pi_t^b) + \varepsilon_t^h$$

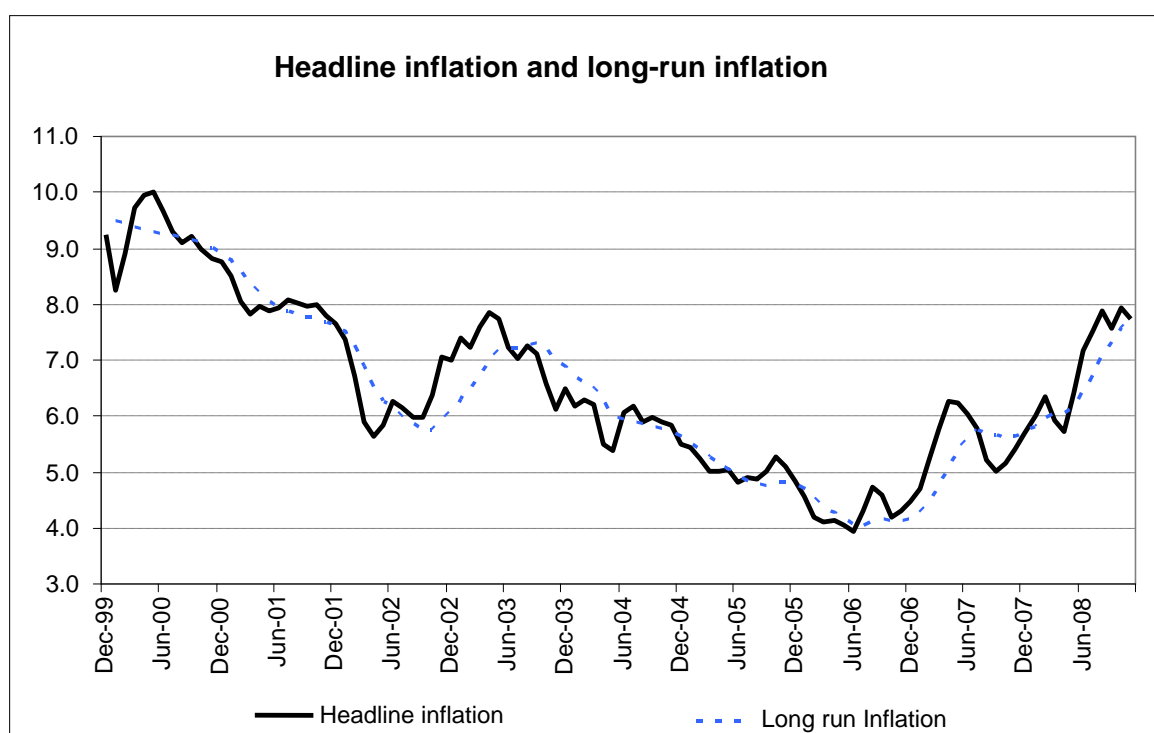
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<sup>24</sup> Note that this does not need to be the case when macroeconomic inflation changes over time.

#### A.4 Ability to track the long-run component of CPI inflation:

One of the most desirable features of a core inflation indicator is its ability to detect turning points of macroeconomic inflation. To check for this characteristic, the deviation of each core inflation indicator with respect to an estimate of long-run inflation was obtained. The indicator with the smallest RMSE is said to be the one that best tracks macroeconomic inflation. The long-run component of CPI inflation was estimated through the following Kalman filter:

$$\begin{aligned}\pi_t &= \pi_t^* + \varepsilon_t; & V(\varepsilon_t) &= \sigma_\varepsilon^2 \gg 0 \\ \pi_t^* &= \alpha_t + \pi_{t-1}^* + \eta_t; & V(\eta_t) &= \sigma_\eta^2 \\ \alpha_t &= \alpha_{t-1} + v_t; & V(v_t) &= \sigma_v^2\end{aligned}$$



Alternatively, the deviations of core inflation measures from the inflation target were compared with a diffusion index that captures the percentage of the CPI basket whose price changes are above the inflation target. The higher the value of the diffusion index, the more widespread inflationary pressures are. In this sense, the deviation of a good core inflation indicator from the target should closely correlate with the diffusion index. This is measured using the corresponding RMSE.

#### A.5 Relationship with macroeconomic determinants of inflation (output gap):

Since core inflation measures supposedly track macroeconomic inflation, they must display a close relationship with the macroeconomic determinants of inflation. In particular, they should be related to lagged values of the output gap and the change in the price of imports. To check for this property, causality tests between output gap and core inflation are performed. To do this, open economy Phillips curves were estimated. The equation includes the industrial production gap, relative prices of imports and lagged information of core inflation. The number of lags to be included in the equation was determined by BIC criteria (12 lags of each variable were considered). In-sample and out-of-sample fit were checked using the

Adjusted – R2 and the RMSE of recursive out-of-sample forecasts for the period January 2006–November 2007. Additionally, we test the hypothesis of all the parameters associated to the IP-GAP be equal to zero:

$$\pi_{b,t+h}^h - \pi_{b,t} = \alpha_0^h + \alpha^h(L)\Delta\pi_{b,t} + \beta^h(L)\tilde{y}_t + \gamma^h(L)\Delta\pi_t^m + \varepsilon_t^h$$



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# Inflation expectations under Czech inflation targeting

Mojmír Hampel<sup>1</sup>

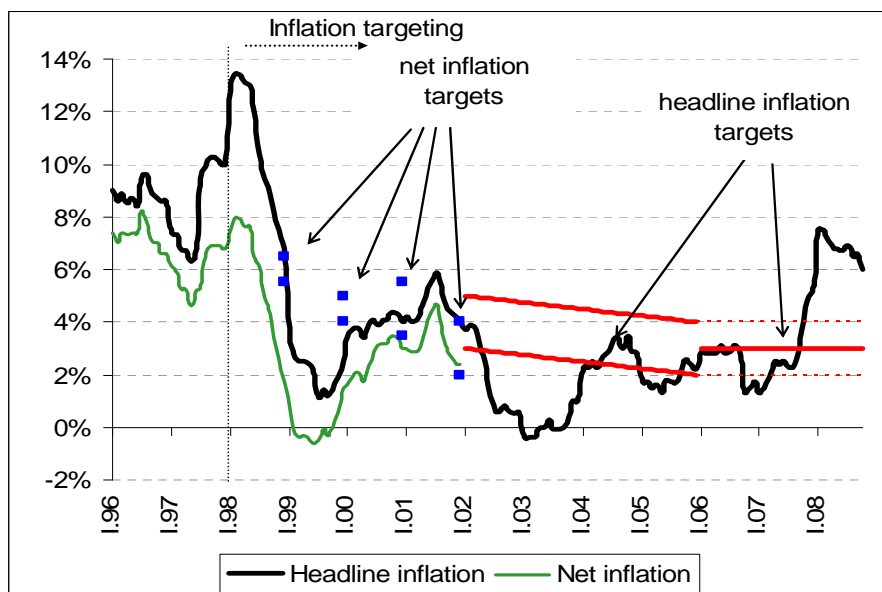
When the inflation targeting framework was introduced in the Czech Republic in late 1997, one of the key ambitions was to anchor inflation expectations (Hrnčíř and Šmídková (1998)). In this brief note I assess to what extent this ambition was actually achieved, building on the available empirical research on this issue that has been done at the Czech National Bank (CNB). I also look in more detail on the high-inflation episode of 2008, which provided a stringent test of the expectation's stability.

## 1. Fulfilment of inflation targets and stability of inflation expectations

During the first 10 years of inflation targeting, ie 1998–2007, there were significant deviations of inflation from the CNB's targets, typically downwards (Šmídková (2008)). The year 2008 was the first in which inflation exceeded the CNB's target significantly (see Figure 1).

Figure 1

### Actual inflation vs CNB's targets



Source: Czech Statistical Office

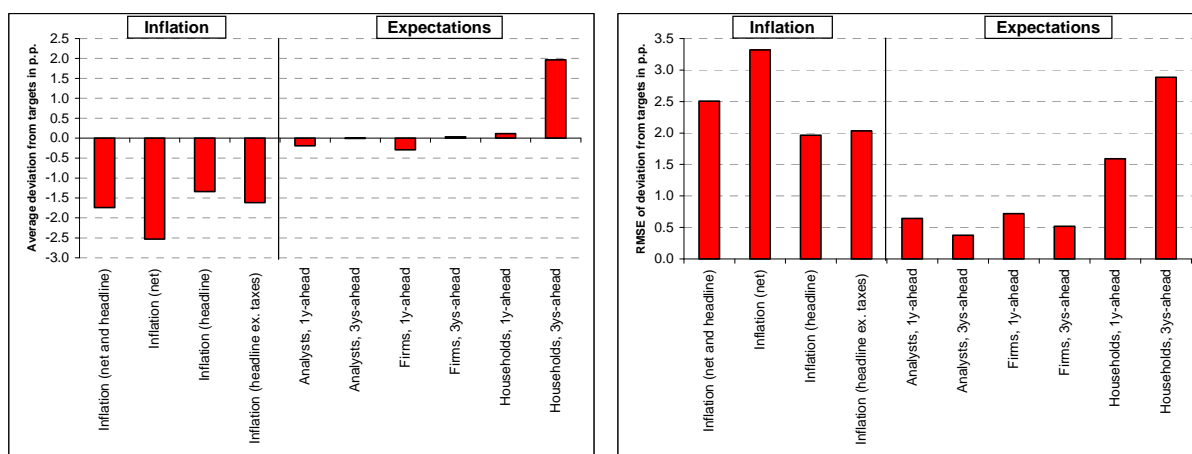
Nevertheless, Holub and Hurník (2008) show that both the one-year-ahead and three-year-ahead inflation expectations, as measured by the CNB's survey of financial market analysts and non-financial corporations, have been anchored to the inflation targets much more closely than actual inflation. This is illustrated in Figure 2 as the average deviation of actual

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inflation and inflation expectations from the inflation target, as well as the root mean square error (RMSE) of these deviations. The only group of economic agents for which the measured inflation expectations are rather volatile and sometimes far from the CNB's target is households, but Holub and Hurník (2008) also claim that an alternative survey of households' inflation expectations, carried out by the European Commission, provides a somewhat more favourable outcome for this group of economic agents.

Figure 2

**Deviations of actual and expected inflation from the targets**



Source: Holub and Hurník (2008)

Holub and Hurník (2008) also estimate a set of VAR models to test formally the formation of inflation expectations under Czech inflation targeting. In particular, they study how the measured inflation expectations respond to some shocks, such as a commodity price shock, food price shock, regulated price shock, and exchange rate shock. They arrive at two general conclusions. First, the magnitude of responses to inflation expectations seems to be relatively low in comparison to the actual inflationary impact of shocks. Second, there are some differences between the ways financial market analysts, firms and households change their expectations when faced with various inflationary shocks.

The inflation expectations of financial market analysts follow the direction of the shock in all cases, but the responses are rather weak. The shock to food prices has the greatest impact on analysts' inflation expectations, but its magnitude is roughly three times lower compared to the response of actual headline inflation. The response of inflation expectations to commodity price shock is evaluated as insignificant, and the same also applies to the impact of administrative price. Exchange rate shock seems to have a heavier impact than commodity or administrative prices shocks, going in the right direction and being statistically significant after one period and marginally significant after two periods.

Firms' inflation expectations are also significantly affected by food price shocks (a little more strongly than in the case of financial markets' expectations), while the impact of exchange rate shock is significant on the margin only. Surprisingly, the impact of commodity prices is insignificant, although one could expect commodity prices to be important for firms' inflation expectations.

Finally, the responses of households' inflation expectations to shocks go in the intuitive direction and their magnitudes are relatively high, which applies especially in case of food and administrative prices, but are evaluated as insignificant. This may be caused by generally higher volatility in households' expectations.

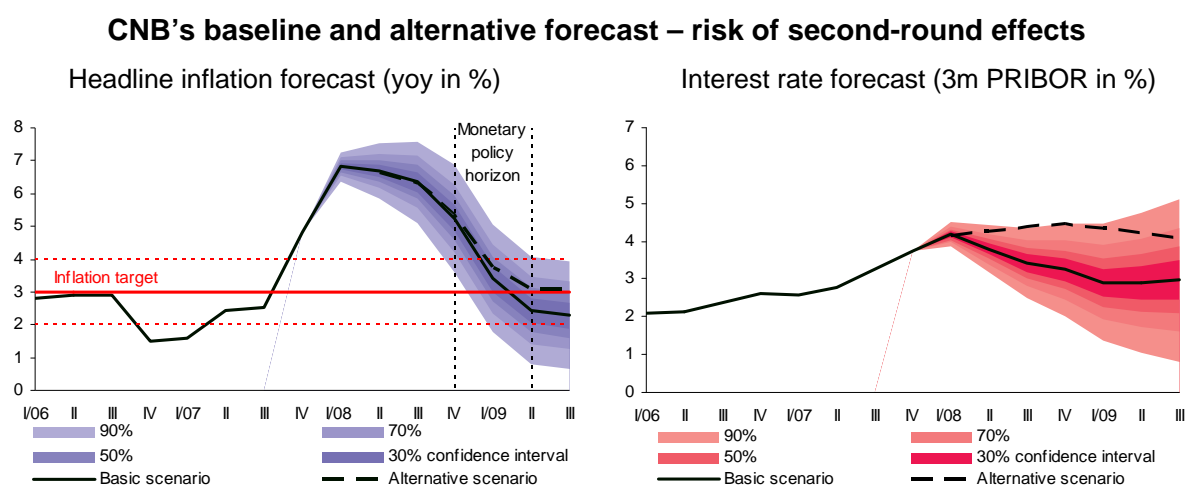
Horváth (2008) also analyses the formation of measured inflation expectations in the Czech Republic econometrically, using VECM and VAR models. He concludes that monetary policy has anchored inflation expectations. In particular, he discovers that the inflation target is a

major determinant of inflation expectations, its importance for inflation expectations surpassing that of the current inflation development. Inflation expectations also decrease significantly in response to stricter monetary policy, implying that the expectations work as an important transmission channel of monetary policy.

## 2. The role of inflation expectations in 2008

Headline inflation increased significantly in the Czech Republic at the beginning of 2008 due to a combination of indirect tax changes, regulated price increases and rising international food and energy prices. The CNB's baseline forecast in early 2008 assumed that inflation expectations should remain relatively well anchored in the presence of these specific price shocks, in line with past experience and the empirical evidence mentioned above. Therefore, the forecast suggested that inflation should drop back to the target in early 2009, as the price shocks fade away and their second-round effects remain muted. The forecast also predicted that after an initial interest rate hike in early 2008, which should help to keep inflation expectations under control, the interest rates could actually start to decline gradually in the second half of the year (see Figure 3).

Figure 3



Source: CNB, Inflation report I/2008

Nonetheless, the CNB perceived a risk of higher second-round effects, because the economy was just beyond the top of the business cycle with tight labour market conditions, and the price shocks concerned a broad range of goods, unlike in the past. Therefore, an alternative scenario was also produced, which led to higher inflation on the monetary policy horizon, and implied a substantially higher interest rate path than in the baseline projection.

With the benefit of hindsight, inflation is now likely to drop even lower than the forecast made at the beginning of this year, and an interest rate easing phase of the monetary policy cycle began already in August 2008. This is, of course, largely attributable to developments in the international economy, which has led to a pronounced slowdown in economic growth, loosening of labour market conditions, fading away of the food and energy price shock, and an appreciation of the Czech koruna. Nevertheless, the anchored inflation expectations probably contributed to this outcome, too.

While inflation expectations have been anchored in broad terms, it should be noted that they have yet not fully reflected the last change in the inflation target. The level of inflation target will fall from the current 3% to 2% as of January 2010. The CNB announced this step in March 2007, but the three-years-ahead inflation expectations have continued to hover at or

slightly above the level of 2.5%, where they had already been for some two years prior to the announcement. While the discrepancy is not great, it remains the same in spite of the fact that the fall in the inflation target is now only one year ahead. In recent months, inflation expectations for the one-year horizon have fallen to 2.5% as well.

### 3. Conclusions

In spite of the substantial shocks to actual inflation developments and relatively frequent missing of the CNB's inflation targets, the available empirical evidence suggests that inflation expectations have been well anchored by the Czech Republic's inflation targeting framework. Stable inflation expectations make the life of the central bank easier, of course. The experience of the high-inflation episode in 2008, through which the CNB was able to go with relatively low nominal interest rates, is an example of this. Turning to the future, it remains to be seen whether inflation expectations will start fully to reflect the most recent reduction of the inflation target.

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# Measures of trend inflation in Hong Kong

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## I. Introduction

The search for an appropriate measure of inflation has been an important task for central banks around the world, particularly those with an inflation targeting framework. Given that the principal monetary policy objective of the Hong Kong Monetary Authority (HKMA) is to maintain exchange rate stability under the Linked Exchange Rate system, there is little room for conducting discretionary monetary policy in Hong Kong. Nevertheless, any significant changes in the trend movement in general prices have significant policy implications for Hong Kong, which should be closely monitored by policymakers. In particular, the trend price indicator provides useful information about the extent of macroeconomic and financial imbalances, which are important for guiding prudential supervisory policies.

Various measures have been used to gauge underlying inflationary pressures based on information extracted from different price indicators, of which the consumer price index (CPI) and the deflator of personal consumption expenditure (PCE) are the most commonly used. In general, there are two steps in constructing a measure of trend inflation. The first is to select a price index that is a good indicator of the general cost of living and is representative of price movement and demand pressure at the aggregate level. The next step is to strip out volatile price components, which are susceptible to transitory shocks that may distort the trend movement of general prices. Broadly speaking, there are two approaches to extracting the trend movements from price indices compiled by official bodies: the exclusion method and the statistical method. The exclusion method removes the price components that are mostly influenced by transitory supply shocks. The most commonly excluded items include fresh or unprocessed food, and energy. By contrast, the statistical method analyses the data property of the price index or its components to determine an optimal measure of trend movements of the price index. Various techniques, such as principal component, exponential smoothing and the Kalman filter have been adopted to arrive at a statistical measure of trend movements of prices.

This paper discusses various measures of trend inflation in Hong Kong. Section II searches for a representative price index that can be used to derive the trend rate of inflation. Section III compares and discusses the properties of trend inflation obtained from the exclusion and statistical methods. Section IV evaluates the performance of different measures of trend inflation. Section V concludes.

## II. Comparison of different price indicators

There are a variety of price indices for measuring price movements. In terms of coverage, the GDP deflator may be the single most comprehensive price indicator. It is a price deflator of major expenditure components of GDP, and consists of the price deflator of domestic demand and terms of trade for goods and services. Chart 1 shows that the year-on-year growth rate of the GDP and domestic demand deflators have strongly converged over recent

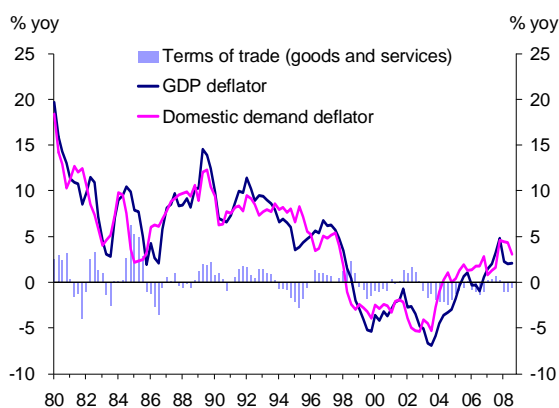
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<sup>1</sup> Hong Kong Monetary Authority

years, as domestic demand accounted for over 90% of GDP. Nevertheless, a significant shift in terms of trade could lead to large deviations in the growth rates of the two. For example, when the growth rate of the domestic demand deflator turned positive in the second half of 2004, the GDP deflator continued to register negative growth due to deterioration in terms of trade.

Chart 1

**GDP deflator, domestic demand deflator and terms of trade**



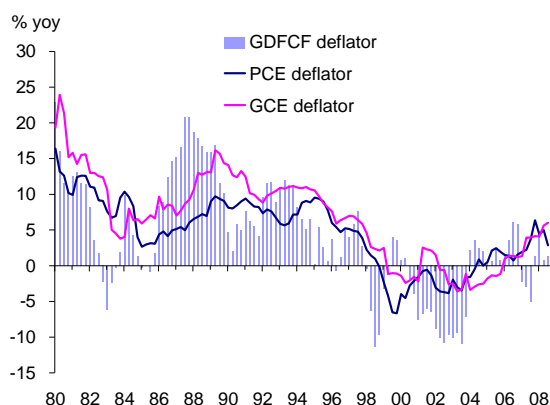
Sources: C&SD and staff estimates.

Since a large component of Hong Kong's trading activities is re-exports, the price movements of which have little implication for prices of retained imports or domestic price movements, fluctuations in terms of trade may compromise the use of GDP deflator as an indicator of trend movements of general price level. To remove the effect of terms of trade on the GDP deflator, we might use the price deflator of domestic demand as a measure of domestic inflation. In general, the domestic demand deflator can be disaggregated into three main components: personal consumption expenditure (PCE) deflator, gross domestic fixed capital formation (GDFCF) deflator, and the government consumption expenditure (GCE) deflator. Chart 2 shows the year-on-year growth rates of the three deflators. The price deflator of GDFCF has been the most volatile component of the three, as it captures movements in prices of machinery and equipment, construction costs, and volatile valuation gains or losses in changes of property ownership. It measures price pressures on capital inputs used in the early or intermediate stages of production. Meanwhile, the GCE price deflator measures prices of goods and services consumed by the government instead of the private sector. Consequently, these deflators are not directly related to price pressures at the end of the supply chain, which affect the general standard of living. The PCE deflator, which captures the price movement of goods and services consumed by households, is directly related to the general cost of living. It also serves as a good measure of overall domestic price pressures, given that private consumption accounts for two thirds of domestic demand (Chart 3). Overall, the PCE deflator is the price measure that has the desirable property of reflecting both the general cost of living and domestic demand pressures.



Chart 2

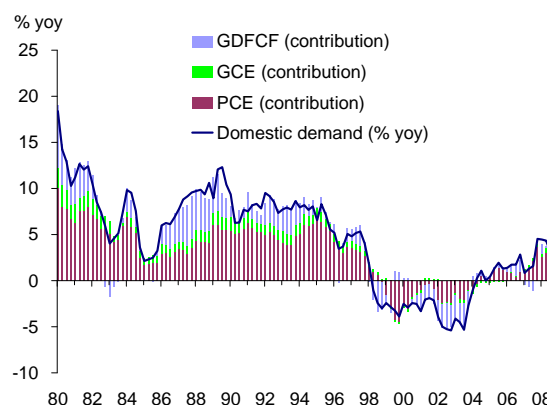
**The price deflators of PCE, GDFCF and GCE**



Sources: C&SD and staff estimates.

Chart 3

**Contribution to changes in domestic demand deflator by component**

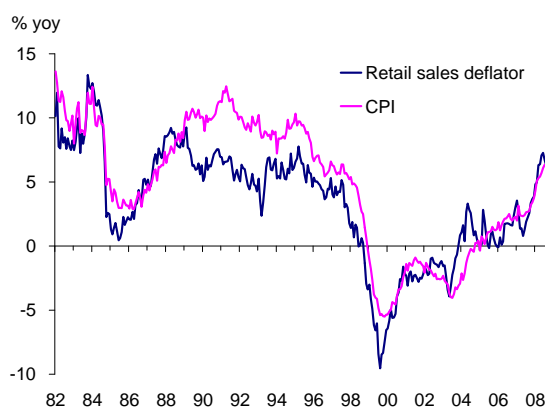


Sources: C&SD and staff estimates.

Other widely used indicators of domestic inflation that can reflect both the general cost of living and domestic demand pressures are the consumer price index (CPI) and the retail price index. CPI measures the price of a basket of goods and services consumed by a representative household, while the retail price index measures prices of goods sold at retail outlets. In Hong Kong, the retail price index is derived from the ratio of value and volume indices of retail sales, which is a price deflator of retail sales. Chart 4 shows that the CPI and the retail sales deflator have generally shown strong co-movement in the past.

Chart 4

**Consumer price index and retail sales deflator**



Sources: C&SD and staff estimates.

Despite the similarity of and close co-movement between the CPI and the retail sales deflator, they differ in terms of coverage and method of compilation. In terms of coverage, the retail sales deflator includes only tradable goods and excludes housing and other personal services, making it a narrower measure of the cost of living. In terms of compilation method, the CPI is constructed based on a basket of consumer goods and services with fixed weights, while the basket weights in the retail sales deflator vary over time. As a result, the CPI may overstate the growth rate of general consumer prices, while the retail sales deflator may understate it due to substitution effect. Judging from these differences, the CPI appears to be a better measure of consumer price inflation than the retail sales deflator.

The above discussion suggests that both the CPI and the PCE deflator could be representative measures of domestic price pressures, given their extensive coverage of price data on consumer goods and services. While both indices contain similar baskets of goods and services consumed by households, they differ in two major aspects. First, the weightings of goods and services are distributed differently in the CPI and the PCE deflator. Table 1 shows that tradable goods and housing have similar weights of 29% in the consumption basket of the CPI, while services account for 42%. The composition is quite different in the PCE deflator, with goods and services constituting 33% and 51%, respectively, of the consumption basket, while the weight of housing is the smallest, at about 16%. In other words, changes in housing rents will have greater impact on CPI inflation than PCE inflation. Apart from the difference in the composition of consumption weights, the PCE deflator includes financial services charges in its consumption basket, while the CPI excludes them. This subtle difference can be seen from a more volatile inflation rate calculated from the PCE deflator in recent quarters, when the domestic stock market and financial sector activities were exceptionally volatile (Chart 5). Despite these differences, the inflation rates calculated by the CPI and the PCE deflator have tended to converge, and have tracked closely the movements in the output gap, which is an indicator of demand pressures on the expenditure side of the economy.

Table 1

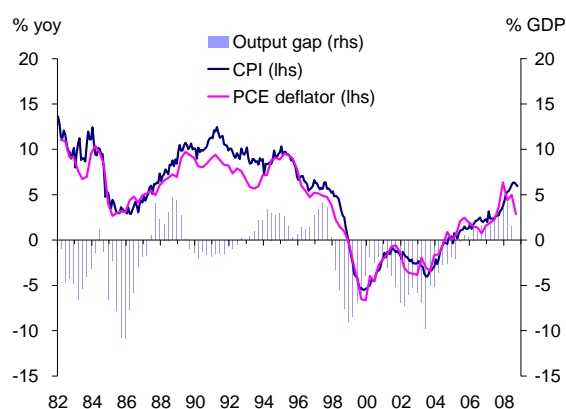
**Composition of the consumption basket in the CPI and PCE deflator**

(% weight)	Composite CPI	Chain-dollar PCE deflator
Tradable goods	29	33
Housing	29	16
Services ex-housing	42	51

Sources: C&SD and staff estimates.

Chart 5

**Output gap and inflation rates calculated by the CPI and PCE deflator**



Sources: C&SD and staff estimates.

### III. Estimation of trend inflation in Hong Kong

Due to their desirable properties, the CPI and the PCE deflator are selected as inflation indicators for constructing measures of trend inflation in the first step. The next step is to extract the trend movement from the headline inflation rate calculated from the CPI and PCE deflator by stripping out transitory components. In general, there are two methods for estimating the trend rate of inflation based on the headline figures, namely the exclusion and statistical methods.

#### A. Exclusion method

The exclusion method is widely used to extract information on the trend movement of the inflation rate calculated from the headline price index. The idea is to strip out those components that are most influenced by short-term price shocks. Commonly excluded items are basic or unprocessed food, and energy, the prices of which are volatile due to supply

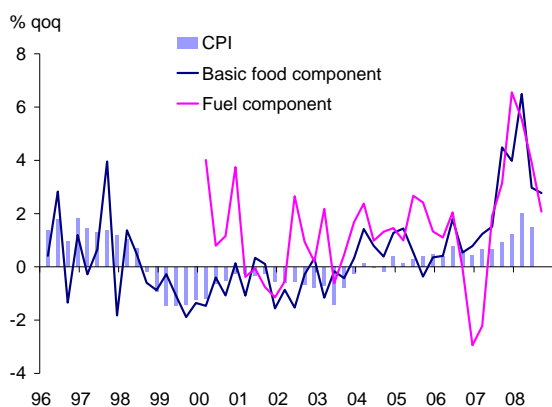
shocks. The inflation rate calculated based on this exclusion method is usually called the “core” measure of inflation, meaning that it captures the most representative movement of general prices and is free from distortions caused by short-term fluctuations in prices.

In practice, it may not be straightforward to decide which components should be excluded from the price index. While basic food and energy-related items are the most commonly excluded items in the construction of the core measure of inflation, a variety of exclusion criteria are used in different jurisdictions. For example, the preferred measure of core inflation in Japan is calculated by the CPI excluding fresh food. For developing Asian economies where fresh and unprocessed food accounts for a significant share of the consumption basket of households, excluding this item from the CPI may not be a good way to measure core inflation.

In Hong Kong, basic food and energy-related items such as electricity and motor fuel are excluded from the composite CPI in the estimation of the core CPI inflation rate. These two items account for roughly 15% of the CPI basket in Hong Kong, as compared to 21% in the CPI basket of the United States. The rationales for excluding these two components are twofold. First, basic food prices and energy costs have been the most volatile components in Hong Kong’s CPI (Chart 6). Second, their prices are sensitive to changes in demand and supply conditions in the international market, which could be transitory and have limited lasting effect on overall costs and prices in the domestic market. Chart 7 compares the quarter-on-quarter rate of change of the headline and core CPIs. It shows that the core inflation rate tracks the headline inflation rate closely.

Chart 6

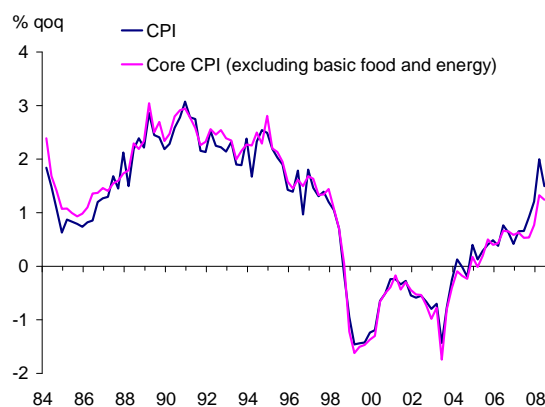
**CPI inflation and the basic food and energy components**



Sources: C&SD and staff estimates.

Chart 7

**Headline vs core CPI inflation**

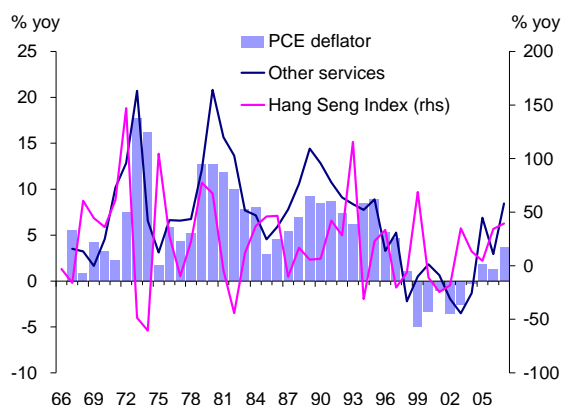


Sources: C&SD and staff estimates.

Based on the same rationale for the construction of the core measure of the CPI, basic food and energy-related items are excluded in the estimation of the core PCE deflator. Moreover, the PCE deflator includes the fees and charges of financial services in its consumption basket, which are pro-cyclical and highly volatile, so this component is also removed in the construction of the core measure of PCE deflator. Past developments show that the other services component (including financial services) of the PCE deflator is positively correlated with stock market performance, which has limited correlation with the general price movement (Chart 8). Thus, excluding financial service charges does not distort the underlying inflation of the PCE deflator. Chart 9 compares the quarter-on-quarter inflation rate of the headline and core PCE deflator. Similarly to core CPI inflation, core PCE inflation tracked the headline PCE inflation closely.

Chart 8

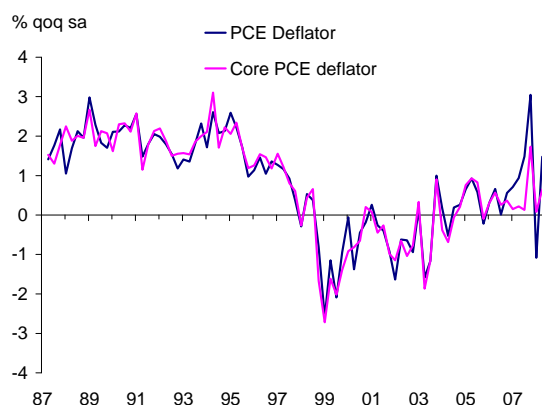
### Other services component of the PCE deflator and stock price movement



Sources: C&SD and staff estimates.

Chart 9

### Headline vs core PCE inflation



Sources: C&SD and staff estimates.

## B. Statistical method

The exclusion method requires judgement on the price component to be excluded in the calculation of core inflation. Furthermore, to keep the core measure credible and consistent, it is preferable not to change the excluded items. These raise concerns about the objectivity and flexibility of the method in removing a variety of price shocks. One possible way of addressing these concerns is to use the statistical method, which estimates an optimal measure of trend inflation based on data properties of the price index.

A number of statistical methods have been explored to produce a trend measure of inflation. These include classical statistical methods such as the trimmed median or trimmed mean approach to identify and eliminate volatile items from the price index. Other statistical methods such as exponential smoothing make use of time-series properties of the price index to estimate the trend inflation from the headline figure. Alternatively, some data reduction methods such as principal component could be used to extract the common trend of movements in various price components embedded in the price index. To extract the most representative trend movement of the CPI and the PCE deflator, we use the principal component method to decompose the movements of headline inflation into a number of distinct trends, which are uncorrelated with each other. The trend that explains the largest part of the movements in various price components of the price index is used as our measure of trend inflation.<sup>2</sup> This estimate of trend inflation is then subject to various statistical tests to ascertain its data property.

Table 2 shows the weights of the price components of CPI and PCE deflator estimated by the principal component method. In comparison with the official basket weights, the weights estimated by the principal component method show that housing rents and the cost of eating out are the major items in the trend CPI inflation, while the weights of basic food, electricity and beverages are the smallest. This suggests that basic food and energy-related items explain little of the trend movement of CPI inflation estimated by the principal component method, which supports removing these items in the exclusion method. Similar results can

<sup>2</sup> The technical note in Annex A explains the details on the estimation of trend inflation using the method of principal component.

be found in the weights of key items of the PCE deflator estimated by the principal component method.

Table 2

**Weights estimated by the principal component method  
for the CPI and PCE deflator**

	Official weight in CPI basket (%)	Weight based on the principal component method (%)
Alcoholic drinks and tobacco	0.87	2.18
Clothing and footwear	3.91	4.43
Durable goods	5.50	6.91
Electricity, gas and water	3.59	2.39
Basic food	10.08	3.26
Housing	29.17	36.72
Meals away from home	16.86	20.65
Miscellaneous goods	4.78	3.56
Miscellaneous services	16.15	10.74
Transport	9.09	9.15
Sum	100.00	100.00

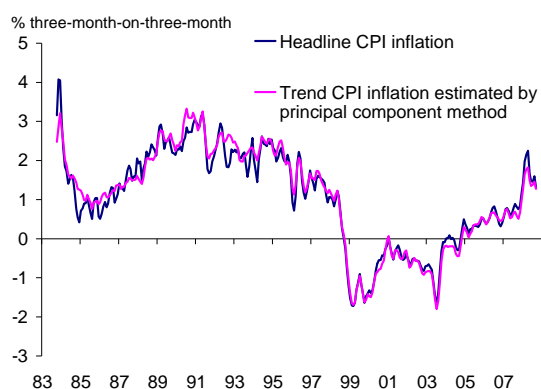
	Official weight in PCE deflator (%)	Weight based on the principal component method (%)
Alcoholic beverages	0.48	0.69
Clothing, footwear and other personal effects	12.00	9.73
Education	1.97	6.65
Food and non-alcoholic beverages	11.15	7.25
Fuel and light	1.70	0.84
Furniture, furnishing and household equipment	7.75	6.17
Household operation	1.88	11.15
Rent, rates, water and housing maintenance charges	15.70	11.97
Medical care and health expense	4.22	12.33
Other services	25.46	5.17
Personal care	2.31	8.15
Recreation and entertainment	6.34	6.81
Tobacco	0.46	2.14
Transport and communication	8.58	10.95
	100.00	100.00

Source: Staff estimates

The main advantage of the principal component method is that it helps identify the relative importance of different price components in driving the trend movement of the CPI/PCE deflator, based on the weights estimated by the principal component method. This is superior to other statistical methods such as the trimmed mean/median and exponential smoothing approaches in terms of transparency, information usage and analytical contents. Charts 10 and 11 compare trend inflation estimated by the principal component method and the headline CPI and PCE inflation respectively.

Chart 10

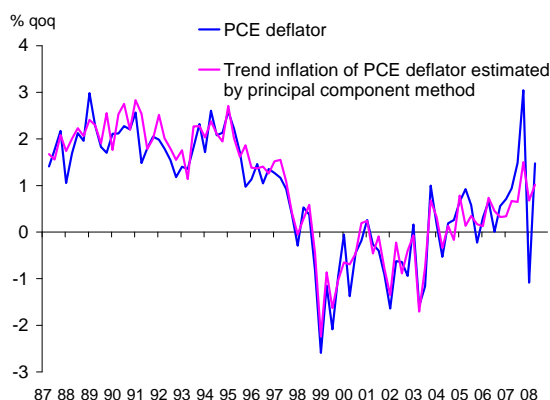
### Headline vs trend CPI inflation estimated by the principal component method



Sources: C&amp;SD and staff estimates.

Chart 11

### Headline vs trend PCE inflation estimated by the principal component method



Sources: C&amp;SD and staff estimates.

## IV. Evaluation of different measures of trend inflation

To compare and evaluate trend inflation estimated by the exclusion and principal component methods for the CPI and PCE deflator, the following criteria are used to identify the strength and weakness of the two estimation methods:

- Transparency, consistency and simplicity of construction
- Information content on underlying inflationary pressures
- Co-integrating relationship between headline and trend inflation
- Forecast performance

### Transparency, consistency and simplicity of construction

The exclusion method is more transparent and straightforward than the principal component method in the construction of the trend inflation rate. Given that the weights of individual price components are fixed in the CPI basket, one can easily calculate the core inflation rate by removing the effects of changes in basic food prices and fuel costs. It is also straightforward to construct the core PCE deflator by excluding the items of basic food, fuel and financial service charges from the value and volume measures of the PCE, which are published along with other national account statistics by official sources.

In terms of computational effort, it would be more demanding to estimate core inflation using the principal component method, which makes use of data on individual price items of the CPI and PCE deflator to estimate a set of weights that can help explain the largest part of variations of the headline figures. That said, with enhancement in computing resources, it is becoming less time-consuming to carry out principal component analysis. Our results also show that the weights estimated from the principal component method are remarkably stable over time when the sample size increases.

Data consistency is another consideration in the evaluation of the property of trend inflation estimated by the exclusion and principal component methods. With transitory shocks tapering off over time, the headline inflation rate tends to revert to its underlying trend. This suggests the long-term average of the trend measure should be close to that of the headline

measure of inflation, while the volatility of the former is expected to be smaller than the latter. Table 3 compares the mean and the standard deviation of the first difference, a measure of volatility, of trend CPI and PCE inflation using the exclusion and principal component methods. It shows that trend inflation estimated by the principal component method performs better than the exclusion method in terms of reduction of volatility. In terms of similarity of mean, the principal component method performs better for the composite CPI, and the exclusion method performs better for the PCE deflator.

Table 3  
**Mean and standard deviation of headline and trend inflation**

	<b>Composite CPI (% 3m/3m)</b>	<b>PCE deflator (% qoq)</b>
<b>Mean</b>	<b>1983Q4 - 2008Q3</b>	<b>1987Q2 - 2008Q2</b>
Headline inflation	1.054	0.824
Core inflation (exclusion method)	1.083	0.772
Trend inflation (principal component method)	1.074	0.917
<b>Standard deviation of the first difference of inflation rate</b>		
Headline inflation	0.240	0.884
Core inflation (exclusion method)	0.202	0.718
Trend inflation (principal component method)	0.169	0.606

Sources: C&SD and staff estimates.

### **Information content on underlying inflationary pressures**

Both the exclusion and principal component methods make use of price data on individual items of the CPI and PCE deflator in the estimation of the trend inflation rate. By calculating the contribution of individual price items to changes in the trend measure of inflation, the key price factor driving the underlying inflation can be identified, which is an important piece of information for policy formulation. The merit of using the principal component method to estimate the trend inflation is that it retains all price items of the CPI and PCE deflator, while basic food, fuel and other volatile items are removed in the exclusion method. Since these excluded items may contain useful hints about the movements of underlying inflation, the trend information estimated by the exclusion method is less comprehensive than that estimated by the principal component method.

### **Co-integrating relationship between headline and trend inflation**

One salient data property of trend inflation is that the headline inflation rate should converge with the trend inflation rate in the long run. This suggests that only noisy signals and temporary shocks should be stripped out from headline inflation in the estimation of the trend inflation rate. Testing the property of convergence is equivalent to testing the existence of a co-integration relationship between headline and trend inflation.

Empirical tests on co-integration are conducted on sequential movements of CPI/PCE deflator and their trend measures. CPI and PCE deflator data used in our empirical analysis are different in terms of data frequency and sample size. For the CPI, the sample consists of monthly data from October 1983 to September 2008, and the three-month-on-three-month percentage change is calculated to capture the sequential movements of CPI inflation and its trend measure.<sup>3</sup> For the PCE deflator, the sample consists of quarterly data from 1987Q1 to 2008Q2, and the quarter-on-quarter percentage change is calculated to measure inflation. All inflation rates are seasonally adjusted.

The test for co-integration involves two steps. The first is to test whether the headline and trend measures of CPI and PCE inflation are stationary. Augmented Dickey-Fuller tests and Zivot and Andrews unit root tests suggest that unit roots are present in the measures of inflation, including both headline and trend CPI and PCE inflation. This means that the inflation series are non-stationary.<sup>4</sup> The next step is to test the existence of a co-integration relationship between the headline and trend inflation. The following error-correction models are constructed to examine the co-integrating relationship between headline inflation ( $\pi_t$ ) and trend inflation measures ( $\pi_t^{Trend}$ ) of the CPI and PCE deflator.

$$\Delta\pi_t = \beta_1(\pi_{t-1} - \pi_{t-1}^{Trend}) + \text{lag terms for first difference of headline inflation} + \varepsilon_{1t}$$

$$\Delta\pi_t^{Trend} = \beta_2(\pi_{t-1} - \pi_{t-1}^{Trend}) + \text{lag terms for first difference of trend inflation} + \varepsilon_{2t}$$

Following the idea of Marques et al (2003), trend inflation should satisfy the following criteria:

1. The trend and headline inflation rates should evolve along the same path in the long run. Technically speaking, both trend inflation and headline inflation follow an I(1) process and are co-integrated with a unitary coefficient.
2. The headline inflation rate tends to converge with the trend inflation rate. This means that the adjustment coefficient of the error-correction term should be negative and statistically significant in the equation, with the first difference of headline inflation as the dependent variable.
3. The trend inflation rate should not converge with the headline inflation rate, suggesting that the trend measure is exogenous. This means the adjustment coefficient of the error-correction term should be statistically insignificant in the equation, with the first difference of trend inflation as the dependent variable.

Tables 4 and 5 summarise the results of the test of co-integration for headline and trend CPI and PCE inflation respectively. The adjustment coefficients on the error-correction terms in the equation of headline CPI/PCE inflation are negative and statistically significant, while those in the equation of core CPI/PCE inflation are statistically insignificant. These imply that the headline inflation rate tends to converge with the trend rate of inflation when the former deviates from the latter. Meanwhile, changes in trend CPI or PCE inflation do not depend on changes in headline inflation in the past, suggesting that trend inflation is exogenous. Overall, both measures of trend inflation satisfy convergence criteria 2 and 3 discussed above.

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<sup>3</sup> The one-off effects of relief measures introduced by the government are removed from the CPI.

<sup>4</sup> The results of unit root tests are summarised in Annex B.



Table 4  
**Error correction model for testing co-integrating relationship  
between headline and trend CPI inflation**

	Core CPI inflation (excluding food and energy)		Trend CPI inflation estimated by the principal component method	
	Equation of headline inflation	Equation of core inflation	Equation of headline inflation	Equation of trend inflation
Dependent variable	$\Delta\pi_t$	$\Delta\pi_t^{Trend}$	$\Delta\pi_t$	$\Delta\pi_t^{Trend}$
Coefficient of $\pi_{t-1} - \pi_{t-1}^{Trend}$ (Adjustment coefficient)	-0.224 (-3.117)**	0.083 (1.679)	-0.324 (-4.549)**	-0.032 (-0.887)
Coefficient of $\Delta\pi_{t-1}$	0.514 (6.721)**	– –	0.526 (7.561)**	– –
Coefficient of $\Delta\pi_{t-1}^{Trend}$	– –	0.540 (11.968)**	– –	0.554 (11.590)**
Adjusted R-square ( $\overline{R^2}$ )	0.239	0.313	0.279	0.300

The t-statistics are in parentheses.

\*\* indicates that the coefficient is statistically significant at the 5% level.

Source: Staff estimates.

Table 5  
**Error correction model for testing co-integrating  
relationship between the headline and trend PCE inflation**

	Core PCE deflator (excluding basic food, energy and financial services)		Trend PCE deflator estimated by the principal component method	
	Equation of headline inflation	Equation of core inflation	Equation of headline inflation	Equation of trend inflation
Dependent variable	$\Delta\pi_t$	$\Delta\pi_t^{Trend}$	$\Delta\pi_t$	$\Delta\pi_t^{Trend}$
Coefficient of $\pi_{t-1} - \pi_{t-1}^{Trend}$ (Adjustment coefficient)	-0.820 (-2.492)**	0.162 (0.819)	-0.946 (-3.265)**	0.137 (0.794)
Coefficient of $\Delta\pi_{t-3}$	0.202 (1.833)	– –	0.183 (2.232)**	– –
Coefficient of $\Delta\pi_{t-3}^{Trend}$	– –	0.262 (2.030)**	– –	0.227 (2.212)**
Adjusted R-square ( $\overline{R^2}$ )	0.169	0.055	0.254	0.049

The t-statistics are in parentheses.

\*\* indicates that the coefficient is statistically significant at the 5% level.

Source: Staff estimates.

## Forecast performance

In addition to the data properties discussed in the previous section, a good measure of trend inflation should have the ability to forecast the near-term movement of consumer prices, which can be used to gauge inflation expectations. To compare the forecast performance of the trend inflation estimated by the exclusion and principal component methods for the CPI and PCE deflator, both within-sample and out-of-sample forecast tests are conducted.

### *Within-sample forecast ability of trend inflation*

Following the method proposed by Clark (2001), Fan (2001), Cogley (2002) and Rich and Steindel (2005), the following regression is used to evaluate the within-sample forecast ability of the trend CPI and PCE inflation.

$$\pi_{t+h} - \pi_t = \alpha + \beta(\pi_t - \pi_t^{Trend}) + \varepsilon_{t+h} \quad (1)$$

Equation (1) suggests that the trend inflation ( $\pi_t^{Trend}$ ) is useful for forecasting the headline inflation ( $\pi_t$ ), given that its deviation of the headline inflation from the trend inflation will correct over the  $h$  period. This suggests that  $\beta$  is negative. The speed of correction depends on the size of  $\beta$ . The greater the absolute value of  $\beta$ , the faster the headline inflation reverts to its underlying trend over the  $h$  period.

Table 6

### Estimation results of within-sample forecast ability (without the output gap as an independent variable)

	CPI		PCE deflator	
	Core CPI inflation (exclusion method)	Trend CPI inflation (principal component method)	Core PCE inflation (exclusion method)	Trend PCE inflation (principal component method)
	$h = 3$		$h = 1$	
$\beta$	-0.550 (-2.081)**	-0.714 (-3.591)**	-0.854 (-2.722)**	-1.023 (-3.597)**
$\overline{R^2}$	0.051	0.109	0.145	0.242
	$h = 6$		$h = 2$	
$\beta$	-0.430 (-1.310)	-0.586 (-1.747)*	-0.497 (-1.870)*	-0.825 (-4.438)**
$\overline{R^2}$	0.021	0.047	0.033	0.118
	$h = 12$		$h = 4$	
$\beta$	-0.257 (-0.624)	-0.429 (-0.804)	-0.453 (-1.436)	-0.786 (-3.567)**
$\overline{R^2}$	0.001	0.012	0.011	0.060

The t-statistics are in parentheses.

\* and \*\* indicate that the coefficient is statistically significant at 10% and 5% levels.

The standard errors are calculated using the Newey-West method.

Source: Staff estimates

As suggested by Cogley (2002) and Rich and Steindel (2005), indicator of demand pressure or other macroeconomic valuables can be added to equation (1) to test the within-sample forecast ability of the estimated trend measure of inflation. To test whether changes in

headline inflation respond to changes in demand pressure, the change in the output gap ( $x_t$ ) is included in equation (1) to evaluate the prediction performance of the estimated trend inflation.

$$\pi_{t+h} - \pi_t = \alpha + \beta(\pi_t - \pi_t^{Trend}) + \gamma \Delta x_t + \varepsilon_{t+h} \quad (2)$$

For trend CPI inflation, the  $h$  period is set to 3, 6 and 12 for monthly data. For the trend PCE inflation, the  $h$  period is set to 1, 2 and 4 for quarterly data. Tables 6 and 7 summarise the estimation results of equations (1) and (2).

Table 7

**Estimation results of within-sample forecast ability  
(with the output gap as an independent variable)**

	CPI		PCE deflator	
	Core CPI inflation (exclusion method)	Trend CPI inflation (principal component method)	Core PCE inflation (exclusion method)	Trend PCE inflation (principal component method)
	$h = 3$		$h = 1$	
$\beta$	-0.425 (-1.973)**	-0.784 (-4.248)**	-0.906 (-2.935)**	-1.012 (-3.607)**
$\gamma$	0.211 (2.880)**	0.243 (3.475)**	0.213 (4.027)**	0.187 (3.863)**
$\overline{R^2}$	0.077	0.179	0.241	0.315
	$h = 6$		$h = 2$	
$\beta$	-0.395 (-1.096)	-0.686 (-2.079)**	-0.536 (-1.966)*	-0.827 (-4.281)**
$\gamma$	0.264 (2.132)**	0.293 (2.401)**	0.115 (1.678)*	0.101 (1.475)
$\overline{R^2}$	0.066	0.113	0.051	0.130
	$h = 12$		$h = 4$	
$\beta$	-0.347 (-0.765)	-0.578 (-1.097)	-0.529 (-1.716)*	-0.765 (-3.596)**
$\gamma$	0.415 (1.992)**	0.446 (2.174)**	0.238 (2.399)**	0.224 (2.212)**
$\overline{R^2}$	0.081	0.102	0.105	0.142

The t-statistics are in parentheses.

\* and \*\* indicate that the coefficient is statistically significant at the 10% and 5% level.

The standard errors are calculated using the Newey-West method.

Source: Staff estimates

The regression results in Table 6 (without the output gap as an independent variable) show that the trend CPI inflation estimated by the principal component method better forecasts future change in headline CPI inflation, as indicated by the more significant estimated coefficient ( $\beta$ ) and a larger adjusted  $R^2$  over different  $h$  periods. A similar conclusion holds for the trend PCE inflation, suggesting that trend inflation estimated by the principal component method performs better in predicting future changes in headline inflation for both CPI and PCE deflator. After adding the change in output gap as an independent variable, the regression results again show that the trend CPI /PCE inflation estimated by the principal component method has better forecast performance than that estimated by the exclusion

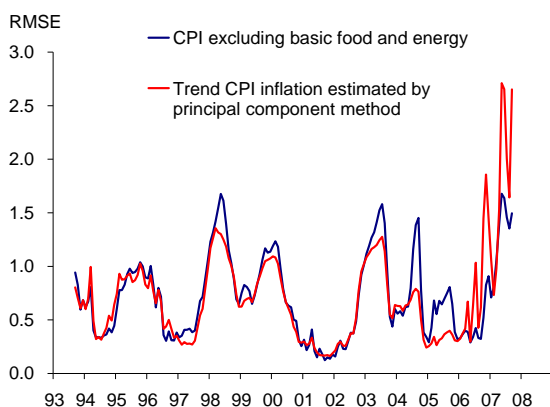
method. Overall, the trend CPI and PCE inflation rates estimated by the principal component method outperform the exclusion method in forecasting future changes in headline inflation in within-sample tests.

### **Out-of-sample forecast ability of trend inflation**

In addition to the within-sample test of forecasting ability, an out-of-sample test is used to compare the forecast performance of different measures of trend inflation. Using a rolling window of 10 years of observations, recursive regressions are estimated based on the model specification in equation (1) with the  $h$  period set to one. A series of forecast error of headline inflation over a forecasting horizon of one year is computed for different measures of trend inflation.<sup>5</sup> The out-of-sample forecast ability of the trend inflation calculated from the exclusion and principal component methods can be evaluated based on the root-mean-square error (RMSE) estimated from the rolling regression.<sup>6</sup> The decision rule is that the smaller the RMSE, the stronger the forecast ability of the trend inflation measure.

Chart 12

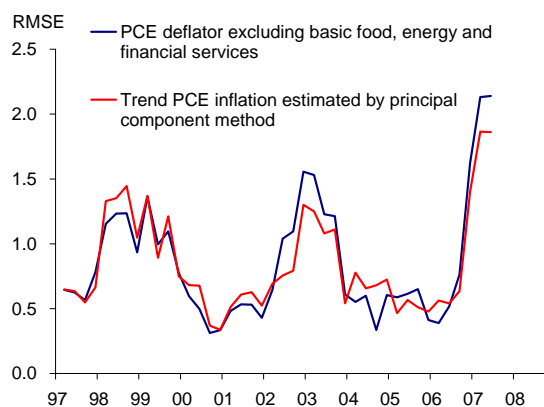
**Out-of-sample forecast ability of the trend CPI inflation: RMSE plot<sup>7</sup>**



Source: Staff estimates.

Chart 13

**Out-of-sample forecast ability of the trend PCE inflation: RMSE plot**



Source: Staff estimates.

Charts 12 and 13 plot the series of out-of-sample RMSE estimated from the rolling regression. Overall, the out-of-sample RMSE of forecasting the headline inflation using the trend inflation estimated by the principal component method do not have absolute advantage over the exclusion method. For the composite CPI, using the trend inflation estimated by the principal component method to perform out-of-sample forecasts yields a lower RMSE for the period from July 1997 to April 2003, but yields higher RMSE for the periods from September 1993 to June 1997 and from May 2003 to September 2008 (Table 8). In particular, the

<sup>5</sup> The dynamic forecast in this exercise is an ex post forecast, in that future exogenous variables of trend inflation are known.

<sup>6</sup> Root mean square error (RMSE) is defined as  $\sqrt{\frac{\sum_{t=1}^T (\pi_t - \hat{\pi}_t)^2}{T}}$ , where  $\pi_t$  and  $\hat{\pi}_t$  are the actual and forecast value of trend inflation, respectively.

<sup>7</sup> For the CPI, the quarterly base is adopted such that the root mean square error is multiplied by  $\sqrt{3}$  to align with the scale of the PCE deflator.

forecasting performance of the CPI trend inflation estimated by the principal component method has been worse in recent years, as shown by distinctly high RMSE in the recent period (Chart 12). Although the principal component method yields lower RMSE in the overall testing period, the results suggest that the out-of-sample forecasting performance varies in different periods. On the other hand, trend PCE inflation estimated by the principal component method outperforms the exclusion method in out-of-sample forecasting, with the principal component method yielding smaller average RMSE than the exclusion method for the whole sample period and the sub-periods (Table 9). Overall, trend inflation estimated by the principal component method outperforms the exclusion method in the within-sample forecast test, but does not consistently outperform in the out-of-sample forecast test.

Table 8

**Average RMSE for forecasting the headline CPI inflation**

Method	CPI			
	All	Sep 1993 - Jun 1997	Jul 1997 - Apr 2003	May 2003 - Sep 2008
Excluding food and energy	0.718	0.619	0.734	0.785
Principal component	0.712	0.620	0.683	0.830

Table 9

**Average RMSE for forecasting the headline PCE inflation**

Method	PCE deflator		
	All	Q1 1997 - Q2 2003	Q3 2003 - Q2 2008
Excluding food, energy and finance	0.856	0.855	0.859
Principal component	0.845	0.850	0.836

The evaluation results of various measures of trend inflation using different selection criteria are summarised in Table 10. In terms of the qualitative criteria such as simplicity and information content, core measures of CPI and PCE inflation estimated by the exclusion method are more familiar to the public, and their information content is also high. In terms of quantitative selection criteria, the trend inflation rates calculated from both the exclusion and principal component methods pass the co-integration test, with headline inflation converging with the trend measures in the long run. The trend inflation rates estimated by the exclusion and principal component methods have relatively strong forecast ability for future changes in headline inflation, which is consistent with their co-integrating property. Based on the forecasting results from the within-sample and out-of-sample tests, neither the principal component nor the exclusion method has clear advantage over the other, although there is some evidence to suggest that trend PCE inflation estimated by the principal component method has had stronger within and out-of-sample predictive ability for changes in headline PCE inflation in recent periods.

Table 10

**Evaluation of various measures of trend inflation  
based on different selection criteria**

	CPI		PCE deflator	
	Core CPI inflation (exclusion method)	Trend CPI inflation (principal component method)	Core PCE inflation (exclusion method)	Trend PCE inflation (principal component method)
Transparency and simplicity	High	Medium	High	Medium
Information content	High	Very high	High	Very high
Co-integrating relationship and error-correction model <sup>8</sup>	Headline inflation converges with core inflation but not vice versa  Adjustment coefficient of headline inflation equation = -0.533	Headline inflation converges with core inflation but not vice versa  Adjustment coefficient of headline inflation equation = -0.691	Headline inflation converges with trend inflation but not vice versa  Adjustment coefficient of headline inflation equation = -0.820	Headline inflation converges with trend inflation but not vice versa  Adjustment coefficient of headline inflation equation = -0.946
Within-sample forecast ability	Principal component approach dominates the exclusion-based measure in terms of size and significance of coefficient and R-square statistics.		Principal component approach dominates the exclusion-based measure in terms of size and significance of coefficient and R-square statistics.	
Out-of-sample forecast ability	Principal component approach has stronger out-of-sample forecast ability in the overall period, but does not consistently outperform in sub-periods.		Weaker out-of- sample forecast ability  Average RMSE = 0.856	Stronger out-of-sample forecast ability  Average RMSE = 0.845

## V. Conclusions

This paper reviews different price indicators for measuring domestic inflation in Hong Kong. As indicators of prices of consumer goods and services, the CPI and PCE deflator are found to be representative measures of the cost of living and domestic price pressures. Trend measure of CPI and PCE inflation can be obtained by removing the effects of volatile price components from them. Both the exclusion and statistical methods are used to construct measures of trend inflation to gauge the underlying inflationary pressures. To estimate core inflation using the exclusion method, basic food and energy-related items are removed from the CPI, while similar items and financial services are removed from the PCE deflator. These two core measures of inflation are compared with the trend CPI and PCE inflation estimated

<sup>8</sup> The adjustment coefficients of the headline CPI inflation equations are converted to quarterly basis for comparison purpose.

by the principal component method, which statistically finds a linear combination of individual price items that explains most of the movements in general prices.

Evaluation results based on qualitative and quantitative criteria suggests that the trend CPI and PCE inflation estimated by the exclusion and principal component methods have their own strengths and weaknesses, and neither of the methods has clear absolute advantage over the other for measuring trend inflation.

## Annex A: Technical note on principal component analysis

This annex describes and illustrates the procedure of using the principal component method to estimate trend CPI and PCE inflation.

### Methodology

Principal components are a linear transformation of multivariate data into a few uncorrelated components that explain most of the variations of the underlying variables. In technical terms, the linear combination of the underlying variables represents the eigenvector estimated from the variance-covariance matrix of the data. The value corresponding to the eigenvector is the eigenvalue, which represents the portion of total variations of the data explained by the principal component formed by the eigenvector. Usually, the first principal component explains most of the variations of the data, followed by the second and the third ones. It should be noted that if there are  $p$  variables, only  $k$  principal components are needed to largely explain or represent the variation of the data, where  $k$  is less than  $p$ . In view of this property, the first principal component that explains most of the movements in headline inflation is used as the measure of trend inflation.

To perform principal component analysis, the sample mean is subtracted from the inflation rates of individual items of the price index and the result is divided by the sample standard deviation for standardisation. This eliminates the distortion caused by differences in measurement units. The standardised data can be represented by:

$$z_{it} = \frac{\pi_{it} - \bar{\pi}_i}{s_i}$$

where  $z_{it}$  is the standardised inflation rate with zero mean and unit standard deviation for item  $i$  in the consumption basket of the CPI or PCE deflator in period  $t$ .  $\pi_{it}$  denotes the inflation rate for item  $i$  in period  $t$ .  $\bar{\pi}_i$  denotes the sample mean for the inflation rate of item  $i$ .  $s_i$  denotes the standard deviation for the inflation rate of item  $i$ .

An alternative but similar measure is to use the standard deviation of the first difference of the underlying data as the denominator, which eliminates the problem of non-stationarity in the data. This is crucial since variance of non-stationary time series is time dependent. We follow Machado et al (2001) in using the sample standard deviation calculated from the first difference of  $\pi_{it}$  as the denominator, ie

$$z_{it}^* = \frac{\pi_{it} - \bar{\pi}_i}{s_{\Delta i}}$$

$z_{it}^*$  is the adjusted standardised inflation rate for item  $i$  in period  $t$  and  $s_{\Delta i}$  is the adjusted standard deviation calculated from the first difference of  $\pi_{it}$ .



The weights used to construct the first principal component ( $\omega^*$ ) maximise the overall variance of the data subject to the normalised vector constraint,<sup>9</sup> ie

$$\text{maximise } Var(\omega Z) = \omega' S \omega \text{ subject to } \omega' \omega = 1$$

with  $\omega^*$  maximising the above problem.

$Z$  is the standardised multivariate inflation rate of the constituent items of the CPI or PCE deflator.  $S$  is the variance-covariance matrix of  $Z$ .

In technical terms,  $\omega^*$  is the eigenvector of the variance-covariance matrix  $S$  with the corresponding eigenvalue that maximises the variance of the dataset  $Z$ . The eigenvalue indicates the portion of total variance of  $Z$ , which is explained by the linear combination of the constituent items of the CPI or PCE deflator based on the estimated eigenvector.

The weights of the first principal component are normalised to sum to one, as illustrated in Table 2 of the main text. The normalised weights are then assigned to the inflation rate of constituent items in the consumption basket to calculate trend inflation. That is,

$$\pi_i^{Trend} = \sum_{i=1}^n \omega_i^* \pi_{it} \text{ with } \omega_i^* \text{ representing the elements inside the normalised } \omega^* .$$

To update the trend inflation with new data on the CPI or PCE deflator, the above procedure is repeated with the latest inflation data incorporated to obtain a new estimate of the principal component. In this study, the weights of the first principal component are volatile in early periods due to limited sample size, but as more data are included in the sample the weights become largely stable in recent periods.

## Illustration

Throughout our principal component analysis, we adopt the adjusted standard deviation to standardise the inflation rate of constituent items of the CPI or PCE deflator. The sample runs from October 1983 to September 2008 for CPI inflation, and from Q2 1987 to Q2 2008 for PCE inflation. To update the estimated trend inflation rate of the CPI and PCE deflator, we repeat the estimation procedure of the principal components when the dataset expands.

For illustration purposes, the estimation method of the latest trend inflation rate of the CPI and PCE deflator are summarised below.

The principal components estimated based on time series data on the constituent items of the CPI are shown in Table A1. It shows the weight distribution of the constituent items of the CPI for the first five principal components, which are derived from the eigenvectors of the variance-covariance matrix of the dataset by normalising the elements of the eigenvector to sum to one.

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<sup>9</sup> Other principal components ( $i$ th principal component) are calculated by solving the above problem with orthogonal restrictions such that the  $i$ th principal component is not correlated to the 1st, 2nd, ... ( $i-1$ )th principal components. The maximum number of principal components equals the number of variables in the dataset. In most cases, a few principal components are sufficient to explain the variations of the underlying data. See Johnson and Wichern (2007) for further details.

Table A1

**Weight distribution of the first five principal components of the CPI**

September 2008

Variables	PC 1	PC 2	PC 3	PC 4	PC 5
Alcoholic drinks and tobacco	0.022	0.071	0.065	-0.290	0.134
Clothing and footwear	0.044	0.005	0.326	0.258	-0.548
Durable goods	0.069	0.161	0.674	0.098	0.275
Electricity, gas and water	0.024	0.123	-0.264	0.889	0.973
Basic food	0.033	0.065	0.021	0.229	-0.697
Housing	0.367	-0.474	-0.063	0.049	0.017
Meals away from home	0.207	0.556	-0.330	-0.085	-0.984
Miscellaneous goods	0.036	0.111	0.378	0.386	-0.412
Miscellaneous services	0.107	0.150	0.202	-0.366	0.518
Transport	0.092	0.230	-0.009	-0.166	1.725

The corresponding explanatory power of the principal components, which are the eigenvalues calculated from the weight distributions in Table A1, are shown in Table A2. It shows that the first principal component explains about 77% (the third column in Table A2) of the total variations of the constituent items of the CPI based on a sample from October 1983 to September 2008. This is in contrast to the second principal component, which explains only 9% of total variations of the data.

Table A2

**Eigenvalues for and proportion of variance explained by principal components of the CPI**

Sum of eigenvalues = 156.127, average of eigenvalues = 15.613						
Order of principal component	Eigenvalue	Difference	Proportion	Cumulative value	Cumulative proportion	
1	120.529	106.547	0.772	120.529	0.772	
2	13.982	8.166	0.090	134.511	0.862	
3	5.817	2.080	0.037	140.328	0.899	
4	3.737	0.672	0.024	144.065	0.923	
5	3.066	0.708	0.020	147.131	0.942	
6	2.357	0.149	0.015	149.488	0.958	
7	2.208	0.424	0.014	151.696	0.972	
8	1.784	0.244	0.011	153.481	0.983	
9	1.540	0.433	0.010	155.021	0.993	
10	1.107	---	0.007	156.127	1.000	

The weight distribution of the first principal component (first column in Table A1) is assigned to the inflation rate of the constituent items of the CPI to obtain the estimated trend CPI inflation. The three-month-on-three-month trend inflation rate in September 2008 is estimated to be 1.28% using the principal component method, compared to 1.16% estimated using the exclusion method for the same period.

For the PCE deflator, the weight distribution of the first five principal components are summarised in Table A3. Table A4 shows that the first principal component explains about 52% of total variations of the constituent items of the PCE deflator based on a sample from Q2 1987 to Q2 2008.

Table A3

**Weight distribution of the first five  
principal components for the PCE deflator**

Second quarter of 2008

Variables	PC 1	PC 2	PC 3	PC 4	PC 5
Alcoholic beverages	0.007	-2.189	1.068	0.114	0.391
Clothing, footwear and other personal effects	0.097	8.864	1.755	-0.718	0.070
Education	0.066	-2.010	-2.112	-0.133	-0.166
Food and non-alcoholic beverages	0.072	5.716	-0.708	0.619	0.005
Fuel and light	0.008	1.337	1.044	0.532	0.009
Furniture, furnishing and household equipment	0.062	1.794	-2.200	-0.038	-0.380
Household operation	0.111	-3.749	-0.038	-0.249	0.139
Rent, rates, water and housing maintenance charges	0.120	-1.813	2.865	0.467	-0.820
Medical care and health expense	0.123	-3.656	-1.701	-0.284	-0.104
Other services	0.052	-1.302	0.700	0.567	0.324
Personal care	0.082	-2.368	0.996	-0.406	0.121
Recreation and entertainment	0.068	-1.672	2.498	-0.050	0.569
Tobacco	0.021	0.164	-0.803	0.208	0.425
Transport and communication	0.110	1.883	-2.365	0.370	0.416

Table A4

**Eigenvalues for and proportion of variance  
explained by principal components of the PCE deflator**

Sum of eigenvalues = 12.910, average of eigenvalues = 0.922)					
Order of principal component	Eigenvalue	Difference	Proportion	Cumulative value	Cumulative proportion
1	6.677	5.822	0.517	6.677	0.517
2	0.855	0.103	0.066	7.532	0.583
3	0.752	0.060	0.058	8.283	0.642
4	0.692	0.032	0.054	8.976	0.695
5	0.660	0.027	0.051	9.636	0.746
6	0.633	0.095	0.049	10.269	0.795
7	0.538	0.086	0.042	10.807	0.837
8	0.452	0.101	0.035	11.258	0.872
9	0.350	0.027	0.027	11.609	0.899
10	0.323	0.039	0.025	11.932	0.924
11	0.284	0.021	0.022	12.217	0.946
12	0.263	0.043	0.020	12.480	0.967
13	0.220	0.010	0.017	12.700	0.984
14	0.210	---	0.016	12.910	1.000

Similarly, the weight distribution of the first principal component is assigned to the inflation rate of the constituent items of the PCE deflator to estimate the trend PCE inflation. The quarter-on-quarter trend inflation rate in the second quarter of 2008 is estimated to be 1.06% using the principal component method, compared to 0.64% estimated using the exclusion method for the same period.

## Annex B: Results of unit root tests on inflation series

### Augmented Dickey-Fuller unit root tests

The augmented Dickey-Fuller (ADF) unit root tests are carried out on various inflation measures. The results do not reject the presence of unit roots in the inflation measures.

Table A5

#### ADF test on various inflation measures

**Hypothesis: the series has a unit root.**

Intercept and trend are not included in the test equation.

#### CPI

	P-value	No. of lags
CCPI adjusted by one-off measures	0.1268	0
CCPI (adjusted) excluding food and energy	0.1655	0
Trend inflation estimated by principal component	0.1679	0

#### PCE deflator

	P-value	No. of lags
PCE deflator	0.0589	1
PCE deflator excluding food, energy and finance	0.0764	1
Trend inflation estimated by principal component	0.1433	1

### Unit root test with structural break

To consider the possibility of a structural break, Zivot and Andrews (1992) unit root test is conducted to test the null hypothesis of the presence of unit root against the alternative hypothesis of trend stationary process with an unknown one-time break point. The testing equation is constructed as follows:

$$y_t = \hat{\theta}I(\hat{\lambda}) + \hat{\mu} + \hat{\beta}t + \hat{\alpha}y_{t-1} + \hat{e}_t$$

$I(\lambda) = 1$  if  $t > T\lambda$  with  $\lambda$  representing the location of the break point in terms of proportion and  $T$  representing the length of the sample period.

The equation considers the one-time break point in the parallel level of the series. Since the break point is unknown, this is determined by choosing a minimum t-statistic for testing  $\hat{\alpha} = 1$  across the set of possible break points throughout the series. The corresponding t-statistic is then compared to the asymptotic significance level. If the t-statistic is less than the asymptotic significance level, the null hypothesis of the presence of the unit root is rejected. Results of unit root tests are given below.

Table A6

**Zivot and Andrews (1992) test on various inflation measures**

	<b>t-statistics</b>	<b>No. of lags</b>	<b>Date of structural break</b>
Headline CCPI	-4.404	4	Jun.98
Core CPI excluding food and energy	-4.602	4	Jan.98
Trend CPI estimated by principal component	-4.267	4	May.97
Headline PCE deflator	-3.138	2	Q4 2003
Core PCE deflator excluding food, energy and financial services	-3.175	2	Q3 1997
Trend PCE deflator estimated by principal component	-3.014	2	Q3 1997

Critical value (asymptotic):

intercept: 5%: -4.80

intercept: 1%: -5.43

The above results show that the null hypothesis of the presence of unit roots are not rejected for all the inflation series, since the t-statistics of the inflation measures are greater than the critical values with 5% significance level. Regarding the structural break, except for the headline PCE deflator, most of the possible structural breaks are located in the period of the Asian financial crisis.

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# Monetary policy under import price shocks: the case of Hungary

Zoltán M. Jakab<sup>1</sup> and Ferenc Karvalits<sup>2</sup>

## Introduction

The general task of inflation targeting for central banks is to find an interest rate path that ensures the achievement of the inflation target by trading off the possible economic sacrifices. Commodities such as oil or food appear directly in the consumer basket, and also serve as input in the production process, especially in the case of oil. Central banks of small, open economies now and again face the problem of dealing with imported price pressures, i.e. terms-of-trade shocks. They often need to judge whether these pressures affect the production side of the economy or inflation expectations, or induce substitution in demand. Imported inflationary pressure can be counterbalanced by nominal exchange rate appreciation; this, however, does not constitute a free lunch, as it can temporarily contract activity in the tradable sector. In this respect, there is a question of whether monetary policies that work under a large terms-of-trade shift would target “*domestic*” inflation (as in Clarida et al (2001)) sometimes proxied by the “*core inflation*”, which excludes food and energy prices from the consumer basket, or whether it is optimal to focus on total inflation.

Around nine months ago, a paper dealing with persistent shifts in terms of trade or the effects of potentially higher oil and food prices would have been the key issue for monetary policy makers of small, open economies. The world is changing, however, at a perhaps surprisingly fast pace. Currently, the question is flipped: what are the monetary policy consequences for a marked slowdown or recession in the world economy accompanied by large (downward) shifts in the price of commodities? Although the likelihood that terms of trade will persistently worsen has diminished, great volatility in the terms of trade may still pose an interesting policy question. In this paper we address the optimal response of monetary policy when terms-of-trade shocks – more precisely import price shocks – hit a small, open economy.

*Figure 1* shows that in Hungary the volatility of import prices (measured in foreign currency) are no more volatile than consumer prices. This is mostly explained by the fact that consumer prices are also affected by other shocks and most notably by exchange rate fluctuations. Higher import prices do not directly translate into consumer prices, for two reasons. First, fluctuations in the nominal exchange rate serve as a natural way of accommodating these types of shocks. Second, large part of imports serve as intermediates in Hungarian production, and thus they have impact on firms’ marginal costs. In addition, firms are able to accommodate to these shocks by adjusting wages, demand for labour and capital. Thus, the impact of import price shocks on final prices of goods might be smoother, and delayed.

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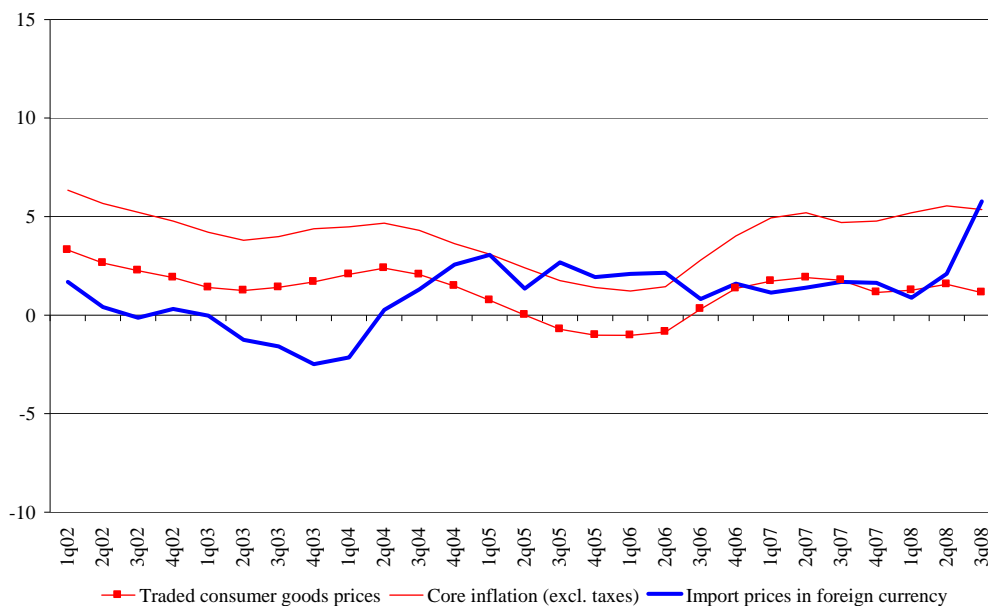
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Figure 1

### Import prices in foreign currency and consumer prices in Hungary

y-o-y changes in %



Source: Central Statistical Office of Hungary

This paper explores the properties of optimal monetary policy under import price shocks in a medium-scale dynamic stochastic general equilibrium (DSGE) model estimated for Hungary. Our framework is a two-sector, open economy model, with imports serving as intermediate inputs for production. We use the method for finding the optimal policy in “medium-scaled” closed economy DSGE (i.e. Smets-Wouters type) models of Altissimo et al (2005) and Adjemian et al (2007). This note builds on the results by Jakab, Szilágyi and Világi (2008) and Karvalits (2008).

Clarida et al (2001) show that the optimal policy problem for a small open economy is isomorphic to the closed economy case. In particular, small open economy dynamics can be reduced to a dynamic system that is identical to that associated with the workhorse sticky price model of a closed economy. Thus, the optimal policy should seek to stabilise domestic (as opposed to total CPI) inflation, and the form of the interest rate rule is not affected by the openness of the economy. Gali-Monacelli (2005) also emphasise this isomorphy where strict domestic inflation targeting turns out to be the optimal monetary policy for open economies. This means that according to the above models, optimal monetary focuses on domestic inflation. In other words, import price shocks’ effects on the optimal policy can be characterised through their impact on output and domestic inflation: monetary policy takes care of the second-round effects of these type of shocks.

On the other hand, Campolmi (2008) argues that the inclusion of sticky wages in an otherwise standard small open economy model rationalises CPI inflation targeting. To our knowledge, there are no publications on the welfare-maximising policy properties of an empirically motivated, fully fledged small open economy model.

We argue that in a small open economy like Hungary, and when imports are production inputs, optimal monetary policy is also concerned with import price shocks. We also find that the way imports are modelled is crucial for the normative implications of import price (terms-of-trade) shocks. That is, while it can be optimal for the monetary policy to overlook international relative price changes if imports are used in final consumption, it no longer holds once they enter into production.



## The model

We use the model of Jakab-Szilágyi-Világi (2008), which is an amended version of the estimated dynamic stochastic general equilibrium (DSGE) model of Jakab and Világi (2008).<sup>3</sup> The model has the usual nominal and real frictions of applied DSGE models. It also has a two-sector, open economy setup, with imports serving as intermediate input to production.

First, we examine the flexible price version of the model. Here we explore how the economy would behave without nominal rigidities. This (flexible price) allocation serves as a natural benchmark as, by assuming away nominal rigidities, it represents a socially optimal solution.<sup>4</sup> Then, we investigate reactions of the economy under the estimated rule, discovering the role of nominal rigidities, which constrain the solution of the optimal policy problem. We compare the optimal policy allocation to both the flexible price model and the one with the estimated rule.

The model of Jakab-Szilágyi-Világi (2008) features a large number of real and nominal frictions usually assumed in the literature (staggered price and wage setting, indexation mechanisms, adjustment costs on investment, habit formation in consumption, fixed costs in production). This model is a simplified version of that of Jakab-Világi (2008). The production process is represented by a two-stage CES (constant elasticity of substitution) production function. In the first stage, imports and labour are combined to a composite production input, and in the second, final output is produced out of the composite input and capital. Adjusting all the three factors of production is costly. There are two sectors: domestic and export. Monetary policy is characterised by a simple Taylor rule with interest rate smoothing estimated for the IT regime (from 2001). The estimated coefficient of inflation is barely 1.4 and less than the standard baseline of 1.5. Rule-of-thumb (non-Ricardian) consumers are assumed away from the original Jakab-Világi (2008) model. A special feature of the full Jakab-Világi (2008) model is that agents' "perception on underlying inflation" is made endogenous by a real-time adaptive-learning algorithm. For simplicity, we abstract from potential problems of imperfect commitment caused by this learning process. Apart, from the differences highlighted above, we imported the parameters estimated by Jakab-Világi (2008) for the inflation targeting regime. Throughout the simulations, the posterior means of the parameters were chosen.

## Optimal policy

Figures 2–4 show the reactions to a 1% increase in import prices. In the *flexible* price model (abbreviated NR), increased import prices act as a negative shock to technology by making production more costly and reducing output in both sectors. Obviously, the rise in import prices leads to strong substitutions in production, mostly of imports for labour. The rising cost of domestic production also makes the domestic firms less competitive in export markets, and induces a sectoral reallocation of inputs from the export to the domestic sector.

With *nominal rigidities* and *under the estimated rule* (Rule), monetary policy reacts with a moderate tightening. *Optimal monetary policy*, too, behaves as if facing a negative technology shock; consequently, the optimal response is a tightening.

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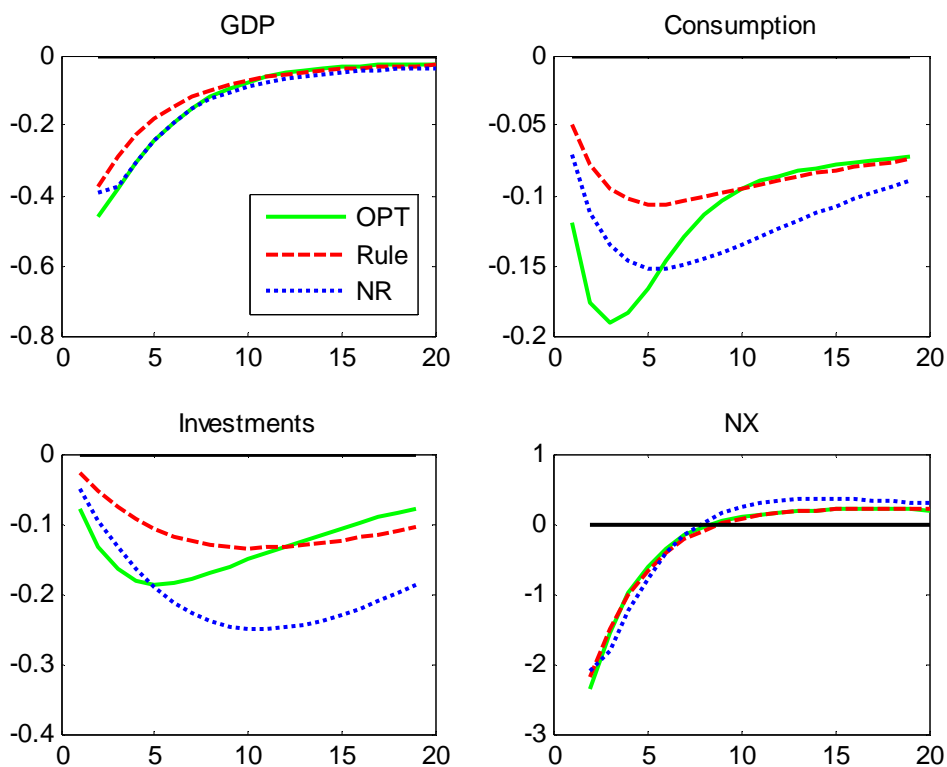
<sup>3</sup> The linear-quadratic (LQ) approximation is used to solve the optimal policy problem, as suggested by Benigno-Woodford (2005); and the standardised algorithm proposed by Altissimo et al (2005) is used.

<sup>4</sup> More precisely, this is the case if the government subsidises producers with a monopoly to supply the amount of output that they would in a perfectly competitive environment (case of the optimal steady state) – an assumption that we maintain throughout.

The reason is that *optimal monetary policy* (OPT) seeks to replicate the flexible price allocation by increasing the policy rate and thus contracting aggregate demand (as is usual in the closed economy setup). In addition, there is another motivation of the central bank of a small open economy: it also seeks to induce “optimal” relative price movements (as it was the case in the flexible price model). Given nominal rigidities, this is achieved by nominal appreciation, which adds a further motive to the monetary tightening. Optimal policy lowers the variability of domestic and wage inflation, and induces real exchange rate movements similar to what would prevail in a flexible price situation.

Figure 2

**Impulse response of policy rate after an increase in import prices**



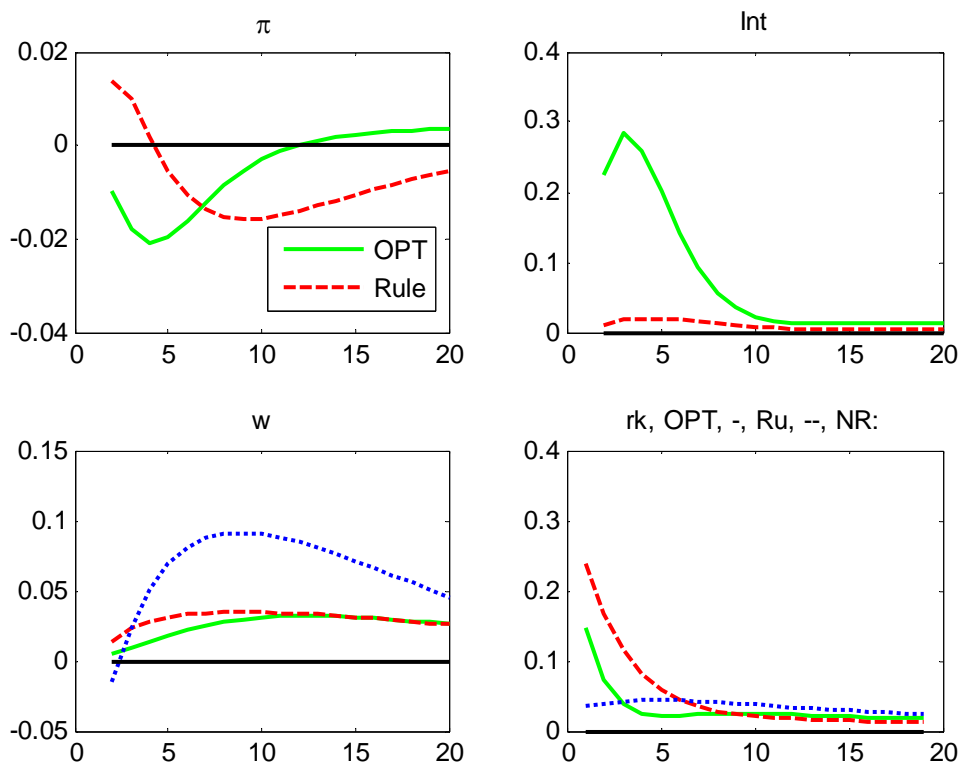
x-axis in quarters and y-axis in percent.

NX = net exports.

Source: Jakab-Szilágyi-Világi (2008).

Figure 3

Impulse response of policy rate after an increase in import prices (cont'd)



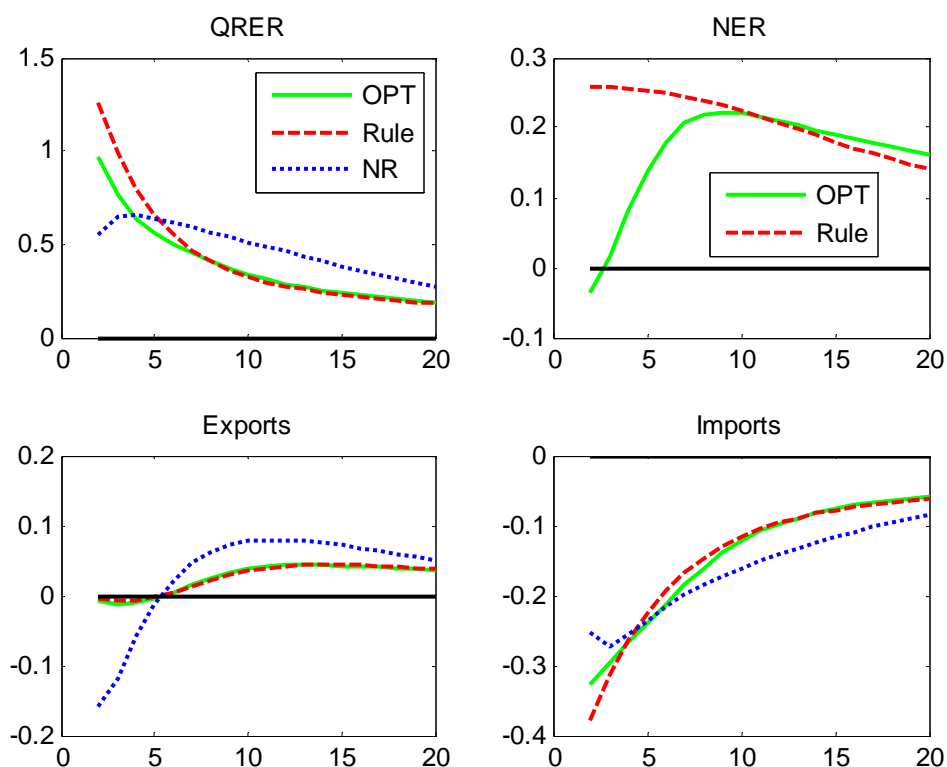
x-axis in quarters and y-axis in percent.

Int = interest rate; w = real wage; rk = real user cost of capital; OPT = optimal; Ru = Rule, NR = Natural rate.

Source: Jakab-Szilágyi-Világi (2008).

Figure 4

**Impulse response of policy rate after an increase in import prices (cont'd)**



x-axis in quarters and y-axis in percent.

QER = real exchange rate; NER = nominal exchange rate.

Source: Jakab-Szilágyi-Világi (2008).

## Conclusions and some policy implications

This paper has analysed the optimal monetary policy reaction to import price shocks in an estimated, small open economy DSGE model of the Hungarian economy. The modelling framework (two-sector setup, with imports modelled as input to production) has clear normative consequences.

According to the simulations, import price changes – imports as an input to production – act like shocks to the technology, and consequently, trigger a monetary action (loosening if prices fall). Imports as an input to production, as opposed to a final consumption good, dramatically changes the normative implications of a terms-of-trade shock. We argue that while it is optimal for the monetary policy to overlook international relative price changes in the latter setup, this no longer applies once imported goods enter into production.

Optimal monetary policy described by the small, open economy model for Hungary is one that actively responds to commodity price movements. This result is in sharp contrast to the theoretical result usually derived in the literature, i.e. terms-of-trade shocks should be overlooked. Our results highlight the striking difference in normative implications of the way imports are modelled (final consumption good vs. intermediary production input).

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# Monetary policy in response to imported price shocks: the Israeli case

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## 1 Introduction

Like any other small open economy, the Israeli economy is exposed to global price shocks, which have recently presented greater challenges to the conduct of monetary policy. The high volatility of international food and energy prices during the last two years highlights the question of whether monetary policy should respond to external price shocks using the same rule it uses to respond to domestic price shocks. Israel adopted the headline (CPI) inflation target range of 1-3% in 2003. Within a flexible inflation targeting framework, the monetary policy responds to both lagged and expected price changes in order to preserve price stability while minimising output (gap) volatility and maintaining interest rate stability. Due to the fact that an external price shock leads to a trade-off between inflation and output gap, a monetary policy that focuses on headline inflation may cause a deeper recession than a policy that responds to a measure of inflation that excludes external price shocks that are highly flexible - known as core inflation.

Since about the fourth quarter of 2007, headline inflation in Israel has been distinguished from core inflation, defined as the CPI excluding the energy, food, and fruit and vegetables components.<sup>3</sup> At that time, and in the first half of 2008, the Bank of Israel faced a dilemma regarding the appropriate interest rate policy response to the increase in inflation that was mainly due to changes in energy and food prices.

In this paper we analyse the impact on inflation and the output gap of different interest-rate-policy responses to external price shocks, using a variant of an estimated New Keynesian (NK) model for Israel (Argov and Elkayam (2007)). The model consists of four structural equations: a New Keynesian Phillips curve for domestic inflation, derived from firms' optimal price setting following Rotemberg (1982); an output gap equation, derived from optimal consumer allocation; a nominal exchange rate (ILS/US\$) equation, based on an uncovered interest parity (UIP) condition with partial indexation; and an expanded forward-looking Taylor rule, by which the central bank (CB) sets the interest rate.

We compare the predicted outcome of the model relating to a transitory shock to imported consumer prices, when the Taylor rule responds to headline (HI) CPI inflation with a Taylor rule that responds to our definition of core inflation, following the literature. Specifically, we follow Aoki (2001), who defined core inflation as resulting from sticky-price sector components of the price index. Assuming that external prices that exhibit high price volatility should be viewed as flexible, and assuming immediate pass-through, we define two core inflation indices for the Israeli model; I) headline inflation excluding housing, fuel, fruit and

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<sup>3</sup> This is informal core inflation.

vegetables and imported consumer price components. II) The same as I, but including the housing price component.<sup>4</sup>

Comparing the response of the economy using the three rules, we find that using the headline (CPI) inflation rule gives higher volatility of inflation than do the core inflation rules, while the volatilities of the output gap and interest rates are lower. Using an ad hoc quadratic welfare-loss function of inflation, consumption gap and interest rate, we find that a Taylor rule that responds to core inflation including the housing price component yields higher welfare for the representative household.

The paper is organised as follows. Section 2 describes the model and defines core inflation, section 3 summarises the literature on the welfare-loss function, section 4 describes inflation and commodity prices in Israel in 2007 and 2008, section 5 discusses the results of the model, and section 6 concludes.

## 2 A New Keynesian (NK) model for Israel

In this section we describe the model used at the Bank of Israel (Argov and Elkayam (2007)) for monetary policy analysis, and we define headline inflation and core inflation. This framework will be used later to analyse the main question of this paper.

### 2.1.1 The model

We use a variant of the small quarterly estimated NK model for Israel used by the Bank of Israel (Argov and Elkayam (2007); Argov et al (2007)). The model consists of four structural equations (see Appendix A for details):

- a) An open economy New Keynesian Phillips Curve (NKPC) derived from firms' optimal price setting a la Rotemberg (1982) for domestic inflation,  $\pi_t^h$ :

$$(1) \pi_t^h = a_\pi E_t \pi_{t+1}^h + (1 - a_\pi) \pi_{t-1}^h + a_y \cdot 0.5 \cdot (y_t + y_{t-1}) + a_p \cdot p_t^{\bar{c}^*} + a_q q_t + v_t^{\pi h},^5$$

where  $y_t$  is the output gap,  $p_t^{\bar{c}^*}$  is the world price of inputs relative to consumer goods expressed in log deviation from trend,<sup>6</sup>  $q_t$  is the real exchange rate, defined as the price of imported consumer goods,  $p_t^*$ , in local currency (ILS) relative to the domestic price, that is  $q_t \equiv p_t^* + e_t - p_t^h$ , where  $e_t$  is the nominal ILS/US\$ exchange rate. Domestic inflation,  $\pi_t^h$ , is defined herein as headline inflation (CPI) excluding prices of housing, fuel, fruit and vegetables, and imported consumer goods. Finally,  $v_t^{\pi h}$  is a cost-push shock.

<sup>4</sup> Housing prices were highly flexible and were linked to the ILS/US\$ exchange rate and, therefore, were traditionally excluded from the definition of core inflation in Israel. However, within the model we use, housing prices are sticky.

<sup>5</sup> The derived Phillips curve should include only the current output gap (see Appendix A). However, a better fit was achieved by including a simple average of the current and lagged output gap.

<sup>6</sup> All variables apart from interest rates are expressed in log deviations from trend, which is calculated by HP filter in the estimation.



- b) A dynamic IS curve, the output gap equation,  $y_t$ , which is derived from optimal consumer allocation (the inter-temporal Euler equation):

$$y_t = a_h E_t y_{t+1} + (1 - a_h) y_{t-1} - a_i (i_t - E_t \pi_{t+1}) + a_q (q_t - a_h E_t q_{t+1} - (1 - a_h) q_{t-1}) \\ (2) + a_g ((g_t^h - a_h E_t g_{t+1}^h - (1 - a_h) g_{t-1}^h) + a_{inv} ((inv_t^h - a_h E_t inv_{t+1}^h - (1 - a_h) inv_{t-1}^h) \\ + ((y_t^* - a_h E_t y_{t+1}^* - (1 - a_h) y_{t-1}^*) + v_t^y,$$

where government consumption,  $g_t$ , investment,  $inv_t$ , world trade,  $y_t^*$ , and  $v_t^y$ , which is an error term, are all given exogenous variables,  $i_t$  is the domestic risk-free interest rate, and  $\pi_t$  is defined as the weighted sum of domestic inflation,  $\pi_t^h$ , and imported consumer goods inflation in local currency,  $\pi_t^*$ .

Argov and Elkayam (2007) estimated the domestic NKPC under two assumptions: a gradual pass-through and an immediate pass-through from the exchange rate and imported consumer goods prices to local prices. In this paper we assume an immediate pass-through of imported consumer inflation, and, as a result, imported consumer price inflation in local currency,  $\pi_t^*$ , is fully flexible. Thus,  $\pi_t^*$  is given by  $\pi_t^* = p_t^* - p_{t-1}^* + de_t + \varepsilon_t^*$ , where  $de_t$  is the nominal depreciation of the ILS against the dollar, and  $\varepsilon_t^*$  is an error term. Finally,  $a_h = \frac{1}{1+h}$ , where  $h \in (0,1)$  represents the strength of external habit formation, and  $\sigma^{-1}$  is the inter-temporal elasticity of substitution in the intra-temporal utility function of the representative household  $j$ , which is assumed to be

$$u(C(j)_t) = \frac{(C(j)_t - hC_{t-1})^{1-\sigma}}{1-\sigma}.$$

- c) A nominal ILS/US\$ exchange rate equation,  $e_t$ , which is derived from an expanded uncovered interest rate parity (UIP) condition for no-arbitrage between domestic and foreign bonds and is given by

$$(3) e_t = \omega E_t e_{t+1} + (1 - \omega) e_{t-1} + (i_t^* - i_t) - (1 - \omega)(i_{t-1}^* - i_{t-1}) + \phi_t - (1 - \omega)\phi_{t-1} + \varepsilon_t^e,$$

where  $i_t^*$  is the foreign risk-free rate,  $\phi_t$  is a risk premium paid on foreign assets, and  $\varepsilon_t^e$  is a nominal exchange rate random shock.

- d) The central bank (CB) sets interest rates following a forward-looking Taylor rule, with interest rate smoothing, given by

$$(4) i_t = (1 - k_i)[r_t + \bar{\pi} + k_\pi (E_t \pi_{t+3}^R - \bar{\pi}) + k_y y_t] + k_i i_{t-1},$$

where  $r_t$  is the forward yield to maturity on indexed-linked Treasury bonds, a proxy to the natural rate, and  $\bar{\pi}$  is the inflation target.

We use a Taylor rule which responds to three-period forward inflation, ie  $E_t \pi_{t+3}^R = 0.25(\pi_t^R + \pi_{t+1}^R + \pi_{t+2}^R + E_t \pi_{t+3}^R)$ , which is regarded as the standard monetary policy that aims to anchor inflation expectations.

The model is closed with three equations for the housing, fuel, and fruit and vegetables price components of the CPI. The CPI housing component equation is a function of the nominal rate of ILS/US\$ depreciation,  $de_t$ , reflecting the indexation of

housing prices to the dollar (Eckstein and Soffer (2006)), and the long run impact of the inflation target,  $\bar{\pi}$  :

$$(5) \pi_t^{housing} = \rho(de_t + \bar{\pi}) + (1 - \rho)(de_{t-1} + \bar{\pi}).$$

The CPI fuel price equation is given by:

$$(6) \pi_t^{fuel} = f\bar{\pi}_t + (1 - f)(de_t + \pi_t^{brent}),$$

where  $\pi_t^{brent} = \bar{\pi}_t + \varepsilon_t^{brent}$  is the price change of a barrel of crude oil, and  $\varepsilon_t^{brent}$  is a random shock.

The fruit and vegetables price equation is:

$$(7) \pi_t^{f\&v} = \pi_t^h + \varepsilon_t^{f\&v}.$$

Finally, the CPI inflation is calculated from the identity:

$$(8) \pi_t^{CPI} = w^H \pi_t^{housing} + w^{fuel} \pi_t^{fuel} + w^{f\&v} \pi_t^{f\&v} + w \pi_t.$$

This completes the description of the dynamic Bank of Israel model for the analysis of monetary policy. We now turn to the definitions of core inflation.

### 2.1.2 Core inflation indices

Within a flexible inflation targeting framework, monetary policy responds to both lagged and expected price changes to preserve price stability while minimising output (gap) volatility and maintaining interest rate stability. Due to the fact that an external price shock leads to a trade-off between inflation and the output gap, a monetary policy that focuses on headline inflation may react too aggressively compared with a policy that responds to core inflation. Hence, most central banks monitor core inflation as part of the interest rate decision-making process, as core inflation reduces transitory noise and could prevent the central bank from responding too strongly to transitory shocks (Mishkin (2007)).

Aoki (2001) shows that in a closed-economy two-sector DSGE model with a flexible-price sector and a sticky-price sector, the sticky-price inflation equation is a function of the relative price of the flexible-price sector. In that framework, following Rotemberg and Woodford (1997), Aoki derives a second-order approximation of the expected utility of the representative household (a loss function), and shows that it is a function of only the sticky-price inflation. As a result, he finds that stabilising sticky-price inflation is the optimal monetary policy. Hence, optimisation in Aoki's model is reached by a rule that responds only to core inflation.

Bodenstein, Erceg and Guerrieri (2008) show that in a DSGE model with a flexible price energy production factor, optimal monetary policy responds to core inflation. This core inflation is defined as the CPI excluding food and energy prices.

Following the above and the assumption in our model of immediate pass-through from the exchange rate and world prices to the import price in the local market, we define two core indices within the framework of the model:

- I. Domestic inflation,  $\pi_t^h$ , which is the CPI index excluding prices of housing, fuel, fruit and vegetables and imported consumer goods. We denote this core inflation index as CI. This price index accounts for about 43% of the CPI.

- II. The weighted sum of CI and the housing price component. We denote this second core inflation as CIH.<sup>7</sup> This price index accounts for about 64% of the CPI.

We compare the impulse response function of inflation, output gap and interest rate to a transitory 1% shock to prices of imported goods using three different inflation indices' Taylor rules:

- I. The year-on year expected CPI (headline inflation rule, HIR).
- II. The year-on year expected CI (core inflation rule, CIR).
- III. The year-on year expected CIH (CIHR).

The above is a simple positive method for analysing the monetary policy response to external imported price shocks. To perform a normative analysis, and following the literature, we use an ad hoc loss function. In the next section we summarise the loss function literature and analyse the implications of the different Taylor rules on the policy loss function.

### 3 The loss function

We assume that the loss function has three terms: the gap between actual core inflation and the inflation target, the consumption gap and the change in the policy interest rate. This is a loss function that represents the welfare of the representative household.

Next, we calculate the loss function defined above using the three alternative Taylor rule responses to a transitory shock in imported consumer goods. By comparing the ratio of the loss function calculated using one Taylor rule to that calculated using an alternative Taylor rule, we can conclude which of the two yields higher welfare.

Rotemberg and Woodford (1997) showed that in a closed economy model with price-setting framework a la Calvo,<sup>8</sup> the second-order approximation of the expected utility of the representative household, the loss function, is a function of inflation and output gap variance. The output gap variance stems from the household utility from consumption, which in a closed economy model without investments and government is equal to output. The inflation variance stems from the price dispersion, which in a staggered price-setting framework distorts the optimal allocation across consumer goods. Following Rotemberg and Woodford's analysis, the loss function has been widely used to compare monetary policy reaction functions in term of representative household welfare.

Levine et al (2008) showed that in a closed economy model for the Euro area with price-setting framework a la Calvo, an external<sup>9</sup> habit formation, investments and government, the external habit formation implies a loss function which is a function of the quasi-change in consumption gap. As consumption, which enters the utility function, does not equal output, the loss function is a function of the consumption gap instead of the output gap. They also showed, similar to Woodford (2003), that in the case of indexation of prices to the lagged

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<sup>7</sup> H stands for the CPI housing component.

<sup>8</sup> Although the Phillips curve in the model we use is derived within Rotemberg and not Calvo price-setting, because its basic structure is similar to a Calvo-style NKPC (although not in deep parameters, of course) we can proceed and follow Woodford.

<sup>9</sup> External habit formation means that the household utility depends on the difference between the household current consumption and the lagged aggregate consumption. Woodford (2003) assumes internal habit formation, ie that the household utility depends on the difference between its current and lagged consumption, when deriving a loss function.

price index, the loss function is also a function of a quasi-change in the inflation, and is given by

$$(9) L_t = (\pi_t - \gamma\pi_{t-1})^2 + \lambda_c (c_t - hc_{t-1})^2,$$

where  $\gamma$  measures the degree of price indexation and  $h$  denotes the level of external habit formation in consumption.

In order to derive the loss function, the utility function of the representative household should include disutility from labour in addition to consumption, and labour should be included in the output production function. Due to the fact that the model we use lacks these two characteristics, the loss function cannot be derived analytically. We therefore use an ad hoc quadratic loss function following the guidelines of Woodford (2003) and Levine et al (2008).

Following Levine et al (2008), the relative weight of consumption gap in the loss function,  $\lambda_c$ , when inflation weight is normalized, is given by:

$$\lambda_c = \frac{(1-h)^{-1} \sigma \gamma_c \phi_F (1-\beta \xi_p) (1-\xi_p)}{(1-1/\eta)(1-\alpha) \zeta \xi_p},$$

where  $\sigma$  is the inverse of the inter-temporal elasticity of substitution in the household utility function,  $\gamma_c$  is the share of consumption gap in the output gap,  $\phi_F$  is the gross share of fixed costs in output,  $\beta$  is the discount factor,  $\xi_p$  is Calvo parameter,  $\eta$  is the CES among differentiated labor types,  $\zeta$  is the elasticity of substitution among the competitive final goods and  $\alpha$  is the capital share in the Cobb-Douglas intermediate-goods-sector production function. Accordingly, in the core model of Levine et al (2008)  $\lambda_c = 0.081$ , assuming  $\alpha = 0.3$  and  $\gamma_c = 0.6$ .<sup>10</sup> Assuming that the Calvo parameter corresponds to our model is 0.75,  $\zeta = 7$ , and setting  $\eta = \infty$  and  $\phi_F = 1$  as our model lacks differentiated labor types and fixed costs respectively, and calibrating  $\alpha = 0.32$  we get that  $\lambda_c = 0.081$  in our model too.

However, for sensitivity analysis we choose to set  $\lambda_c = \{[0, \dots, 0.1], \text{ by } 0.005\}$ .

The observed tendency of central banks to adjust interest rates gradually implies that the loss function should also include an interest smoothing term. By including an interest rate smoothing term we use the ad hoc intra-temporal loss function

$$(10) L_t = (\pi_t - \gamma\pi_{t-1})^2 + \lambda_c (c_t - hc_{t-1})^2 + \lambda_i (i_t - i_{t-1})^2.$$

The result of estimation and calibration of a three-term loss function with an interest rate smoothing term is a wide range for the relative weight of the interest rate change,  $\lambda_i$ . In a small-scale NK model for the American economy, Dennis (2004) finds that  $\lambda_i = 12.82$  from 1966:Q1 to 2002:Q2,  $\lambda_i = 2.5$  for the Volker-Greenspan period, and  $\lambda_i = 2.78$  for the Greenspan period. Argov (2005) calibrates  $\lambda_i = 4$  for a small NK model for Israel, and Segal (2007) finds by calibration that  $\lambda_i$  should be higher than one, for a variant of the model we

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<sup>10</sup> Following Smets and Wouters (2003), which Levine et al (2008) use their model.

use in this paper. Hence, for sensitivity analysis we choose to set  $\lambda_i = \{[0, \dots, 16], \text{ by } 0.25\}$ .

The difference between the various policy rules in terms of the approximated welfare of the representative household can now be summarised by the expected loss function,

$$Loss(t, \infty) = E_t \sum_{j=0}^{\infty} \beta^j L_{t+j}$$

#### 4 Israeli data 2007–08

In this section we describe the main implications of the recent changes in commodity and oil prices on inflation and monetary policy in Israel.

The high volatility in international commodity and oil prices during the last two years was reflected both in the CPI and in core inflation indices in Israel. From January 2007 to July 2008 the Reuters commodity price index rose by 52.2% and oil prices by 131.1% (Figure 1); in the second half of 2008 the Reuters commodity price index fell by 53.1% and the price of oil by 69.1% as the global financial crisis intensified and economic activity contracted.

Figure 1  
The commodity price index and oil prices,  
2003 to December 2008



Source: Bloomberg.

The high volatility in international prices trickled into the CPI in Israel, which rose by 3.4% in 2007 and by 4.5% during the 12 months to November 2008 (Table 1). This inflation environment is considerably higher than the upper limit of the Israeli inflation target (1–3%).

However, this high price volatility was not fully reflected in core inflation indices,<sup>11</sup> which were separated from the CPI in August 2007. Hence, a monetary policy dilemma emerged regarding the appropriate inflation index to which to respond (Figure 2).

Table 1  
**The CPI and selected core inflation indices in Israel,  
 2007 to November 2008**

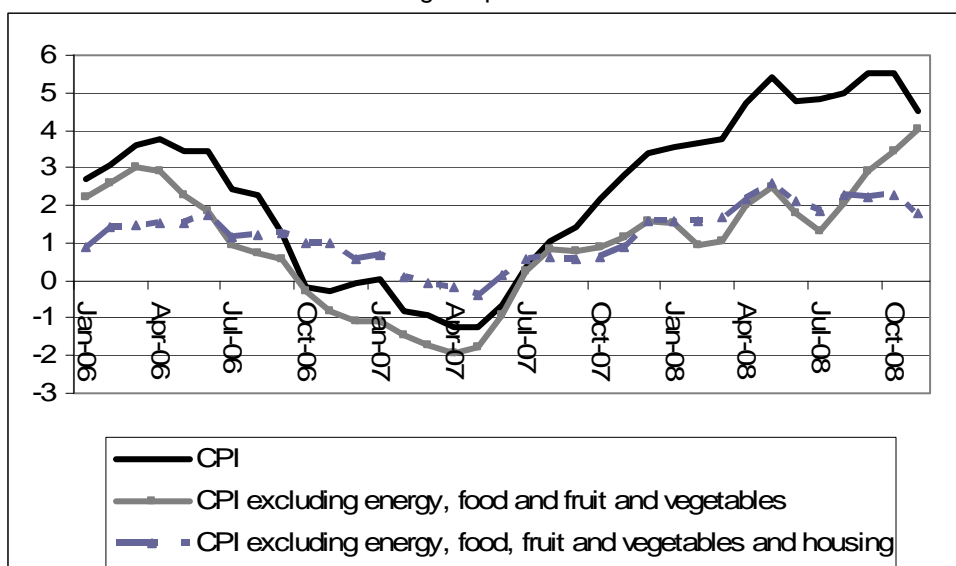
Percentage change in annual term

	2007	Dec. 2007- Nov. 2008	Jan.-June 2008	July-Nov. 2008
<b>CPI</b>	<b>3.4</b>	<b>4.5</b>	<b>4.7</b>	<b>0.9</b>
Energy	14.4	-2.8	11.5	-27.9
Food (excluding fruit and vegetables)	6.3	10.4	17.2	0.6
Fruit and vegetables	7.0	6.9	3.8	2.5
Housing	1.9	10.3	-2.6	23.4
<b>CPI excluding energy, food and fruit and vegetables</b>	<b>1.6</b>	<b>4.0</b>	<b>1.8</b>	<b>4.5</b>
<b>CPI excluding energy, food, fruit and vegetables and housing</b>	<b>1.5</b>	<b>1.8</b>	<b>3.6</b>	<b>-1.8</b>

Source: Based on Central Bureau of Statistics.

Figure 2  
**CPI and core inflation indices development in Israel,  
 2006 to November 2008**

Percent change in previous 12 months



Source: Based on Central Bureau of Statistics.

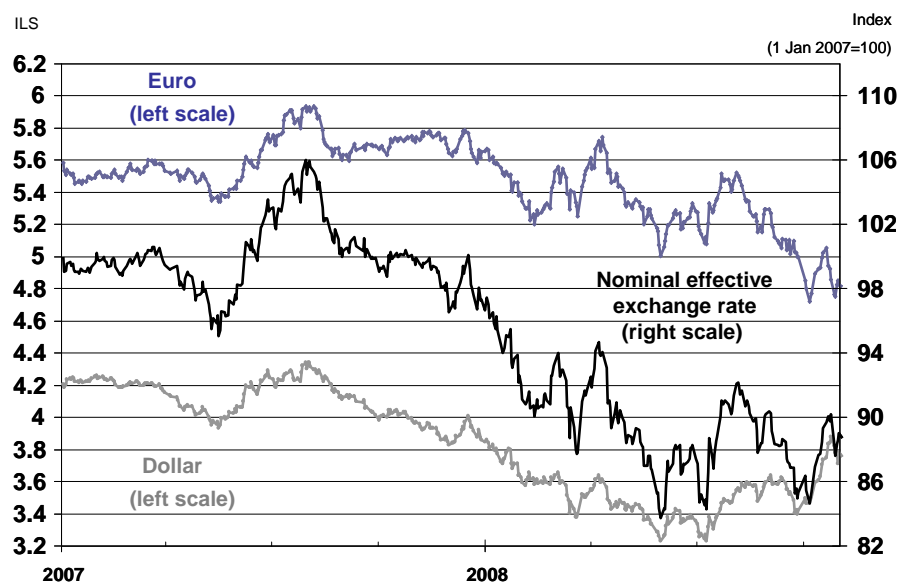
<sup>11</sup> These observable indices, unlike the indices in the model, do not relate to the unobserved imported consumer goods inflation,. Also, these indices exclude food and energy prices while the indices in the model exclude fuel prices instead..

The change in world food and oil prices has been reflected only partly in local prices due to the appreciation of the ILS throughout most of the period. The nominal effective exchange rate<sup>12</sup> showed appreciation of 12.9% from January 2007 to July 2008 (Figure 3), continuing the trend that started in 2006; in that period the ILS appreciated by 8.5% against the euro, and by 20.1% against the dollar. In March 2008 the Bank of Israel announced a plan to increase foreign exchange reserves by \$10 billion over the next two years by purchasing approximately \$25 million per day in the market, starting on 24 March. As a result of strengthening of the ILS, the indexation of the housing component<sup>13</sup> to the USD that resulted from the high inflation era of 1978-85 (Eckstein and Soffer (2006)) has weakened. Another reason for the fact that the change in domestic energy prices does not fully reflect the global change is the high tax component in the fuel price.<sup>14</sup>

Whereas the steep rise in local prices until the third quarter of 2008 mainly resulted from increases in food and energy prices, in the second half of 2008 the housing index, which rose by 9.2% (regular terms), led the rise in the CPI. This rise in the housing index was primarily the result of the renewal of rental contracts.<sup>15</sup>

Figure 3

**The ILS/US\$, ILS/Euro and the nominal effective exchange rates, 2007 to December 2008**



Source: Bank of Israel.

In the second half of 2008 the trend of the strengthening ILS against the dollar reversed, and the ILS depreciated by 21.8%. This occurred against the background of the worldwide strengthening of the dollar and the Bank of Israel announcement on 10 July to increase the rate of its purchases of foreign currency in the framework of its plan to increase the forex reserves (see above), from \$25 million to \$100 million per day.

<sup>12</sup> The weighted average exchange rate of the shekel against the currencies of Israel's trading partners.

<sup>13</sup> The housing component accounts for about 21% of the CPI.

<sup>14</sup> Tax accounts for 62% of the price of fuel (ILS5 per litre in December 2008).

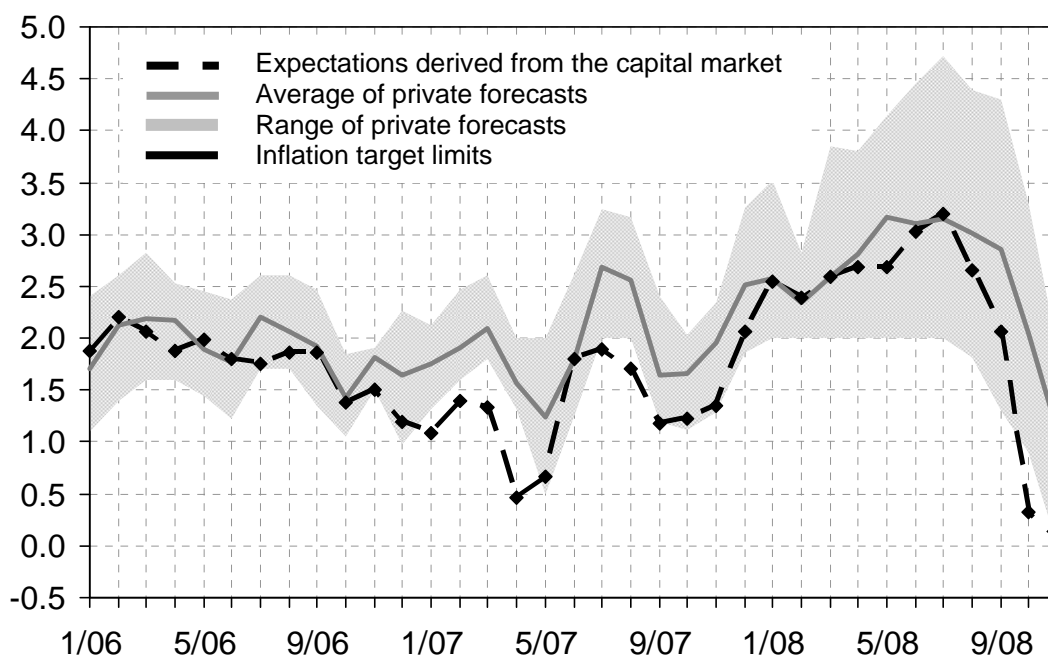
<sup>15</sup> Renewed rental contracts constitute about 75% of the housing index.

Israel's economic growth continued in the third quarter of 2008, albeit at a slower pace than in the last four years, when growth had averaged 5.3% a year. This slowdown was expected in light of the previous high growth rates and the global slowdown in economic activity.

Following these developments, policy decisions became more complex, with inflation risks countered by considerations of financial stability on the one hand and the support of real economic activity on the other. Expectations of inflation for the next 12 months, those derived from the capital market and those of private forecasters, were highly volatile during the last two years (Figure 4).

Figure 4

**Expectations of inflation for the next 12 months,  
derived from the capital market and according to private forecasters,  
December 2005 to November 2008**



Source: Private forecasters' reports and Bank of Israel.

In the first half of 2007 expectations were around the lower limit of the inflation target, due to the appreciation trend of the ILS. As a result, Bank of Israel gradually lowered the interest rate from 5.5% in October 2006 until it reached a level of 3.5% in June 2007. The appreciation trend, which reversed temporarily in the second quarter of 2007, together with the steep rise in food and energy prices and rapid domestic growth, brought inflation expectations to around the middle of the inflation target and led to increases in the Bank of Israel's interest rate for August and September 2007 and January 2008.

In March and April 2008 the interest rate was lowered again in light of expectations of an economic slowdown, but following the further rises in world and local prices, expectations in the second and third quarters climbed to the upper limit of the inflation target, and the interest rate was raised again in order to maintain credibility. In the end of the third quarter of 2008, in light of the deterioration in the global financial market and the economic slowdown, inflation expectations fell sharply to below the lower limit of the target. Hence, similarly to other central banks throughout the world, in the fourth quarter of 2008 the interest rate was cut sharply, twice in unscheduled decisions, and again for January 2009, to reach an unprecedented low level of 1.75%.



The question of whether monetary policy reacted too aggressively during 2008 arises because core inflation increased by less than 2% until August 2008, while headline inflation was significantly above the upper limit of the inflation target from December 2007. We analyse this question empirically in the next section.

## 5 Core inflation or headline inflation?

A 1% shock to the world price of imported goods raises inflation, and raises the real exchange rate as foreign prices denominated in local currency are higher than local prices. As a result, the different measures of inflation increase in the following order,  $HI > CI > CIH$ , and hence the policy rule implies that the interest rate should be raised. Figure 5 summarises the impulse response of the endogenous variables determined by the model as a result of import price shock.<sup>16</sup>

As the nominal interest rate increases, and due to nominal frictions in prices, the real interest rate also increases. Figure 5 indicates that the real interest rate path under policy rule that responds to core inflation, either  $CI$  or  $CIH$ , is higher than under headline inflation rule. Hence, the output gap and consumption gap are lower under core inflation rules (See Appendix B). As a result of the rise in the interest rates, both nominal and real exchange rate decrease and converge back to steady state.

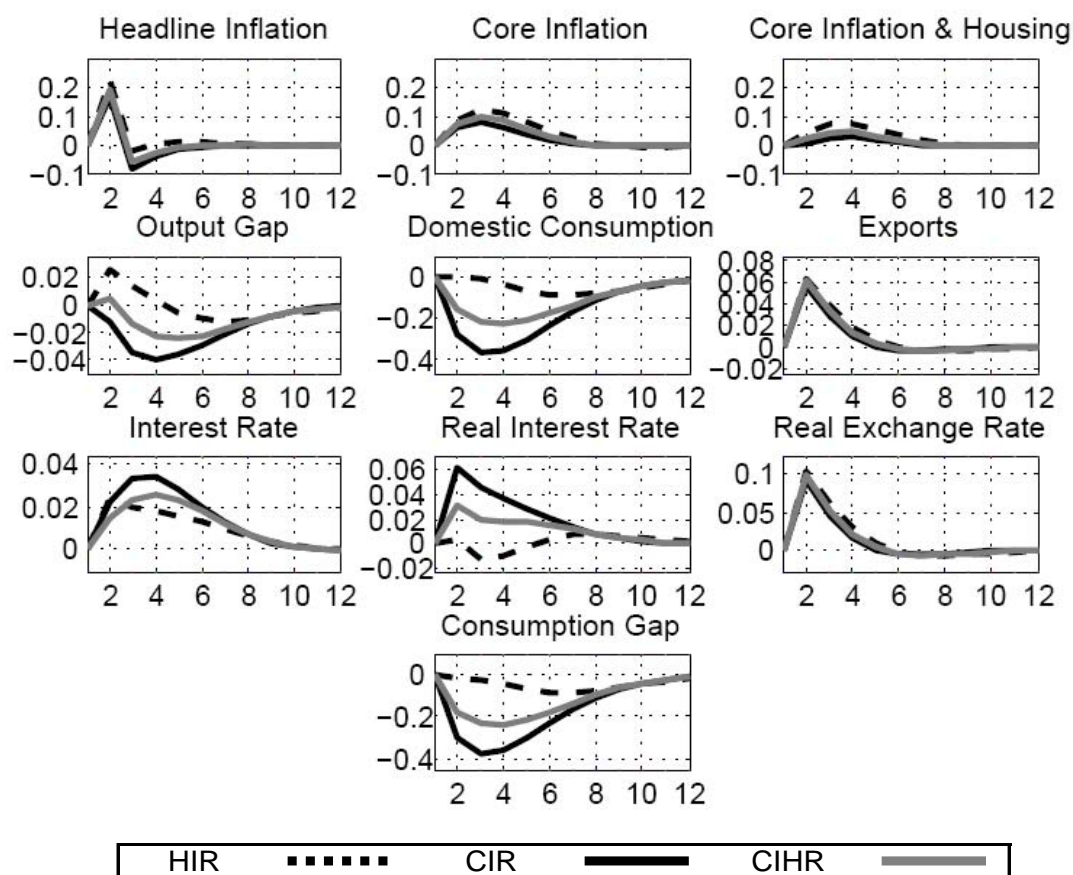
By assumption, investments and government spending are exogenous, hence the change in the output gap can be decomposed into two components: domestic consumption and exports. Affected by the real depreciation, domestic consumption declines (dominant effect), whereas exports rise.

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<sup>16</sup> All variables are expressed in log deviations from trend.

Figure 5

**Impulse response function relating to a 1% shock  
to world price of imported goods, alternative policy rules**



As a result of the shock, CI is higher than CIH due to the indexation of the housing component to the current and lagged nominal ILS/US\$ exchange rates. Due to the fact that the interest rate rises in response to the shock, according to the UIP condition, the expected nominal exchange rate reflects appreciation. Thus, CIH is lower than CI and the implication is a more moderate interest rate response for the CIH. The reason for the higher rise in the interest rate under CIR than under HIR is the negative headline inflation gap ( $CPI - \bar{\pi}$ ) from the third quarter, whereas the CI gap is positive until the seventh quarter. The higher decline in the expected output gap under CIR also contributes to the further increase in the interest rate.

Table 2 summarises the variances of the key variables among the alternative policy rules. The headline (CPI) inflation rule gives higher volatility of inflation than do the core inflation rules, while the volatilities of the output gap, consumption gap and interest rates are lower.

Table 2

**Output gap, inflation and interest rate variances  
among alternative policy rules**

	Output gap	Headline inflation	CI	CIH	Interest rate	Consumption gap
<b>HIR</b>	0.00009	0.00316	0.00215	0.00084	0.00007	0.00096
<b>CIR</b>	0.00021	0.00239	0.00078	0.00009	0.00017	0.02055
<b>CIHR</b>	0.00009	0.00276	0.00124	0.00028	0.00010	0.00853

The volatility of the consumption gap under CIR is 21 times higher than HIR and 9 times higher than CIHR. Furthermore, the volatility of the consumption gap under the CIR is higher than all other volatilities by more than the ratio of the corresponding relative weights in the loss function. The result is that the CIR is "out of the game," as shown below. The fact that interest rate volatility is lower under the CIH Taylor rule than under the CI Taylor rule is explained by the lower inflation—as the interest rate rises, the resulting nominal appreciation leads to a decline in the housing component of the CPI.

In what follows we describe the welfare implications of the different Taylor rules using the above loss function. As described in section 3, we use the following loss function:

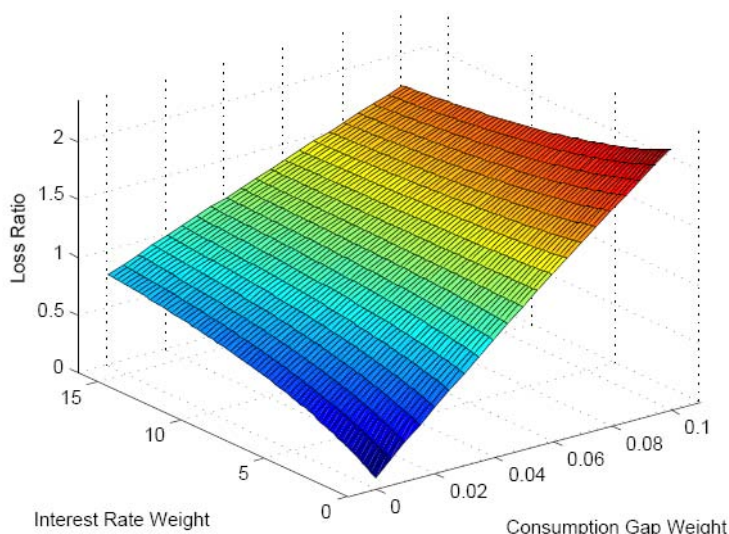
$$L_t = (\pi_t^{CIH} - \gamma\pi_{t-1}^{CIH})^2 + \lambda_c(c_t - hc_{t-1})^2 + \lambda_i(i_t - i_{t-1})^2,$$

where  $\pi^{CIH}$  enters the loss function because the CPI housing prices are sticky, by assumption, as housing prices develop as a function of both current and lagged nominal rates of ILS/US\$ depreciation.

Using Argov and Elkayam (2007) estimates, we set the degree of price indexation,  $\gamma = 0.42$ , and the level of external habit formation,  $h = 0.542$ . We found, as it is expected and described in Table 2, that the ratio of the loss function under the domestic inflation Taylor rule (CIR), to the loss function under the CPI Taylor rule (HIR) is above unity when the relative weight of the quasi-change in consumption is  $\lambda_c > 0.014$ . This implies that HIR is preferable to CIR for plausible loss function parameters (Figure 6).

Figure 6

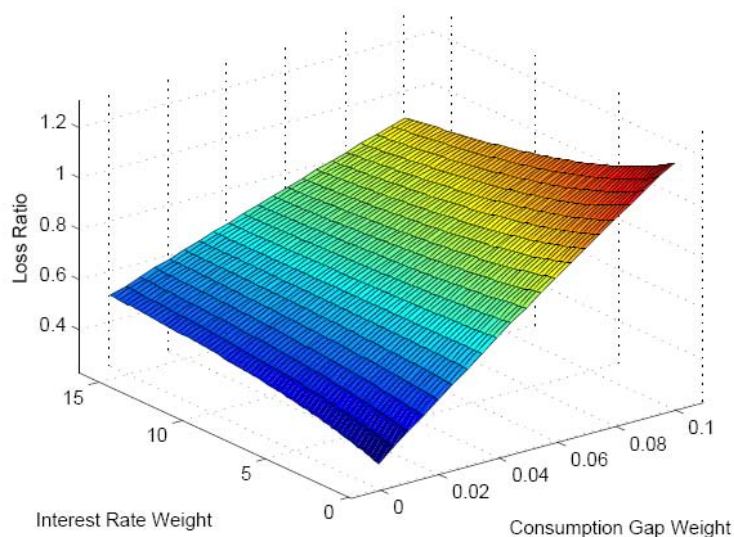
**Welfare loss ratio of CI Taylor rule to headline inflation Taylor rule**



Next, we calculated the ratio of the loss function under CIHR to that under HIR (Figure 7).

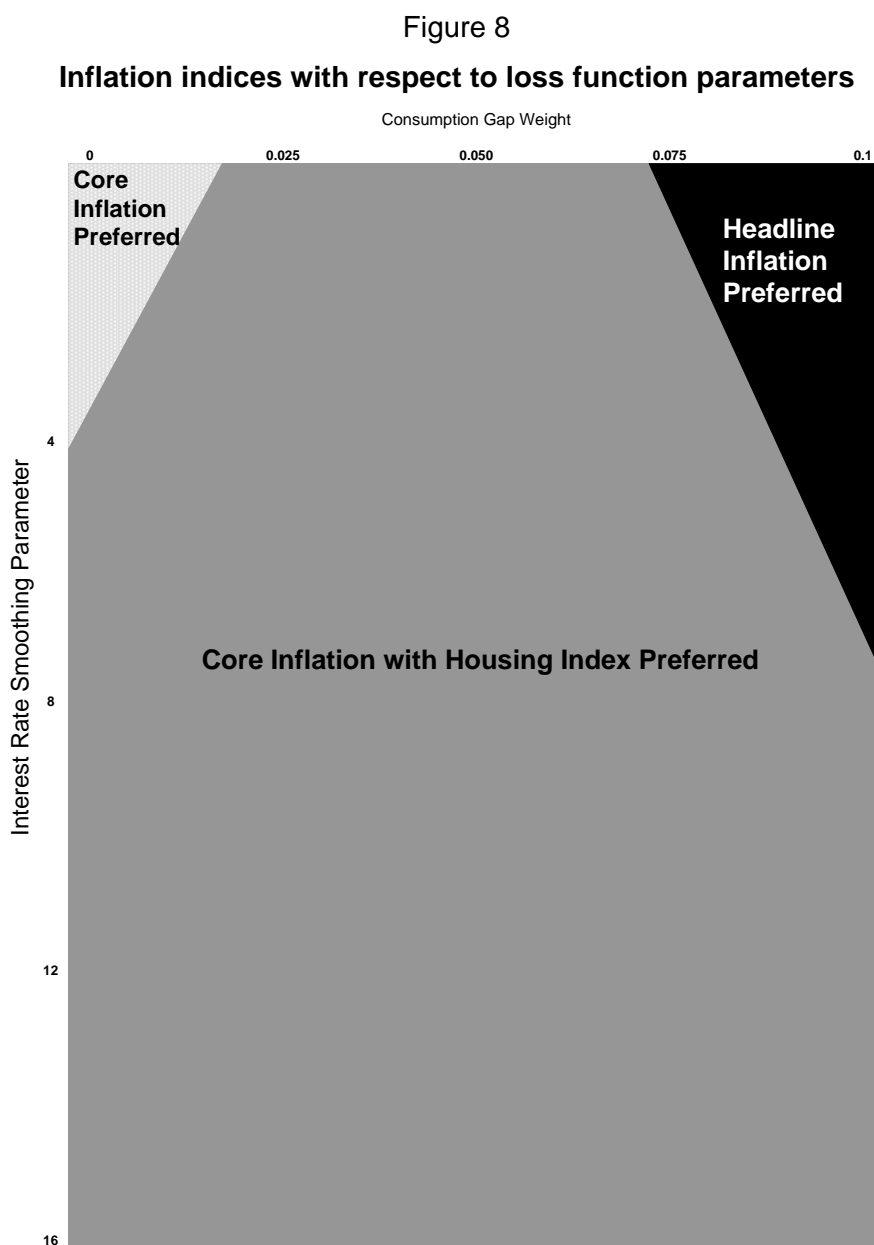
Figure 7

**Welfare loss ratio - CIH Taylor rule over headline inflation Taylor rule**



On the other hand, Figure 7 implies that for most of the plausible range of the loss function parameter values, monetary policy should respond to core inflation including housing, CIH, rather than to headline inflation. The advantage of CIHR (Figure 7) derives from the lower core inflation than that measured by HIR and the lower ratio between the volatilities of the consumption gap under the two policy rules, compared to the CIR and HIR consumption-gap ratio. This result is enhanced with the decrease in the weights of the consumption gap, but it is not monotonic with respect to the weights of the interest rate; for low weights of the consumption gap, the loss function ratio increases with the increase in the weights of the interest rate, while for high weights of the consumption gap it decreases.

Figure 8 summarises the results of Figure 6 and Figure 7.



## 6 Conclusions

Should monetary policy respond to headline inflation or core inflation? Most central banks' primary mandate is to achieve overall CPI price stability. However, as an external price shock leads to a trade-off between inflation and the output gap, most central banks monitor core inflation as part of the policy decision-making process, as it reduces transitory noise and could prevent the central bank from responding too strongly to transitory shocks. For example, the January 2009 minutes of the Federal Open Markets Committee (FOMC) contain projections of PCE (Personal Consumption Expenditures) inflation as well as Core PCE, which is the price index for PCE excluding food and energy. Similarly, The Bank of Israel minutes of discussions on the interest rate for February 2008-January 2009 contain overall CPI change in the last 12 months as well as CPI excluding food, energy and fruit and vegetables.

We answer this question using a small open economy New Keynesian model and a simple loss function adapted to the Israeli economy. We find that a Taylor rule that responds to core inflation that includes the CPI housing component is preferred. Analysing an impulse response function relating to a shock to imported consumer prices, we find that the output gap loss is lower when policy responds to headline inflation rather than to core inflation. However, as welfare is affected not only by output gap volatility but also by inflation volatility and interest rate changes, using an ad hoc quadratic loss function we find that the monetary policy should respond to core inflation in order to maximise the welfare of the household, despite the higher loss in terms of the output gap and consumption gap.

However, the conclusion that monetary policy should respond to core inflation cannot be viewed as a general result, as the welfare loss function depends on the particular structure of the model, and by definition, contains price components that are not flexible. Moreover, the analysis above ignores credibility considerations. When headline inflation diverges from core inflation for a long period, a central bank that responds to core inflation may find it hard to communicate with the public and explain the advantages of its policy.

## Appendix A: The stages of development of the model (Argov and Elkayam (2007))

### I. Households

The representative household  $j$  consumes a Dixit-Stiglitz bundle of domestic and imported goods,  $C_t^h$  and  $C_t^f$  respectively. The households' utility is characterised by external habit formation - it depends on households' current consumption relative to lagged aggregate consumption:

$$(1) u(C(j)_t) = \frac{(C(j)_t - hC_{t-1})^{1-\sigma}}{1-\sigma},$$

where  $h \in (0,1)$  represents the strength of habit formation and  $\sigma^{-1}$  is the inter-temporal elasticity of substitution. Household  $j$  chooses consumption, domestic bond holdings,  $B(j)_t$ , and foreign bond holdings,  $B(j)_t^f$ , which maximises its expected utility subject to the budget constraint:

$$(2) C(j)_t + \frac{B(j)_t}{(1+i_t)P_t^c} + \frac{\varepsilon_t B(j)_t^f}{(1+i_t^*)\Phi_t P_t^c} = \frac{B(j)_{t-1}}{P_{t-1}^c} + \frac{\varepsilon_t B(j)_{t-1}^f}{P_t^c} + X(j)_t,$$

where  $\Phi_t$  is a risk premium paid on foreign assets,  $\varepsilon_t$  is the nominal exchange rate,  $X(j)$  is the household share of aggregate real profits in the domestic economy,  $i_t$  and  $i_t^*$  are domestic and foreign risk-free rates, respectively, and  $\beta$  is the subjective quarterly discount rate.

Log-linearisation of the first-order conditions of the household problem yields the inter-temporal consumption condition (Euler equation):<sup>17</sup>

$$(3) c_t = \frac{1}{1+h} E_t c_{t+1} + \frac{h}{1+h} c_{t-1} - \frac{1-h}{(1+h)\sigma} (i_t - E_t \pi_{t+1}^c),$$

the UIP condition:

$$(4) e_t = E_t e_{t+1} + i_t^* - i_t + \phi_t,$$

and the demand for domestically produced goods bundles:

$$(5) c_t^h = c_t - \eta(p_t^h - p_t^c),$$

where  $\eta$  is the intra-temporal elasticity of substitution. The aggregate price level, excluding housing, fuel, and fruit and vegetables prices, which is a CES function of domestic goods,  $p_t^h$ , and imported goods,  $p_t^f$ , is given by

$$(6) p_t^c = (1 - w_c^f) p_t^h + w_c^f p_t^f,$$

---

<sup>17</sup> Lower-case letters denote log deviations from steady-state of the variables.

where  $w_c^f$  is the long-run share of imports in consumption. Assuming the same intra-temporal elasticity of substitution  $\eta$  abroad, the demand for the local economy's exports is

$$(7) \quad x_t^h = y_t^* - \eta(p_t^h - e_t - p_t^*),$$

where  $y_t^*$  is world trade and  $p_t^*$  is the price of consumer goods in the foreign economy. Assuming the law of one price, and that prices in the export sector are flexible,  $p_t^h - e_t$  is the export price in foreign currency. Finally, the real exchange rate is defined as

$$(8) \quad q_t = p_t^* + e_t - p_t^h.$$

Log-linearisation of the national account identity yields:

$$(9) \quad y_t = \gamma_c c_t^h + \gamma_g g_t^h + \gamma_x x_t^h + (1 - \gamma_c - \gamma_g - \gamma_x) \text{inv}_t^h,$$

where  $y_t$  is the output gap,  $g_t^h$  and  $\text{inv}_t^h$  are government consumption and investment, in value added terms, and  $\gamma_i$  is the long-run share in output of component  $i$ .

Using (3)–(9) the output gap equation is given by:

$$(10) \quad y_t = a_h E_t y_{t+1} + (1 - a_h) y_{t-1} - a_i (i_t - E_t \pi_{t+1}) + a_q (q_t - a_h E_t q_{t+1} - (1 - a_h) q_{t-1}) \\ + a_g ((g_t^h - a_h E_t g_{t+1}^h - (1 - a_h) g_{t-1}^h) + a_{\text{inv}} ((\text{inv}_t^h - a_h E_t \text{inv}_{t+1}^h - (1 - a_h) \text{inv}_{t-1}^h) \\ + ((y_t^* - a_h E_t y_{t+1}^* - (1 - a_h) y_{t-1}^*) + v_t^y),$$

where

$$a_i = -\frac{(1-h)\gamma_c}{(1+h)\sigma}; \quad a_q = \frac{\eta(\gamma_c w_c^f + \gamma_x)}{1 - w_c^f}; \quad a_g = \gamma_g; \quad a_{\text{inv}} = (1 - \gamma_c - \gamma_g - \gamma_x); \quad a_x = \gamma_x,$$

$$\text{and } \pi_t^c = p_t^c - p_{t-1}^c.$$

According to equation (10), the output gap is determined by the real interest rate, the real exchange rate, government spending, investments and world trade.

## II. Domestic producers inflation equation

Following Rotemberg's (1982) price-setting, firms choose a price sequence to minimise the cost of price changes due to a menu cost shock and the cost of deviating from the flexible price:

$$(11) \quad \min E_t \sum_{\tau=0}^{\infty} \delta^\tau [(p(i)_{t+\tau}^h - \tilde{p}(i)_{t+\tau}^h)^2 + c(p(i)_{t+\tau}^h - p(i)_{t+\tau-1}^h)^2],$$

$$\{p(i)_{t+\tau}^h\}_{\tau=0}^{\infty}$$

where  $\tilde{p}(i)_t^h$  is the optimal flexible price that would have been chosen by the firms in the absence of adjustment costs, and  $\delta$  is a discount factor.

The first order condition for the firm's optimisation problem is

$$(12) \quad p(i)_t^h - p(i)_{t-1}^h = \delta(E_t p(i)_{t+1}^h - p(i)_t^h) + \frac{1}{c} (\tilde{p}(i)_t^h - p(i)_t^h),$$

where  $\tilde{p}(i)_t^h$  is solved from the profit maximisation under flexible prices:



$$(13) \max \quad \tilde{P}(i)_t^h C(i)_t^h + \tilde{P}(i)_t^x \varepsilon_t X(i)_t^h + P_t^g G_t^h + P_t^{inv} INV_t^h - P_t^z Z(i),$$

$$\tilde{P}(i)_t^h, \tilde{P}(i)_t^x, Z(i)$$

subject to the aggregate output identity, and the production function

$$(14) Y(i)_t = Z(i)_t^{1-\theta} = [(Z(i)_t^h)^{1-w_f^z} (Z(i)_t^f)^{w_f^z}]^{1-\theta},$$

where  $Z(i)_t^h$  and  $Z(i)_t^f$  are intermediate domestic and imported inputs respectively,  $P_t^z$  is the aggregate price of intermediate inputs and  $w_f^z$  is the share of imports in intermediate goods. The price and quantity of government spending and investments are, by assumption, exogenous.

The local demand function (5), demand for export (7), the production function (14) and F.O.C. of the flexible price optimisation problem yield the optimal flexible price

$$(15) \tilde{p}_t^h = p^t z + \frac{\theta}{1+\theta} y_t.$$

The RHS of the optimal flexible price is the log deviation of nominal marginal cost, where the cost minimising input price aggregator is given by

$$(16) p_t^z = (1 - w_f^z) p_t^{zh} + w_f^z p_t^{zf} ..,$$

where  $p_t^{zh}$  and  $p_t^{zf}$  are the prices of domestic and imported inputs to production. The local price of inputs is, by assumption, equal to domestic consumer prices,  $p_t^{zh} = p_t^h$ .

From this assumption and the first-order condition for the firm's optimisation problem, the optimal flexible price and the input price aggregator, the inflation of domestically produced consumer goods is given by

$$(17) \pi_t^h = \delta E_t \pi_{t+1}^h + \frac{1}{c} \frac{\theta}{1-\theta} y_t + \frac{w_f^z}{c} (p_t^{zf} - p_t^h).$$

Assuming that only a fraction  $\lambda$  of the firms set their price accordingly, while a fraction  $(1-\lambda)$  adjust their price to last period's domestic inflation (and set  $\delta=1$ ), domestically produced consumer goods inflation is given by:

$$(18) \pi_t^h = \lambda E_t \pi_{t+1}^h + (1-\lambda) \pi_{t-1}^h + \lambda \frac{1}{c} \frac{\theta}{1-\theta} y_t + \lambda \frac{w_f^z}{c} (p_t^{zf} - p_t^h).$$

The assumption of an immediate pass-through from the exchange rate and world prices to the import price in the domestic market yields  $p_t^f = e_t + p_t^*$ . The unobservable difference  $p_t^{zf} - p_t^h$  can be written as the sum of two components:<sup>18</sup> the temporary deviation (from trend) in the world relative price of inputs,  $p_t^{zc*} = p_t^{z*} - p_t^*$ , and a weighted real exchange rate,

$$\frac{1}{1-w_f^c} q_t.$$

<sup>18</sup> See Argov and Elkayam (2007), Appendix A.

Plugging this decomposition, the Phillips curve for domestically produced consumer goods, which can be estimated, is

$$(19) \pi_t^h = \lambda E_t \pi_{t+1}^h + (1-\lambda)\pi_{t-1}^h + \lambda \frac{1}{c} \frac{\theta}{1-\theta} y_t + \lambda \frac{w_f^z}{c} [p_t^{zc*} + \frac{1}{1-w_f^c} q_t].$$

### III. The nominal exchange rate equation

According to the UIP condition (4), the spot nominal exchange rate is affected by future rate expectations,  $e_{t+1}^{\text{exp}}$ , and the interest rate differential:

$$(20) e_t = e_{t+1}^{\text{exp}} + i_t^* - i_t + \phi_t.$$

By assuming that households' expectations with respect to the exchange rate are partly rational and partly adaptive,

$$(21) e_{t+1}^{\text{exp}} = (1-\omega)e_t^{\text{exp}} + \omega E_t e_{t+1},$$

the equation for the exchange rate is given by

$$(22) e_t = \omega E_t e_{t+1} + (1-\omega)e_{t-1} + (i_t^* - i_t) - (1-\omega)(i_{t-1}^* - i_{t-1}) + \phi_t - (1-\omega)\phi_{t-1}.$$

### IV. The monetary policy rule

The central bank sets its interest rate according to an expanded forward-looking Taylor rule:

$$(23) i_t = (1-k_i)[r_t + \bar{\pi}_t + k_\pi (E_t \pi_{t+\mathcal{G}}^R - \bar{\pi}) + k_y y_t] + k_i i_{t-1},$$

where  $\pi_{t+\mathcal{G}}^R$  is the year-on-year inflation rate at  $t+\mathcal{G}$ ,  $\bar{\pi}$  is the inflation target,  $r_t$  is the forward yield to maturity on indexed-linked Treasury bonds, a proxy to the natural rate, and the inflation forecast horizon is  $\mathcal{G}$  quarters.

### V. CPI component equations

The model is closed with three ad hoc equations for housing, fuel, and fruit and vegetable prices in the CPI. The CPI housing component equation is a function of the nominal rate of depreciation of the ILS against the dollar,  $de_t$ , and the inflation target,  $\bar{\pi}_t$ :

$$(24) \pi_t^{\text{housing}} = \rho(de_t + \bar{\pi}) + (1-\rho)(de_{t-1} + \bar{\pi}).$$

The CPI fuel component equation is given by

$$(25) \pi_t^{\text{fuel}} = f\bar{\pi} + (1-f)(de_t + \pi_t^{\text{brent}}),$$

where  $\pi_t^{\text{brent}} = \bar{\pi} + \varepsilon_t^{\text{brent}}$  is the price change of a barrel of crude oil, and  $\varepsilon_t^{\text{brent}}$  is a random shock.

The equation for the fruit and vegetables component is

$$(26) \pi_t^{f\&v} = \pi_t^h + \varepsilon_t^{f\&v}.$$

CPI inflation is calculated from the identity

$$(27) \pi_t^{\text{CPI}} = w^H \pi_t^{\text{housing}} + w^{\text{fuel}} \pi_t^{\text{fuel}} + w^{f\&v} \pi_t^{f\&v} + w \pi_t.$$

Finally, imported consumer goods inflation in local currency, assuming an immediate pass-through, is given by

$$(28) \pi_t^* = p_t^* - p_{t-1}^* + de_t + \varepsilon_t^* .$$

## Appendix B: Deriving the consumption gap from the Euler equation

Starting from the Euler equation

$$(3) \quad c_t = \frac{1}{1+h} E_t c_{t+1} + \frac{h}{1+h} c_{t-1} - \frac{1-h}{(1+h)\sigma} (i_t - E_t \pi_{t+1}^c),$$

we obtain:

$$(1+h)c_t = E_t c_{t+1} + hc_{t-1} - \frac{1-h}{\sigma} (i_t - E_t \pi_{t+1}^c)$$

⇓

$$(c_t - hc_{t-1}) = (E_t c_{t+1} - hc_t) - \frac{1-h}{\sigma} (i_t - E_t \pi_{t+1}^c),$$

which by iterating forward, and assuming the law of iterated expectations, yields

$$(c_t - hc_{t-1}) = -\frac{1-h}{\sigma} \sum_{j=0}^{\infty} (E_t i_{t+j} - E_t \pi_{t+j+1}^c).$$

Hence, the consumption gap is given by:

$$c_t = hc_{t-1} - \frac{1-h}{\sigma} \sum_{j=0}^{\infty} (E_t i_{t+j} - E_t \pi_{t+j+1}^c).$$

**Appendix C:  
Estimated and calibrated parameters  
(Argov and Elkayam (2007))**

$\beta$	$h$	$\sigma$	$\eta$	$w^f$
0.99	0.542	0.336	0.379	0.39
$\gamma_c$	$\gamma_x$	$\gamma_g$	$\lambda$	$k_i$
0.48	0.156	0.225	0.58	0.8
$k_y$	$k_\pi$	$\rho$	$f_1$	$k$
0.5	2.0	0.75	0.75	0.0254

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# Measures of core inflation in Korea

Jae Chun Kim,<sup>1</sup> Yang Woo Kim<sup>2</sup> and Seung Yong Lee<sup>3</sup>

## I. Introduction

Most central banks adopting inflation targeting as a monetary policy regime take the headline consumer price index (CPI) as a target index. This is because the CPI broadly mirrors the changes of prices in goods and services and can capture effectively the changes in inflation and welfare that people experience in daily life.

Headline CPI, however, includes various items, the prices of which are critically influenced by temporary shocks such as weather conditions, unexpected surges in international raw material price, or one-off effects stemming from the change in government policies. Thus, headline CPI is sometimes not the most useful index for grasping the underlying trend of inflation in the short run.

Meanwhile, having generally enjoyed low and stable prices since the early 2000s, most of the key economies in the world are now going through the final phase of a boom and bust cycle in asset (housing) prices based upon liquidity expansion, owing to sustained low interest rates and financial market innovations such as derivatives. In this regard, the argument may be put forward that monetary policy may fail to cope properly with increasing pressure on asset prices under an inflation targeting regime using headline CPI as its target index, which does not include asset prices.

In this paper, we examine the possibility that we can fix the problems mentioned above to improve the usefulness of CPI. First, we measure the core inflation indices that reflect cross-sectional information in the Korean CPI series. Second, we calculate the dynamic factor index (DFI), which Bryan et al (2002) have proposed to reflect the trend of asset prices in the CPI, and evaluate its usefulness as an information variable for monetary policy.

## II. Measures of core inflation and its usefulness

### 1. CPI based measures of core inflation<sup>4</sup>

The cross-sectional distribution of the growth rates of the individual CPI components is different from a normal distribution in that it is fat-tailed. Table 1 gives some important statistics on the monthly cross-sectional distribution of the Korean CPI, where the kurtosis measuring the extent of the thickness of tails is 8.8 on a monthly average; greater than the

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<sup>4</sup> This section is based on Seung Yong Lee and Jung Min Park (2008).

3 under a normal distribution. The fat tail, which means that items with high volatility are concentrated at both extremes of the distribution, implies that the rate of increase in the Korean CPI is generally affected by items located at both tails of the cross-sectional distribution.

The skewness is 0.75 on a monthly average, meaning that the distribution is right-skewed and differs significantly from normal distribution, where skewness is zero. Resulting from downward stickiness, this means that the number of items with prices that decrease is smaller than that of those with prices that increase.<sup>5</sup>

Table 1  
**Statistics on the cross-sectional distribution  
of the rate of increase in the CPI**

	Average	Standard deviation	Skewness	Kurtosis
Whole period (Jan. 1991–Dec. 2007)	4.27	6.74	0.75	8.80
Before currency crisis (Jan. 1991–Nov. 97)	5.77	7.13	0.47	8.07
After currency crisis (Jun. 2000–Dec. 2007)	3.06	5.86	0.91	9.88
Currency crisis period (Dec. 1997–May 2000)	3.78	8.32	1.05	7.55

The characteristic of Korean CPI distribution shows that the growth rate in headline CPI has high volatility, influenced by some items that increased or decreased greatly. Thus, in addition to headline CPI, it is necessary to develop an index that minimises misleading signals such as temporary or one-off factors in order to determine the appropriate stance of short-term monetary policy. For this purpose, we measured core inflation in Korea using a trimmed mean method and an exclusion-based method, which appropriately remove the influence of the items located at both tails of the cross-sectional distribution.

### ***Trimmed mean method***

The trimmed mean method obtains the core inflation for a given month by first sorting the individual price changes in ascending order; second, discarding a certain fraction of the tails in the distribution; and finally calculating the weighted average of the remaining components. The fraction to be trimmed is predetermined but the components to be excluded vary with each trim. Since the cross-sectional distribution of consumer price changes for Korea is asymmetric, we also apply a different fraction of extreme observations to each tail.<sup>6</sup>

To apply the different fraction of exclusion to each tail, the percentile that corresponds to the sample mean of the distribution is calculated and is designated the mean percentile. The result indicates that the 57th percentile is the mean percentile for the 1991–2007 period. If we use 10% as the fraction of total exclusion, the 57th percentile gives us 5.7% for the left tail and 4.3% for the right tail.

<sup>5</sup> Comparing the cross-sectional distributions of growth rates in the Korean CPI before and after the 1997–98 currency crisis tells us that the skewness and kurtosis increased, which means that the price movements of some items had greater influence on total CPI after currency crisis than before.

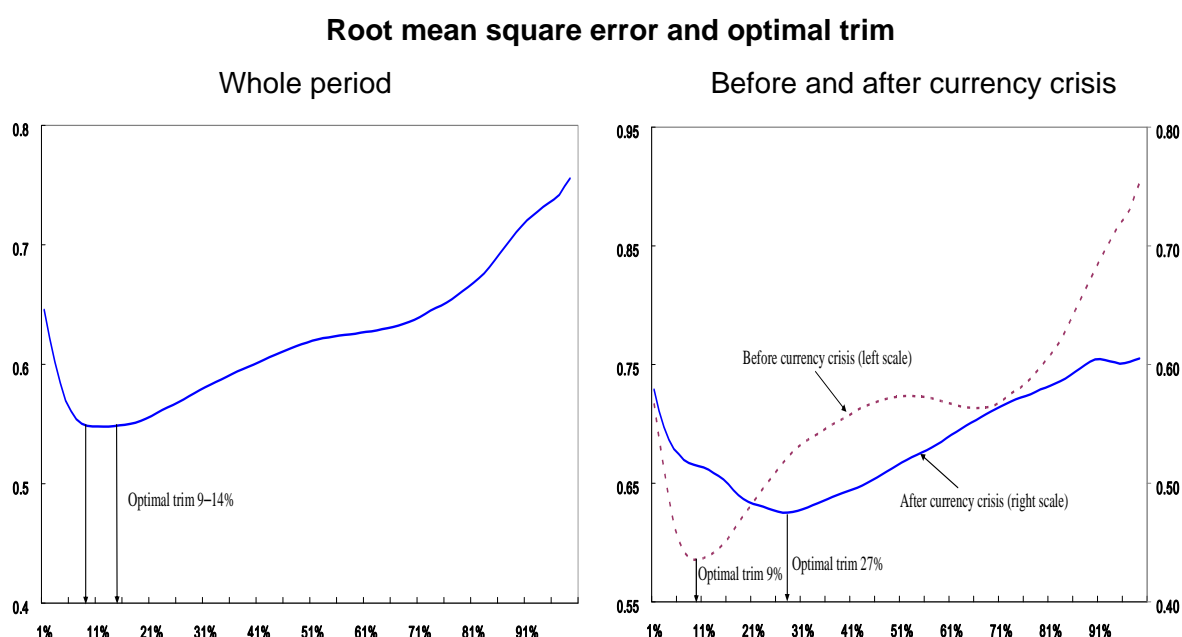
<sup>6</sup> If the cross-sectional distribution is symmetric, the same fraction of extreme observations is trimmed from each tail; for asymmetric distribution, a different fraction is applied. This is because if the distribution is asymmetric and the same fraction is trimmed from each tail, the mean will not be an unbiased estimator.



To find the optimal trim, we obtained 99 different trimmed series, from 1% to 99% trimmed series, and calculated the root mean square error (RMSE) of these series versus a measure of trend inflation. The trend or benchmark inflation rate is defined as the centred 24-month moving average of CPI inflation. We found that the smallest RMSE lies in the range of 9% (left tail: 5.13%, right tail: 3.87%) to 14% (left tail: 7.98%, right tail: 6.02%). When we divided the period into two, before and after the currency crisis, the optimal trim was 9% before the crisis and 27% after it (see Figure 1).

We also used other series of the benchmark inflation rates, the 30-month and 36-month moving average series and the HP-filtering series to find the robust optimal trim. For the 30-month and HP-filtering benchmark, 18% was optimal, and for the 36-month benchmark, 20% was optimal during the whole period. For the period after the crisis, the optimal trim was in the range of 26–30%.

Figure 1



Based on these calculations, we conclude that the optimal trim is 18%<sup>7</sup> for the whole period and 27% for the period after the crisis. But we face the problem of choice between the two candidates. We chose 18% as the optimal trim because the period after the currency crisis is rather short. A long series has been used for the calculation of the optimal trim in most research papers, even though there seems to have been a structural change during the crisis period. This method using the 18% trimmed mean is termed TRIM<sub>82</sub>.

### **Exclusion-based method**

The exclusion-based method is a core inflation measure that selects ex ante the items that have been frequently at the extreme of cross-sectional distribution of price changes and excludes these items. This method has the fixed items excluded from the CPI basket. To select the volatile items in the CPI basket, the specific criteria below are applied:

- 1) Items of which 12-month changes exceed 1.5 times the standard deviation from the average.

<sup>7</sup> For the 24-month and 36-month benchmarks, the 18% trim shows a difference of within 1% from the smallest RMSE, and 30-month and HP-filtering benchmarks obtain the smallest RMSE at the 18% trim.

2) Items that are among the items fulfilling criterion 1 for more than 25% of the observation period.

Table 2 shows 11 items (fruit, vegetables, other agricultural products, salted and dried fish, other livestock products, durables for culture and recreation, other durables, fuel for transport, fuel for heating and cooking, municipal gas, cigarettes) that are frequently located on the tails of a cross-sectional distribution of price changes. However, we do not exclude durables for culture and recreation or other durables from the CPI basket, because their prices have shown a persistently decreasing tendency due to innovation in the information technology industries.<sup>8</sup> Salted and dried fish and other livestock products are not eliminated either, because their weights in the CPI are too small.

Table 2  
Highly volatile items in the CPI

	Frequency of elimination (%)	Average	Standard deviation
Fruit (16.7)	72.1	7.8	17.4
Vegetables (14.5)	51.5	8.0	16.2
Other agricultural products (7.1)	25.5	6.3	10.7
Fuel for heating and cooking (6.9)	49.5	10.8	15.3
Fuel for transport (47.0)	27.5	9.5	11.6
Municipal gas (16.1)	31.4	6.0	11.5
Cigarettes (10.8)	30.4	7.2	9.5
Durables for culture and recreation (9.4)	43.1	-6.1	5.5
Other durables (4.3)	39.2	-6.3	7.3
Other livestock products (2.8)	34.8	4.1	13.1
Salted and dried fish (2.1)	24.5	5.4	9.1

1) Figures in parentheses are the weights (%) in the CPI basket

Below, we categorise remaining seven items into agricultural products, petroleum products and cigarettes, and then make the various compositions including public service charges. Public service charges are included because they are affected by the one-off effects of government policies and are mainly adjusted in a specific period (first quarter every year), although their variance does not fulfil the criteria. In addition, we chose a candidate excluding food and energy, which is the most popular core inflation measure in the United States. Table 3 shows six candidates.

<sup>8</sup> Durables for culture and recreation and other durables have fulfilled the criteria 88 times (43.1%) and 80 times (39.2%) respectively. However, these two items have almost always been located in the left extreme.

Table 3

**Coverage of each case using exclusion-based method**

	<b>Excluded items</b>	<b>Weights</b>
Case 1	<ul style="list-style-type: none"> <li>• Agricultural products excluding cereals</li> </ul>	961.7
Case 2	<ul style="list-style-type: none"> <li>• Petroleum products including municipal gas</li> </ul>	930.0
Case 3	<ul style="list-style-type: none"> <li>• Agricultural products excluding cereals</li> <li>• Petroleum products including municipal gas</li> </ul>	891.7
Case 4	<ul style="list-style-type: none"> <li>• Agricultural products excluding cereals</li> <li>• Petroleum products including municipal gas</li> <li>• Cigarettes</li> </ul>	880.9
Case 5	<ul style="list-style-type: none"> <li>• Agricultural products excluding cereals</li> <li>• Petroleum products including municipal gas</li> <li>• Public service charges</li> </ul>	733.9
Case 6	<ul style="list-style-type: none"> <li>• Food excluding alcoholic beverages</li> <li>• Petroleum products including municipal gas</li> <li>• Electricity charges</li> </ul>	668.1

Next, the ability of candidate indicators to track trend inflation is compared by using the centred 24-month moving average of CPI inflation as a benchmark. Table 4 shows various exclusion-based methods compared with benchmark inflation by using the RMSE and the mean absolute deviation (MAD).

Table 4

**RMSE<sup>1)</sup> of various exclusion-based methods**

in per cent

	<b>Case 1</b>	<b>Case 2</b>	<b>Case 3</b>	<b>Case 4</b>	<b>Case 5</b>	<b>Case 6</b>
Whole period	22.3 (12.4)	0.0 (2.3)	5.1 (0.0)	9.8 (4.8)	36.3 (33.6)	15.5 (10.0)
Before currency crisis	0.0 (0.0)	20.8 (17.2)	17.1 (10.5)	20.0 (12.4)	61.9 (60.4)	17.1 (5.4)
After currency crisis	25.5 (21.8)	11.9 (11.8)	0.0 (0.0)	11.3 (10.4)	41.2 (30.7)	45.4 (40.5)

Notes: 1) [RMSE/minimal RMSE – 1] × 100. 2) Figures in parentheses are MAD.

In the results of the comparison, Case 3 (CPI\_X1), which excludes agricultural and petroleum products (including municipal gas) from the CPI, and Case 2 (CPI\_X2), which excludes petroleum products (including municipal gas), are evaluated as effectively eliminating the temporary and disturbing factors of inflation. CPI\_X1, which is officially calculated by the Korean National Statistical Office, turns out still to be a useful indicator. Also, CPI\_X2 can be used as a supplementary indicator when oil prices are on the rise.

The exclusion-based method is easy to measure and we can therefore select the excluded items according to the characteristics of supply shocks. For example, the core measure used in the United States (Case 6, Core\_US), which excludes energy and food, is helpful in assessing the trend of underlying inflation when both oil prices and agricultural prices are rising steeply.

### Usefulness of CPI-based measures

Core inflation indicators measured by the trimmed mean method and exclusion-based method are evaluated for their usefulness based on a variety of criteria. Trimmed mean core inflation has relative superiority in its ability to track the underlying trend of inflation. In ability to forecast the future direction of headline inflation, there is no meaningful difference between them. Concerning the reversion of headline CPI inflation to core indicators, we find that both indicators show statistically significant reversion over the six-month horizon, which means that headline inflation in Korea has tended to revert more strongly towards core indicators than core indicators have moved towards headline inflation (see Table 5). It should, however, be taken into account that exclusion-based core inflation is comparatively superior in the sense of being a simple indicator whose method is transparent and readily understood by the public. Accordingly, the indicators from both methods seem to have their own particular usefulness.

A single core inflation measure cannot account for all types of shocks and can at times be misleading about what is happening to the underlying rate of overall inflation (Mishkin (2007)). Accordingly, we should consider a collection of underlying inflation indices rather than focus on a single measure. This is what we seem to have seen recently in Korea. From late 2005 to the middle of 2006, the price of cereals fell sharply due to a change in government policy. That move led to marked falls in headline CPI inflation and CPI\_X1 core inflation, while TRIM\_82 core inflation remained quite stable during this period because this one-off effect had been properly eliminated.

Table 5  
Evaluation of the various measures of core inflation

(Sample period: Jan. 1991–Dec. 2007)

		Exclusion-based methods		Trimmed mean
		CPI_X1	Core_US	Trim_82
Deviations of core inflation from trend <sup>1)</sup>	RMSE	1.01	1.11	0.90
	MAD	0.72	0.79	0.66
Predictability <sup>2)</sup>	6 months	1.57	1.58	1.52
	12 months	2.23	2.06	2.18
Reversion <sup>3),4)</sup>	$\beta_h^{5)}$	-0.90*** (0.23)	-0.73*** (0.19)	-1.41*** (0.28)
	$B_h^{6)}$	0.16 (0.19)	0.15 (0.15)	0.67*** (0.22)

Notes: 1) Statistics between the benchmark inflation (24-month centred moving averages of actual CPI inflation) and each measure of core inflation. 2) Prediction errors (RMSE) for 6-month and 12-month forecasting horizons. 3) \*\*\*, \*\*, \* represent significance levels of 1%, 5% and 10%, respectively. 4) Figures in brackets are standard errors calculated using the Newey-West method.

$$5) \pi_{t+6} - \pi_t = \alpha_h + \beta_h(\pi_t - \pi_t^{core}) + \varepsilon_{t+h} \quad 6) \pi_{t+6}^{core} - \pi_t^{core} = \alpha_h + B_h(\pi_t^{core} - \pi_t) + \varepsilon_{t+h}$$

## 2. Asset price based measure of core inflation<sup>9</sup>

### *Estimation of the DFI*

Considering the defect that the calculation methods of the CPI and variance weighted price indices do not reflect the persistence of goods prices, Cecchetti (1996) and Bryan et al (2002) have presented a method of deriving trend inflation (DFI), where goods prices reflect dynamically changing behaviours. The DFI model, based on the Kalman filter and the state space model presented in these research papers, can be represented as an observation equation and transfer equations that are not observable in the actual time-series data such as trend inflation and the relative price fluctuation of each good. In other words, inflation of individual goods seen in equation (1) can be common to all goods prices containing similar asset prices, but consists of non-observable trend fluctuations ( $\Pi_t$ , of core inflation) and peculiar fluctuations of individual goods (relative price fluctuation,  $x_{i,t}$ ). It is assumed that common trends and peculiar fluctuations follow a polynomial lag distribution in equations (2) and (3), respectively.

$$\text{Observation equation: } \pi_{i,t} = \Pi_t + x_{i,t}, \quad i = 1, \dots, n \quad (1)$$

$$\text{Transfer equation: } \Psi(L)\Pi_t = \delta + \xi_t, \quad \xi_t \sim N(0, \sigma_\xi^2) \quad (2)$$

$$\text{Transfer equation: } \Theta(L)x_{i,t} = \eta_{i,t}, \quad \eta_{i,t} \sim N(0, \sigma_\eta^2) \quad (3)$$

Let us suppose that common trends and peculiar fluctuations are mutually independent in all lags for identifying the model. Each parameter and the common trends ( $\Pi_t$ ) are estimated by maximum likelihood estimation employing the Kalman filter.

Following this methodology, we set up the DFI model for Korea, which consists of 14 variables: 12 commodity groups of the CPI such as food and non-alcoholic beverages, housing prices, and stock prices. We estimated 31 parameters in the state space model composed of observation and transfer equations employing the maximum likelihood estimation and then derived trend inflation and the relative price fluctuation of the commodity index (refer to Appendix). The variance ( $\sigma_\xi^2$ ) of trend inflation is fixed as 1 in Bryan et al (2002) and, for reflecting the dynamic volatility, the estimation is performed by setting up the AR (2) model. Under the same condition in Korea, however, the statistical significance of the estimated model is not high. That based upon the AR (1)<sup>10</sup> model shows the highest statistical significance; accordingly, we verify the model's stability by estimating and comparing the model that is directly estimated without fixing  $\sigma_\xi^2$  as 1 (baseline model), the model where  $\sigma_\xi^2$  is fixed as 1 (model 2), and the model where only housing prices are regarded as asset prices (model 3).

According to the analysis, it can be seen that each value of the coefficients is estimated as comparatively consistent, showing a similar value regardless of the estimation method. In the case of estimated trend inflation, its constant terms and AR (1) coefficients are statistically significant, and the long-term inflation level calculated at an annual rate has also values within 3.7%. Stock prices, however, have almost no effect on trend inflation. Figure 2 shows

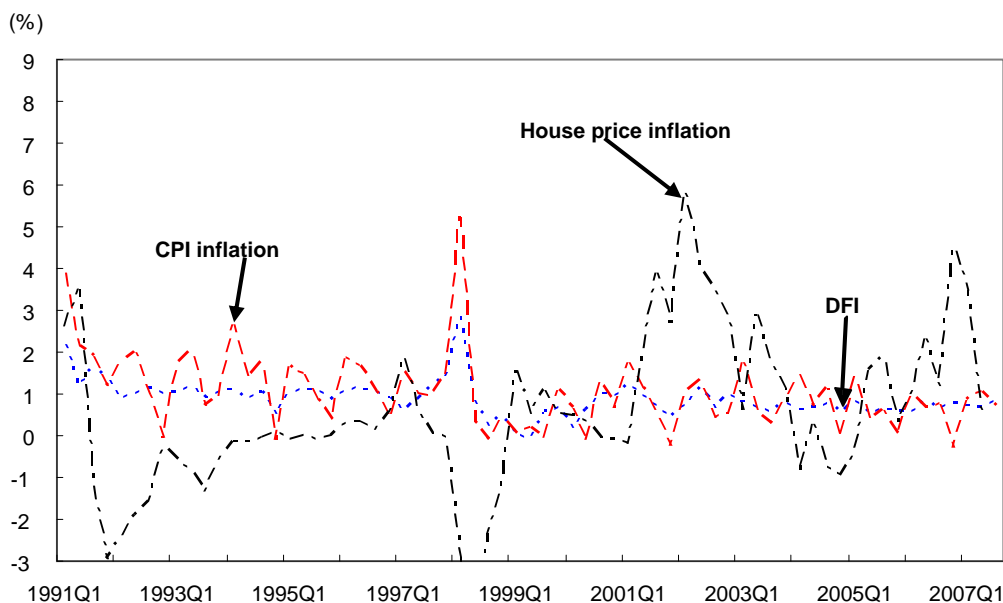
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<sup>9</sup> This section is based on Yang Woo Kim and Joon Myoung Woo (2008).

<sup>10</sup> According to the estimation result of the AR(2) model, both trend inflation and most of the second lag coefficient of the index by item are not statistically significant.

the comparison between CPI inflation and the estimation result of model 3 using the data in which housing prices are regarded as the only asset prices. In the estimation result of the model, the DFI growth rate remains at stable levels of 0.8–1.2% (based on the previous quarter), and fluctuations in the CPI growth rate centre on the DFI growth rate. The DFI growth rate was below the CPI inflation level in the 1990s when housing prices remained stable with a downward tendency for a long period. The growth rate was also relatively low right after the currency crisis when CPI inflation surged.

Figure 2  
Trends of DFI and CPI inflation (from the previous quarter)

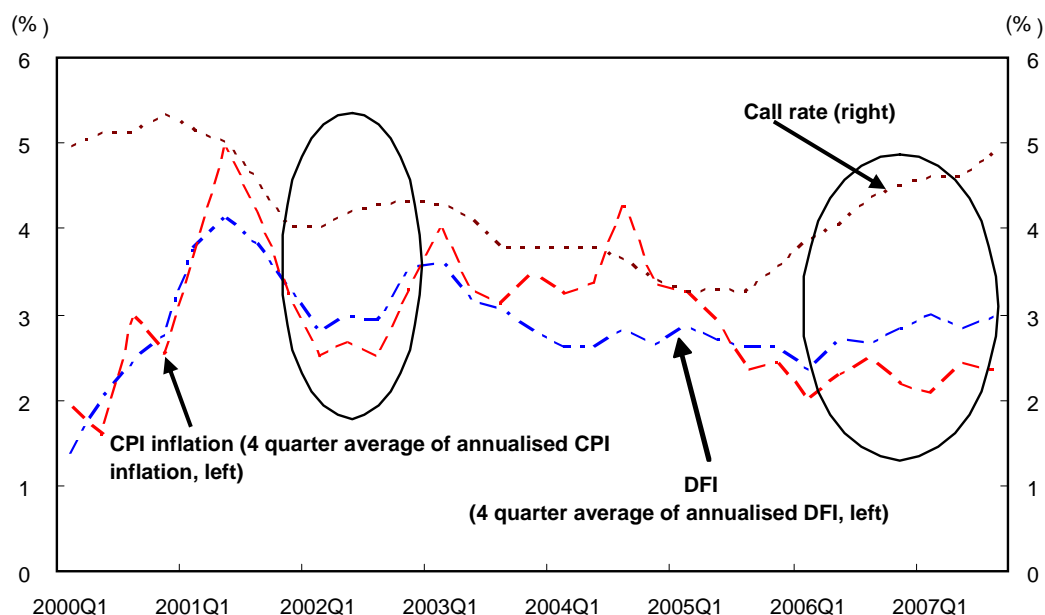


To compare the DFI and the CPI year by year, Figure 3 displays the annualised growth rates over the previous quarter. During periods of a sharp rise in housing prices, the DFI growth rate generally records higher levels than CPI inflation. The DFI – unlike the CPI – is considered sensitively to reflect purchasing power fluctuations caused by housing price fluctuations. That is, when the DFI showed 3.1% and 3.0% growth rates in 2002 and 2007 when the housing inflation rate was high, CPI inflation increased by 2.8% and 2.5%, respectively, which was lower than the DFI growth rates.<sup>11</sup> During 2004 and 2005, by contrast, the DFI growth rate was 2.7%, which was lower than the CPI growth rate (3.6% and 2.8%, respectively).

<sup>11</sup> In 2003, despite an exceptional hike in housing prices, the CPI growth rate was higher than the DFI growth rate. A base effect, caused by the markedly low CPI growth rate of the previous year, seems to have been at work to a certain extent.

Figure 3

**Trends of DFI and CPI inflation**



**Usefulness of the DFI**

An analysis is conducted to investigate whether it is possible to use the DFI as an information variable for CPI inflation, which is an indicator of price stability. The result shows that the DFI not only contains useful information in predicting CPI inflation, but also itself plays a role on the long-term trend of CPI inflation.

The analysis based on equation (4) demonstrates that, in predicting future CPI inflation, the lagged dependent variable of the DFI shows slightly better inflation-forecasting power than that of the CPI, having lower prediction errors for long- and short-term inflation.

$$\pi_{t+i} = a + \beta_0 A_t + \beta_1 \Delta ULC_t + \beta_2 GAP_t + \beta_3 \Delta MPI_t \quad (4)$$

$i$  : forecasting horizon,  $\Delta ULC$  : growth rate of unit labour cost,

$GAP$  : GDP gap ratio,  $\Delta MPI$  : growth rate of import prices,  $A_t$  : CPI or DFI inflation

Table 6

**(RMSE) prediction error by forecasting horizon**

Forecasting horizon		2002Q1–2006Q4	2004Q1–2006Q4	2006Q1–2006Q4
$A_t$ : CPI inflation	$i=4$	0.714	0.608	0.595
	$i=8$	0.667	0.577	0.574
	$i=12$	0.597	0.572	0.623
$A_t$ : DFI	$i=4$	0.691	0.565	0.580
	$i=8$	0.656	0.566	0.566
	$i=12$	0.573	0.564	0.576

We conduct a variance decomposition of prediction error using a three-variable VAR model consisting of GDP growth rate, DFI and CPI inflation. The result indicates that the degree of DFI's contribution to CPI inflation volatility reaches 55%, which is higher than the degree of CPI inflation's contribution, 21%.<sup>12</sup> This is because housing prices containing substantial information on future inflation are taken into account in the DFI.

Table 7  
Variance decomposition result

Period	DFI		CPI	
	DFI	CPI	DFI	CPI
1	82.10	0.00	58.67	29.01
2	82.60	0.67	60.53	27.89
3	82.05	0.64	60.27	26.36
4	78.17	0.73	59.36	23.98
5	75.50	0.71	57.99	22.07
6	73.40	0.75	56.84	21.88
7	72.26	0.92	56.25	21.38
8	71.49	0.94	55.84	21.01
9	70.97	0.99	55.55	20.77
10	70.62	1.03	55.37	20.60

Given that the DFI eliminates the part of relative fluctuations caused by temporary disturbing factors from the price fluctuations of many commodities and extracts trend fluctuation, it can be also interpreted as a kind of core inflation index. If the DFI has the characteristics of trend inflation, it is expected to be effectively used to predict consumer prices in the future. If the current CPI growth rate is lower than that of the DFI, which shows inflationary pressure arising from temporary factors, inflation will increase above its current level and is highly likely to converge on the trend level in the future.

In order to examine this likelihood, we estimate an error correction model, which can analyse the long-run equilibrium relationship between DFI and CPI inflation. According to the analysis, even if we change the lag value of the error correction model, the error correction coefficient ( $\gamma$ ) appears significant. Even though there appears a disparity between CPI inflation and DFI inflation in the short run, the DFI containing housing price information can be used as a long-term trend for CPI inflation, which is underpinned by the finding that the CPI inflation converges with DFI inflation in the long run.

$$\Delta\pi_t = \sum_{i=1}^k \alpha_j \Delta\pi_{t-i} + \sum_{i=1}^k \zeta_j \Delta DFI_{t-i} + \gamma(\pi_{t-1} - DFI_{t-1}) + \varepsilon_t \quad (5)$$

<sup>12</sup> The lag of the VAR model is set as 3 according to the AIC criterion. Therefore, even if the lag is changed, the result will not differ substantially.



Table 8

**Estimation result of error correction coefficient ( $\gamma$ )**

LAG (k)	Estimate	Standard error	LAG (k)	Estimate	Standard error
1	-0.931**	0.300	2	-0.869**	0.282
3	-1.093**	0.340	4	-1.064**	0.383

**III. Conclusion**

The Bank of Korea changed the target indicator for its inflation targeting system from core inflation to headline CPI in 2007, and this has encouraged a variety of studies on the measurement of core inflation. This paper is a summary of two recent research papers.

The first subject deals with the measurement of core inflation by the trimmed mean method and the exclusion-based method, reflecting the characteristics of cross-sectional distribution of Korea's consumer price increases. The trimmed mean method excludes both extremes of the cross-sectional distribution asymmetrically, taking into account the fact that the distribution is fat-tailed and right-skewed. Findings on the exclusion-based method show that official indicators announced by the Korean National Statistical Office are still useful, and that the excluded items were very often located at the both extremes of the cross-sectional distribution. The second subject considers the computation of a dynamic factor index (DFI) containing asset prices, in which housing prices are added into the CPI in Korea as an eclectic method that can take into account price stability and asset price fluctuations at the same time.

Measures of core inflation by the trimmed mean method and exclusion-based method can be evaluated to determine their usefulness from the criteria of deviations from the trend and predictive ability. The evaluation shows that trimmed mean core inflation has relative superiority in ability to track the underlying trend of inflation over exclusion-based core inflation. In predictability, there are no meaningful differences. It should, however, be taken into account that exclusion-based core inflation is comparatively superior in the sense of being readily understood by economic agents and possessing transparency. According to the above analysis, the indicators from each method seem to have their own particular usefulness.

As for the DFI, the study reveals that it can be used as an information variable. This is because it not only contains useful information for predicting CPI inflation, but also itself plays the role of a long-term trend of CPI inflation. Recent researchers suggest that central banks should adopt policies that are adaptable to the specific market conditions of each country because the effectiveness of monetary policy's response to asset price fluctuations could depend on the characteristics of macroeconomic conditions and the housing and financial markets country by country.<sup>13</sup> With regard to the response of monetary policy to

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<sup>13</sup> The IMF pointed out in its World Economic Outlook (April 2008) that the monetary policy measures taken in response to rapid change in housing prices should be carried out depending on the degree of the development of the mortgage market. This is because, in the case of a country like the US where the mortgage market is well developed, the effects of monetary policy on housing prices and of housing prices on the business cycle are becoming greater.

asset price fluctuations, therefore, there is no clear consensus as yet. Since the experiences of policy effects differ from country to country and from model to model, it is essential to conduct a close examination and in-depth research of this continuously.

**Appendix:**  
**MLE estimation result of the DFI model**

	<b>Baseline model (includes housing and stock prices)</b>	<b>Model 2 (variance of trend = 1, includes housing and stock prices)</b>	<b>Model 3 (includes housing prices only)</b>
Trend inflation (DFI)	$\pi_t = 0.4904 + 0.4724\pi_{t-1} + n_t$ (0.01422) (0.1396) $\sigma_n^2 = 0.4277$ (0.0444)	$\pi_t = 0.5505 + 0.4593\pi_{t-1} + n_t$ (0.2106) (0.1844) $\sigma_n^2 = 1(\text{fixed})$	$\pi_t = 0.4814 + 0.4812\pi_{t-1} + n_t$ (0.1406) (0.1379) $\sigma_n^2 = 0.4278$ (0.0444)
Long-run level (annual rate)	<b>0.93%</b> <b>(3.72%)</b>	<b>0.93%</b> <b>(3.74%)</b>	<b>0.93%</b> <b>(3.71%)</b>

**DFI configuration by item**

Food and non- alcoholic beverages	$x_{1,t} = 0.2232x_{1,t-1} + \xi_{1,t}$ (0.1100) $\sigma_{\xi_1}^2 = 1.4528$ (0.1143)	$x_{1,t} = 0.2180x_{1,t-1} + \xi_{1,t}$ (0.1105) $\sigma_{\xi_1}^2 = 1.4475$ (0.1145)	$x_{1,t} = 0.2233x_{1,t-1} + \xi_{1,t}$ (0.1101) $\sigma_{\xi_1}^2 = 1.4530$ (0.1144)
Alcoholic beverage and cigarettes	$x_{2,t} = -0.0275x_{2,t-1} + \xi_{2,t}$ (0.1070) $\sigma_{\xi_2}^2 = 2.1667$ (0.1685)	$x_{2,t} = -0.0153x_{2,t-1} + \xi_{2,t}$ (0.0000) $\sigma_{\xi_2}^2 = 2.1826$ (0.1700)	$x_{2,t} = -0.0268x_{2,t-1} + \xi_{2,t}$ (0.1142) $\sigma_{\xi_2}^2 = 2.1676$ (0.1686)
Clothing and footwear	$x_{3,t} = 0.5598x_{3,t-1} + \xi_{3,t}$ (0.0998) $\sigma_{\xi_3}^2 = 0.6995$ (0.0600)	$x_{3,t} = 0.5147x_{3,t-1} + \xi_{3,t}$ (0.1061) $\sigma_{\xi_3}^2 = 0.7382$ (0.0637)	$x_{3,t} = 0.5603x_{3,t-1} + \xi_{3,t}$ (0.0997) $\sigma_{\xi_3}^2 = 0.6996$ (0.0600)
Housing, water and fuels	$x_{4,t} = 0.1586x_{4,t-1} + \xi_{4,t}$ (0.1215) $\sigma_{\xi_4}^2 = 0.9028$ (0.0759)	$x_{4,t} = 0.1216x_{4,t-1} + \xi_{4,t}$ (0.1286) $\sigma_{\xi_4}^2 = 0.8562$ (0.0736)	$x_{4,t} = 0.1535x_{4,t-1} + \xi_{4,t}$ (0.1225) $\sigma_{\xi_4}^2 = 0.9019$ (0.0753)
Furnishings and household equipment	$x_{5,t} = 0.3118x_{5,t-1} + \xi_{5,t}$ (0.1254) $\sigma_{\xi_5}^2 = 0.7047$ (0.0606)	$x_{5,t} = 0.2961x_{5,t-1} + \xi_{5,t}$ (0.1350) $\sigma_{\xi_5}^2 = 0.7025$ (0.0620)	$x_{5,t} = 0.3120x_{5,t-1} + \xi_{5,t}$ (0.1255) $\sigma_{\xi_5}^2 = 0.7043$ (0.0605)
Healthcare	$x_{6,t} = 0.2735x_{6,t-1} + \xi_{6,t}$ (0.1085) $\sigma_{\xi_6}^2 = 1.1771$ (0.0933)	$x_{6,t} = 0.2653x_{6,t-1} + \xi_{6,t}$ (0.1095) $\sigma_{\xi_6}^2 = 1.1965$ (0.0958)	$x_{6,t} = 0.2736x_{6,t-1} + \xi_{6,t}$ (0.1085) $\sigma_{\xi_6}^2 = 1.1764$ (0.0937)
Transport	$x_{7,t} = 0.2030x_{7,t-1} + \xi_{7,t}$ (0.1116) $\sigma_{\xi_7}^2 = 1.6141$ (0.1270)	$x_{7,t} = 0.2032x_{7,t-1} + \xi_{7,t}$ (0.1131) $\sigma_{\xi_7}^2 = 1.5778$ (0.1248)	$x_{7,t} = 0.2018x_{7,t-1} + \xi_{7,t}$ (0.1118) $\sigma_{\xi_7}^2 = 1.6141$ (0.1270)

Notes: 1) Figures in parentheses are standard deviations. 2) The long-run level is calculated by substituting  $L=1$  into  $\Pi = \frac{\delta}{(1-\Psi L)}$  and then multiplying by 4.

**MLE estimation result of the DFI model (continued)**

Item	Baseline model	Variance of trend = 1	Includes housing prices only
Communications	$x_{8,t} = 0.3532x_{8,t-1} + \xi_{8,t}$ (0.1071) $\sigma_{\xi 8}^2 = 2.2431$ (0.1741)	$x_{8,t} = 0.3629x_{8,t-1} + \xi_{8,t}$ (0.1067) $\sigma_{\xi 8}^2 = 2.2515$ (0.1749)	$x_{8,t} = 0.3532x_{8,t-1} + \xi_{8,t}$ (0.1072) $\sigma_{\xi 8}^2 = 2.2433$ (0.1741)
Culture and recreation	$x_{9,t} = 0.7754x_{9,t-1} + \xi_{9,t}$ (0.0838) $\sigma_{\xi 9}^2 = 0.4657$ (0.0490)	$x_{9,t} = 0.7678x_{9,t-1} + \xi_{9,t}$ (0.0883) $\sigma_{\xi 9}^2 = 0.4788$ (0.0563)	$x_{9,t} = 0.7743x_{9,t-1} + \xi_{9,t}$ (0.0838) $\sigma_{\xi 9}^2 = 0.4659$ (0.0489)
Education	$x_{10,t} = 0.7511x_{10,t-1} + \xi_{10,t}$ (0.0741) $\sigma_{\xi 10}^2 = 0.8139$ (0.0686)	$x_{10,t} = 0.7481x_{10,t-1} + \xi_{10,t}$ (0.0754) $\sigma_{\xi 10}^2 = 0.8157$ (0.0699)	$x_{10,t} = 0.7512x_{10,t-1} + \xi_{10,t}$ (0.0741) $\sigma_{\xi 10}^2 = 0.8141$ (0.0687)
Eating out and accommodation	$x_{11,t} = 0.6928x_{11,t-1} + \xi_{11,t}$ (0.0824) $\sigma_{\xi 11}^2 = 0.8822$ (0.0736)	$x_{11,t} = 0.6858x_{11,t-1} + \xi_{11,t}$ (0.0849) $\sigma_{\xi 11}^2 = 0.8495$ (0.0745)	$x_{11,t} = 0.6915x_{11,t-1} + \xi_{11,t}$ (0.0826) $\sigma_{\xi 11}^2 = 0.8828$ (0.0740)
Miscellaneous goods and services	$x_{12,t} = 0.1134x_{12,t-1} + \xi_{12,t}$ (0.1175) $\sigma_{\xi 12}^2 = 0.9551$ (0.0812)	$x_{12,t} = 0.1498x_{12,t-1} + \xi_{12,t}$ (0.1215) $\sigma_{\xi 12}^2 = 0.9202$ (0.0776)	$x_{12,t} = 0.1110x_{12,t-1} + \xi_{12,t}$ (0.1179) $\sigma_{\xi 12}^2 = 0.9549$ (0.0784)
Stock price	$x_{13,t} = 0.4428x_{13,t-1} + \xi_{13,t}$ (0.1006) $\sigma_{\xi 13}^2 = 12.1934$ (0.9356)	$x_{13,t} = 0.4477x_{13,t-1} + \xi_{13,t}$ (0.1003) $\sigma_{\xi 13}^2 = 12.1935$ (0.9356)	na
Housing price	$x_{14,t} = 0.6687x_{14,t-1} + \xi_{14,t}$ (0.0784) $\sigma_{\xi 14}^2 = 1.6568$ (0.1295)	$x_{14,t} = 0.6607x_{14,t-1} + \xi_{14,t}$ (0.0794) $\sigma_{\xi 14}^2 = 1.6844$ (0.1320)	$x_{14,t} = 0.6890x_{14,t-1} + \xi_{14,t}$ (0.0784) $\sigma_{\xi 14}^2 = 1.6569$ (0.1295)

Notes: 1) Figures in parentheses are standard deviations. 2) The time series (housing prices, stock indices, and CPI index by item) used in the analysis are data from 1986Q1–2007Q2, and are used after being seasonally adjusted.

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# On the predictive content of the PPI on CPI inflation: the case of Mexico

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## 1. Introduction

It would be natural to expect that shocks to producer prices, as they spill over through the production chain, should eventually have some effect on consumer prices. This should hold true for “cost-push” shocks that are expected to appear initially during the first stages of the production chain. In this case, it would also be natural, from a statistical point of view, for producer prices to “cause” consumer prices (ie producer prices should Granger-cause consumer prices). Following these considerations, information on producer prices could therefore be useful for central banks in identifying cost-push shocks and improving forecasts of consumer prices inflation.

The international experience, however, seems to suggest that the connection between producer and consumer prices is not as close as the abovementioned rationale would imply. For example, empirical studies for the United States, such as those by Clark (1995), and Blomberg and Harris (1995), find that the producer price index (PPI) does not have a significant predictive content for the future pattern of the consumer price index (CPI). The lack of robust evidence regarding a close causal link between the PPI and the CPI, along with the fact that most central banks define their inflation targets in terms of a certain measure of consumer prices, has led some central bankers to disregard the PPI as a relevant indicator for assessing inflationary trends.

Nevertheless, there are several shortcomings in the literature concerning this issue. Among these, the most relevant are:

- i) In general, the range of prices included in both producer and consumer price indices differs significantly. Indeed, it is common for PPI baskets to include mainly domestically produced goods, while CPIs include comprehensive sets of goods and services.
- ii) The previous literature has not given enough relevance to the role played by the statistical properties and dynamic interactions of CPI and PPI time series in the analysis. In particular, most previous studies have assessed Granger-causality between these two indices by using VAR models in first differences. However, this procedure relies on two assumptions: a) price levels are I(1) series and therefore inflation rates are stationary; and, b) consumer and producer prices are not cointegrated. Should either of these two assumptions not hold, the estimation of a VAR in differences is thus not the appropriate tool for analysis. In particular, if the price-level series are I(2), then the causality analysis should take this property into account, which further complicates the study. Regarding cointegration, it is well known that, if two series are cointegrated, the VAR in first differences suffers from omitted-variable biases, because it does not include the relevant error correction mechanism (ECM) term. These biases can make Granger-causality tests lead to misleading conclusions (an issue pointed out by Granger (1988)).

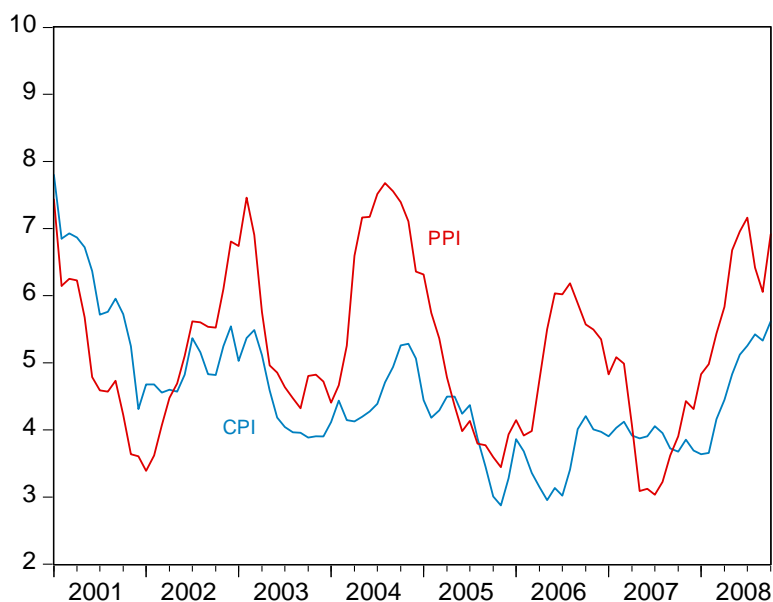
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<sup>1</sup> Banco de México. The views and conclusions expressed in this paper are solely those of the authors and do not necessarily reflect those of Banco de México. We would like to thank José Antonio Murillo and Antonio Noriega for their help and comments and Gabriel López-Moctezuma for excellent research assistance.

This note readdresses the previous evidence concerning the possibility of a causal relationship between the PPI and the CPI, using data of both price indices in Mexico. We believe this country is an appropriate case for studying the dynamic relationship between the two indices. Indeed, since 1994, the range of prices in the PPI has included the service sector, and the methodology to compute both indices is homogeneous. Although in this case the CPI and PPI still differ, the analysis should not be as affected as in other countries by issues concerning the range of prices included in such indices. For the purposes of this paper, the statistical and dynamic interactions of both time series are considered to be significantly relevant. Evidence is presented showing that from mid-2000 onwards, the inflation rates of both the CPI and PPI became stationary. The analysis is therefore restricted to the period when consumer and producer price inflation rates may be safely assumed to be  $I(0)$ . The biases implicit in using a VAR in differences are explicitly avoided. We first show evidence that both PPI and CPI series seem to be indeed cointegrated and, thus, the causality analysis is based on a vector error correction model (VEC), which explicitly considers the role of the ECM term in the estimates.

Figure 1

**Annual inflation: CPI vs PPI**



Source: Bank of Mexico.

In contrast with previous studies, the results suggest that, in the case of Mexico, recent information on the PPI seems to be useful for improving forecasts of CPI inflation. In particular, CPI inflation responds significantly to disequilibrium errors with respect to the long-run relationship between consumer and producer prices (ie whenever producer prices suffer a shock, CPI inflation increases temporarily until consumer price levels adjust to their long-run relationship with producer prices). Thus, what may have led previous literature to conclude that the PPI is not useful in predicting CPI movements seems to be precisely the omission of this relevant transmission mechanism in the analysis.<sup>2</sup>

<sup>2</sup> The Bank of Mexico's latest experience with the PPI in assessing consumer inflationary pressures tends to confirm these conclusions. In some of the recent episodes in which the trajectory of CPI inflation has changed course, the PPI did in fact provide an early warning about the inflection point (see Figure 1).



The rest of the document is organized as follows: Section 2 analyzes the statistical properties of the CPI and the PPI series over time, and in particular, their degree of persistence. Section 3 describes the methodology used to determine the usefulness of the PPI as a predictor of CPI inflation. Section 4 summarizes the empirical results. Finally, Section 5 presents some final remarks regarding the possible lessons that may be obtained from the Mexican experience on the use of output-based price indices to assess inflationary pressures.

## 2. Changes in the persistence of the CPI and the PPI

In order to analyze the change in the persistence of both the CPI and PPI, the first step is to identify their basic time series properties. These properties constitute a building block for further research. It is of particular relevance to identify the order of integration of the data; that is, to assess whether PPI and CPI inflation rates are stationary  $I(0)$  processes or not. As mentioned before, if inflation rates are non-stationary  $I(1)$  processes, then the price levels would be  $I(2)$  processes, and the analysis to identify the pass-through of producer price shocks to consumer prices would therefore be more complicated.

Identifying whether inflation rates are stationary or not becomes more difficult when shifts in monetary policy, among other factors, make inflation rates switch from non-stationary to stationary regimes, or vice versa. However, several tests have recently been developed to accurately decompose the sample in a time series observed in stationary and non-stationary behavior segments. Regarding the Mexican economy, evidence based on this type of tests supports the idea that consumer price inflation shifted from a non-stationary to a stationary regime around 2000 (see Chiquiar, et al (2007)). This date nearly coincides with the period when the Bank of Mexico formally adopted an inflation targeting regime.

The latest development in this methodology is based on a test for multiple changes in persistence by Leybourne, Kim and Taylor (2007), which also allows for estimating the dates of change in a consistent way. Their test identifies all stationary periods within the sample, effectively decomposing the data into stationary (or  $I(0)$ ) and non-stationary (or  $I(1)$ ) subsamples. When no  $I(1)$  behavior is detected, the series is stationary. The periods identified as  $I(0)/I(1)$  can then be analyzed in terms of both timing and operating rules of monetary policy.

Table 1  
Test for changes in persistence

Series	Sample	Starting date for $I(0)$ period
CPI inflation	1994:02–2008:10	2000:05
PPI inflation	1994:02–2008:10	2000:04

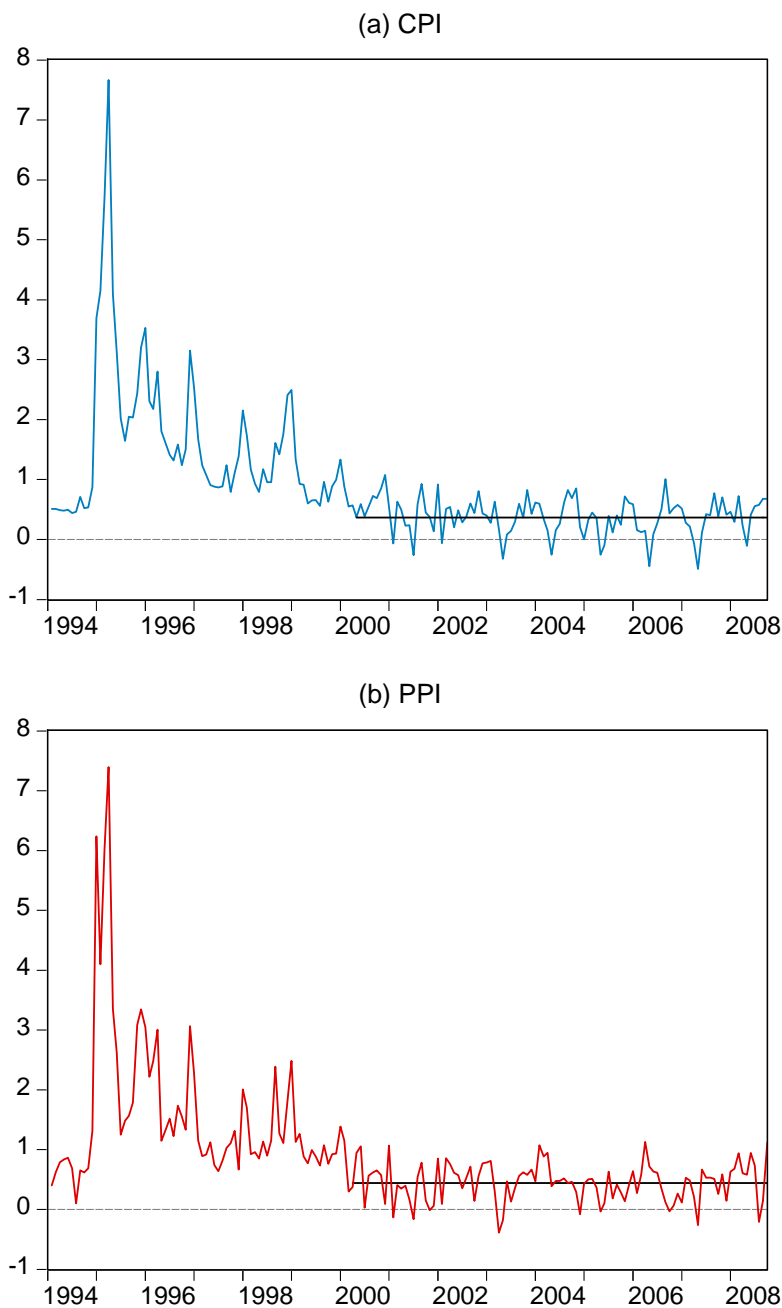
Source: Own calculations with data from Bank of Mexico.

The results of the test for monthly inflation data based on CPI and PPI inflation rates in Mexico suggest that, in both cases, inflation shifted from a non-stationary to a stationary regime around mid-2000. Table 1 summarizes the results. The second column refers to the sample to which the testing procedure was applied. The following column reports the date identified by the procedure as the beginning of the  $I(0)$  subsample. For instance, for the CPI, the test identifies a single  $I(0)$  period from May 2000. This means that from 1994:02 to 2000:04, CPI inflation seems to have behaved in a non-stationary fashion (ie as a  $I(1)$ )

process), while from 2000:05 onwards, the test suggests that this inflation rate behaved as a stationary process. Very similar conclusions can be reached regarding PPI inflation. Apparently, from the beginning of the sample to the year 2000, the data behaves as a non-stationary process, while from mid-2000 onwards, the inflation indices behave in a stationary way. The level of significance for all changes in persistence was 1%. These findings are similar to those reported by Chiquiar et al (2007).

Figure 2 represents the results graphically. The graphs plot the two inflation series, together with straight horizontal lines indicating the stationary period, as identified by the persistence change test. For convenience, this line is drawn at the inflation mean during the  $I(0)$  period identified by the test.

Figure 2  
**Monthly CPI and PPI inflation**



Source: Bank of Mexico.

To conclude, the two inflation measures analyzed apparently switched from non-stationary to stationary behavior during 2000. Considering that inflation is the difference between the (log) price indices, from 2001 onwards, both price indices can be treated as I(1) variables. Given the latter, for the rest of the paper, the analysis will be conducted by restricting the sample to the period from January 2001 to the last observation available (October 2008), in order to ensure that the variables are stationary in differences (I(1) in levels) and, thus, that the conventional cointegration analysis is applicable.<sup>3</sup>

### 3. Methodology to evaluate the predictive content of the PPI for the CPI

In this paper, the methodology proposed by Granger (1969) and later popularized by Sims (1972) is used to analyze if the PPI can help forecast the CPI (ie if PPI Granger-causes CPI).

The most commonly used test of Granger causality, otherwise known in econometric textbooks and software as “Granger test”, is performed under a bivariate vector autoregression (VAR), where a joint exclusion test is used. In order to investigate the predictive ability of PPI inflation for CPI inflation, the relevant equation from the VAR would be:

$$\pi_t^{CPI} = \mu_0 + \sum_{j=1}^p \alpha_j \pi_{t-j}^{CPI} + \sum_{j=1}^p \beta_j \pi_{t-j}^{PPI} + \varepsilon_t, \quad (1)$$

where  $\varepsilon_t$  is considered as white noise. The VAR is typically estimated by ordinary least squares (OLS), and the number of lags,  $p$ , is usually determined by using an information criterion such as the Bayesian information criterion (BIC), or Schwarz Criterion. Then, a test of the null hypothesis

$$H_0 : \beta_1 = \beta_2 = \dots = \beta_p = 0, \quad (2)$$

is conducted, either with the usual F-test, or with the Wald variant.<sup>4</sup> If the null hypothesis is rejected, then it can be concluded that PPI inflation does Granger-cause CPI inflation. These types of tests have been used in the literature to investigate the relation between PPI and CPI inflations (eg Clark (1995)).

Engle and Granger (1987), however, show that if the variables under investigation are I(1), and a linear combination of them is I(0), that is, if the variables are cointegrated, then the series will be generated by an error-correction model. Considering the natural logarithm of the price indices ( $p^{CPI} = \ln(\text{CPI})$  and  $p^{PPI} = \ln(\text{PPI})$ ), their first difference will be the (monthly) inflation rate. The first equation of the VEC representation would thus be:

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<sup>3</sup> Augmented Dickey-Fuller tests (Dickey and Fuller (1979)) for this period cannot reject the hypothesis of a unit root in each price index at the 1% level. The tests were performed using a constant and a linear trend, and the number of lags was selected using the BIC criterion, starting with 18 lags.

<sup>4</sup> The F-test applies if  $\varepsilon_t$  is assumed to be Gaussian. However, even in such a case, the F-distribution would apply only asymptotically because the lagged dependent variables that appear as regressors make the assumption of fixed regressors untenable.

$$\pi_t^{CPI} = \mu_0 + \gamma_1(z_{t-1}) + \sum_{j=1}^p \alpha_j \pi_{t-j}^{CPI} + \sum_{j=1}^p \beta_j \pi_{t-j}^{PPI} + \eta_t, \quad (3)$$

$$z_{t-1} = p_{t-1}^{CPI} - \phi_0 - \phi_1 p_{t-1}^{PPI}$$

where  $\eta_t$  is considered as white noise,  $z_{t-1}$  is the error correction term, and can be interpreted as the degree to which the system is out of equilibrium from the long-run relationship between the series,  $\gamma_1$  is the speed of adjustment, and  $\phi_1$  is the cointegration coefficient. After comparing equations (1) and (3) it is clear that if the price indices are cointegrated, then equation (1) is missing the error correction term, and hence, is misspecified.

Indeed, Granger (1988) shows that a consequence of the error-correction model is that at least one of the variables in the system must be caused by  $z_{t-1}$ , (which is a function of the lagged price levels). Therefore, if two variables are cointegrated, (Granger) causation must follow at least in one direction. Granger and Lin (1995) define clearly the existence of two important sources of causation in the error-correction model (3). One originates from the effect of the error correction term (ie from the long-run relationship), if  $\gamma_1$  is different from zero, and the other, from the lags of the PPI inflation rate (ie from the short-run dynamics), if  $\beta_s$  are different from zero. Accordingly, the former is called long-run Granger causality while the latter is short-run Granger causality. If the CPI and the PPI are cointegrated, then there can be short-run causation from the PPI to the CPI, long-run causation, or both. No causation from the PPI to the CPI can also occur, although this would imply some type of causation from the CPI to the PPI.

Since the results in the previous section suggest that both price indices under study are I(1) variables in the sample since 2001, it is important to emphasize that, if the two series are shown to be cointegrated, the model in equation (1) would be misspecified if  $z_{t-1}$  is not used explicitly. In this case, if equation (1) is used, the possible relevance (in levels of significance) of the PPI as a predictor of the CPI could be missed. In extreme cases, this misspecification could invalidate completely the possible use of the PPI in forecasting the CPI (eg if both variables are cointegrated and there is only long-run causality from the PPI to the CPI).

#### 4. Granger causality from the PPI to the CPI: empirical results

In this section, the error-correction model (3) is used to investigate the causal relation between the PPI and the CPI, in both the long and short runs. First, the series must be tested for cointegration. Once evidence of cointegration is provided, equation (3) is estimated. As a final step, significance tests on  $\gamma_1$  and on  $\beta_s$  are performed to assess causality from the PPI to the CPI. All estimations consider the period from January 2001 to October 2008, a subsample characterized by the stationarity of both CPI and PPI monthly variations (see Section 2).

To test for cointegration, we employ the methodology proposed by Engle and Granger (1987). A regression of the log CPI was run on a constant, the log PPI, and 11 (centered) seasonal dummies. Then, an augmented Dickey-Fuller test was applied to the residuals of that regression (see Table 2 for test results). The null hypothesis of a unit root in the residuals can be rejected at the 5% significance level. Thus, at the same significance level, the hypothesis that both CPI and PPI are not cointegrated is rejected.

Table 2  
Cointegration test

Variables	ADF t-stat <sup>a</sup>
CPI – PPI	–3.5030**

<sup>a</sup> Engle-Granger (1987) test. Critical Values: 1%: –3.96, 5%: –3.41, 10%: –3.12 (following Hansen (1992)). Model with constant and 11 (centered) seasonal dummies.

Source: Own calculations with data from Bank of Mexico.

Given these results, the cointegration coefficient,  $\phi_1$ , is then estimated using the dynamic ordinary least squares estimator proposed by Stock and Watson (1993). This is a simple procedure that produces asymptotically standard normal distributed t-values, so that inference on  $\phi_1$  can be performed in the usual manner.<sup>5</sup> The point estimate is 0.8017 with a standard error of 0.0043. Therefore, the null hypothesis that the cointegration coefficient is 0.8 cannot be rejected at the 1% level, while the hypothesis that this coefficient is 1 can be rejected at the same level. A cointegration coefficient below one implies that, in the long run, the pass-through from producer prices to consumer prices is not complete, although some considerable pass-through in equilibrium exists. This scenario could arise, for example, in a situation of monopolistic competition with non-negligible fixed costs.

Since we do not reject the hypothesis that price indices are cointegrated, it is more appropriate to estimate equation (3) rather than equation (1). The results of the estimation of the corresponding bivariate VEC (where equation (3) is the first equation of the VEC) are reported in Table 3. The cointegration coefficient is again estimated to be around 0.8. The estimates of interest correspond to equation (3), which, in the VEC reported in Table 3, corresponds to the first column, and the behavior of CPI inflation. As may be noted, the error correction term is significantly different from zero at the 5% level in the CPI inflation equation.<sup>6</sup> Hence, there is evidence of long-run Granger causality from the PPI to the CPI. The speed of adjustment is –0.1014, which means that a shock to the equilibrium relationship is corrected by around 10% each month, so that the total effect vanishes in less than a year. It is relevant to note that a Wald test performed on the null hypothesis that the coefficients associated with the two lagged values of PPI inflation are not significant is not rejected (the p-value is 0.8774). Therefore, no short-run (Granger) causation from the PPI to the CPI is found. This result suggests that if we had estimated a VAR in first differences without including the ECM term, we might have erroneously concluded that the PPI does not cause CPI inflation. Finally, the adjusted R-squared from this regression is slightly below 0.6, which implies that this model explains slightly less than 60% of the total variation of monthly CPI inflation.

To conclude, the results of the VEC estimates and its corresponding Granger causality tests suggest that producer prices are useful for predicting CPI inflation in Mexico. In particular, even though Granger causality tests summarized in Table 3 suggest that producer price inflation is not significant for predicting consumer price inflation in the short run, the latter responds significantly to disequilibrium errors with respect to the long-run relationship between consumer and producer prices. This means that, whenever producer prices suffer a

<sup>5</sup> The procedure proposed by Stock and Watson is to augment the equation in levels used in the Engle-Granger tests with leads, lags, and the contemporaneous value of the difference of the (log) PPI. In this case, 4 leads and equal number of lags were used, chosen according to the BIC, from a maximum of six lags (or leads).

<sup>6</sup> Inference in the VEC can be performed as usual given that all variables entered in the equation are stationary.

shock (ie a “cost-push” shock), consumer price inflation increases temporarily until consumer price levels adjust completely to their long-run relationship with producer prices. Indeed, as can be seen in the results summarized in Table 3, the error-correction mechanism appears significantly in the consumer price inflation equations while its coefficient in the producer price inflation equation is insignificant. This suggests that, in the long run, it is consumer prices that respond to produce price shocks, and not vice versa. In turn, this means that knowledge of shocks that affect producer prices is useful to predict future changes in consumer price inflation.

Table 3  
**Vector error correction estimates<sup>a</sup>**

Sample (adjusted): 2001M04 2008M10  
 endogenous variables: CPI – PPI

<b>Cointegrating equation</b>		
<b>Cointegrating Eq:</b>	<b>CointEq1</b>	
LCPI(-1)	1	
LPPI(-1)	-0.7944 [-76.2523]	
C	-1.0081	
<b>Error correction:</b>	<b>D(LCPI)</b>	<b>D(LPPI)</b>
CointEq1	-0.1014 [-2.1542]	0.0918 [1.3369]
D(LCPI(-1))	0.2410 [1.9134]	-0.5183 [-2.8220]
D(LCPI(-2))	-0.0926 [-0.6787]	0.0704 [0.3541]
D(LPPI(-1))	0.0302 [0.3184]	0.5271 [3.8159]
D(LPPI(-2))	-0.0468 [-0.5016]	-0.0957 [-0.7035]
C	0.0032 [5.3416]	0.0042 [4.7436]
Adj. R-squared	0.5732	0.1604
Granger causality (p-val)	0.8774	
Schwarz Criterion	-17.4552	

<sup>a</sup> t-statistics in brackets. Eleven seasonal dummies (centered) were also included in each equation.

Source: Own calculations with data from Bank of Mexico.

## 5. Final remarks

This note presents evidence from Mexico suggesting that the PPI may have a significant predictive content for the subsequent development of CPI inflation. The causality relation from the PPI to the CPI identified in this paper is not driven by coefficients associated with short-run dynamics, but by the long-run response of consumer prices to shocks to producer prices, which leads to a temporarily higher inflation rate until the long-run equilibrium relationship between these two indices is satisfied again. Thus, in other countries that may have price-setting characteristics similar to Mexico, finding a relevant causal relationship from the PPI to the CPI may also require the specification of a statistical model for these two series that adds a long-run cointegration relationship to the short-run dynamics of these two series. The Mexican experience described in this paper could thus be useful for other central banks seeking to uncover the dynamic relationship between producer and consumer prices.

It is relevant to mention, however, that the model estimated in this paper is fundamentally a reduced form. In particular, although we have found what seems to be a significant transmission channel from producer to consumer prices, which could potentially improve the forecasting ability of the latter, we do not claim that the model presented here is the most efficient for producing inflation forecasts. Indeed, the information concerning the development of producer prices must be combined with other relevant inflation predictors to produce efficient forecasts. What the approach taken in this paper suggests is simply that, within the full set of indicators that could be used, the PPI seems to be a valuable piece of information for assessing inflationary pressures.

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# Measurement of price indices used by the central bank of Peru

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## 1. Introduction

The Central Reserve Bank of Peru has conducted monetary policy under a fully fledged inflation targeting (IT) regime since 2002. Over this period the monetary policy process of the central bank has evolved to suit better the challenges posed by the IT framework. During these years, the intensive gathering and analysis of price information relevant for policymaking has become a key feature of the IT approach in Peru. It has also been an activity with fruitful development within the central bank.

Although the IT regime officially started in 2002, the central bank of Peru has been announcing yearly numerical targets for CPI inflation since 1994. The numerical CPI inflation target is and has been defined in terms of CPI inflation in Lima Metropolitana.

In a developing country like Peru, the food component in the CPI weighs quantitatively high. As food prices suffer frequent relative price changes due to seasonality and supply shocks, the overall CPI becomes opaque in providing good signals of underlying inflationary pressures in the economy. This feature of the Peruvian economy further imposes a challenge to monetary policy, especially during world commodity price boom-bust cycles such as the one observed in 2007–08.

Due to the above-mentioned facts, the central bank of Peru incorporates a broad information set concerning relative and overall price movements that help assess their persistent or transitory nature. This paper describes this set of information in particular detail and concentrates on explaining the various price indices followed by the central bank and the construction of additional indicators useful for monetary policy analysis. Sections 2 and 3 of the paper thus describe the use of headline CPI as well as other price indices tracked by the central bank.

The key goal of monetary policy in Peru is to achieve overall price stability. So the central bank operates its policy by reacting to current and impending headline inflationary pressures. The conduct of monetary policy needs indicators of lasting inflationary pressures because they give central banks guidance to set monetary policy instruments in a forward-looking fashion. Therefore, measures of core or underlying inflation that capture strong inflationary trends are of paramount importance. Thus, even though the target is defined in terms of a widely known number provided by an independent statistical agency, the central bank needs to measure different alternative inflation indicators to shade out noisy components. Section 4 of the paper provides an overview of various core inflation measures and evaluates them in terms of desirable properties.

An important conclusion of this paper is that monetary policy in a noisy environment like Peru needs to track a number of inflation indicators and assess their information value on a real-time basis. There is no suitable indicator that is best at all times.

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<sup>1</sup> The assistance of Renzo Castellares, Milenka Moschella and Luis Valdivia is gratefully acknowledged.

## 2. Headline inflation

In the context of the IT framework, the numerical target used by the central bank is headline inflation calculated on the basis of the consumer price index (CPI), covering the area of Lima Metropolitana. An official and independent agency, the Instituto Nacional de Estadísticas (INEI), produces the index according to the Laspeyres Index, with its base year set to December 2001.

The general index presents eight major items broken down into 31 groups, 55 subgroups, 163 items and 515 varieties. Approximately 40,000 prices are collected each month from 5,000 commercial establishments including 41 markets, five supermarkets, 500 rented homes, 505 educational centres, and 210 urban and interurban transport lines.

The weights for aggregating the index are derived from the national survey (Encuesta Nacional de Propósitos Múltiples – ENAPROM) that was carried out from October 1993 to September 1994 in Lima. These weights were updated in January 2002 following revision of the INEI methodology. The main results of the revision were an increase in the number of households included in the sample, the inclusion of 45 new products, the exclusion of 18 outdated items, the updating of the sample of outlets and brands, and the use of the geometric mean to aggregate heterogeneous varieties. The index base was changed from 1994 to December 2001.

In measuring the CPI index, substitution bias is likely to stand as the main measurement bias. This is due to the outdated ENAPROM survey and the use of the Laspeyres Index. This substitution bias means that the CPI Index does not include new products, new outlets and changes in quality. To tackle this problem, the INEI will start a new consumption survey during this year. This survey will lead to a new index based on 2010.

As is clear from Figure 1, the weight of food items in the current CPI basket (47.5%) is comparatively higher than that of countries with similar per-capita income, such as Colombia or Thailand. Since the 1993–94 ENAPROM survey, Peru has seen an important rise in per-capita income, which might have lessened the food weight within the basket of the average consumer. The new 2010 base index is therefore likely to correct the food weight downwards.

As in the rest of emerging economies, 2008 will be remembered as a high-inflation year. Inflation in 2008 rose to 6.65% (from 1.1% in 2006 and 3.9% in 2007) and was mainly driven by higher commodity prices (wheat, soybean oil, corn), which translated into domestic food prices (bread, noodles, oil, chicken). The rise in food prices was an international feature of 2008 but had a higher impact in countries like Peru where foodstuffs weigh high in the consumption basket.

Figure 1  
GDP per capita and food share in total CPI

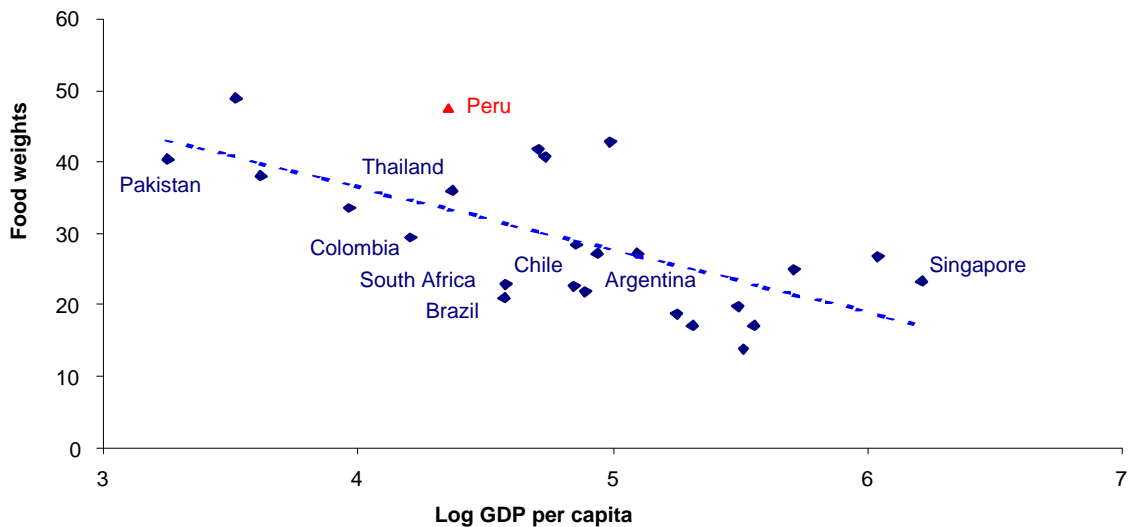


Table 1 gives a record of inflation during the IT regime so far. Until 2006, average inflation was broadly in line with the inflation target.<sup>2</sup> The story changes from 2007 onwards when world food commodity prices started rising dramatically. The hike in food prices increased core and non-core components of inflation, a fact that tainted underlying inflationary signals due, for example, to demand pressures in the economy. In other words, the task of disentangling noisy inflationary pressures related to food price dynamics from monetary inflationary pressures connected to a booming economy became extremely difficult. It was in this state of affairs that the central bank started to pay careful attention to other core inflation indicators, other price indices, and whatever key information it deemed relevant for monetary policy decision purposes.

Table 1  
Official core and non-core year-on-year inflation

	Weight	2002	2003	2004	2005	2006	2007	2008	Feb-09	2002–09*
<b>Inflation</b>	<b>100.0</b>	<b>1.5</b>	<b>2.5</b>	<b>3.5</b>	<b>1.5</b>	<b>1.1</b>	<b>3.9</b>	<b>6.7</b>	<b>5.5</b>	<b>2.9</b>
Core inflation	60.6	1.2	0.7	1.2	1.2	1.4	3.1	5.6	5.8	2.1
Core food	25.0	0.7	0.2	2.3	0.8	1.4	4.9	8.3	8.2	2.7
Core non-food	35.5	1.6	1.1	0.5	1.6	1.3	1.9	3.5	3.9	1.7
Non-core inflation	39.4	2.0	5.2	6.7	1.9	0.8	5.1	8.1	5.1	4.0
Non-core food	22.5	0.3	3.7	5.8	1.6	2.1	7.2	11.0	8.5	4.6
Non-core non-food	16.9	4.2	7.0	7.9	2.2	-0.7	2.4	4.4	0.6	3.2

\* February 2009.

<sup>2</sup> The inflation target was defined to be 2.5% with a tolerance of  $\pm 1\%$  until 2006; from 2007 the central bank lowered the target to  $2.0\% \pm 1\%$ .

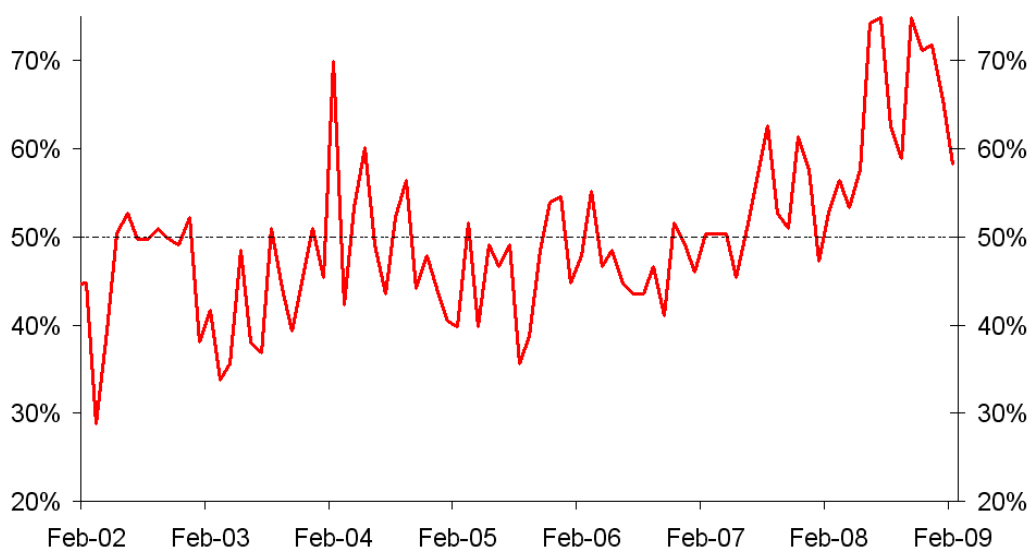
We now discuss some features of the inflationary process in Peru such as the breadth of price increases, the time-series and cross-sectional volatility of price changes, price stickiness, and inflation expectations.

### The CPI diffusion index

One indicator used to scrutinise the tendency of the bulk of prices to move in one direction is the diffusion index, defined as the percentage of items with positive percentage variations in their monthly prices. Figure 2 shows that until 2003 the index remained slightly below 50%, then up until mid-2007 we observe that it moved roughly around 50%. It is from mid-2007 onwards that the diffusion index starts showing important increases up to the end of 2008, when it starts abating.

Figure 2

#### Percentage of items with positive monthly price changes



### Times-series and cross-sectional volatility

Using the standard deviation of different time-series aggregates within inflation as a measure of volatility, we confirm that core inflation shows lower volatility than headline inflation. Importantly, the standard deviation for the period from 2002 to February 2009 has been about 1.5 times greater than mean monthly inflation for the same period. This means that the monthly variation in inflation can in fact be sizeable.

Table 2

## Standard deviation of official core and non-core monthly inflation

	Weight	2002	2003	2004	2005	2006	2007	2008	2002–09*
<b>Inflation</b>	<b>100.0</b>	<b>0.4</b>	<b>0.4</b>	<b>0.3</b>	<b>0.2</b>	<b>0.3</b>	<b>0.2</b>	<b>0.3</b>	<b>0.3</b>
Core inflation	60.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Core food	25.0	0.1	0.1	0.1	0.2	0.1	0.3	0.1	0.3
Core non-food	35.5	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.2
Non-core inflation	39.4	1.0	1.0	0.8	0.5	0.8	0.5	0.6	0.8
Non-core food	22.5	1.5	1.1	1.5	0.9	1.3	0.8	1.1	1.2
Non-core non-food	16.9	0.6	1.7	0.6	0.5	0.3	0.5	0.7	0.9

\* February 2009.

Following Bryan and Cecchetti (1999), we construct measures of cross-sectional volatility (csv) and skewness (css) based on 163 CPI items

$$csv_t = \sum_{i=1}^N w_i (\pi_{i,t} - \pi_t)^2 \quad [1]$$

$$css_t = \sum_{i=1}^N w_i (\pi_{i,t} - \pi_t)^3 (csv_t)^{-\frac{3}{2}} \quad [2]$$

where  $w_i$  represents the weight of item  $i$  in the CPI basket,  $\pi_{i,t}$  stands for the percentage change in the price index of item  $i$ , while  $\pi_t$  is the mean weighted percentage change across all items.<sup>3</sup> When the cross-sectional skewness is positive, the cross-sectional distribution of price changes is skewed to the right, so there are some large price changes, most likely from real shocks. Ball and Mankiw (1995) have provided a menu-cost theory to explain the positive correlation between higher moments of the cross-sectional distribution of inflation and mean inflation. If price changes are small, firms do not adjust prices due to menu costs, but if price changes are large, then firms as a whole will increase nominal prices and mean inflation must rise.

To see the implications of this theory for the Peruvian case, we first run Ball-Mankiw type regressions with csv and css on the right-hand side and CPI inflation as the variable to be explained, using monthly data from January 1998 to February 2009.

$$\pi_t = b_0 + b_1 \pi_{t-1} + b_2 csv_t + b_3 css_t + e_t \quad [3]$$

The results are shown in Table 3. The statistics are striking: that both the variance and skewness of inflation affect mean inflation positively. This means that there is in fact some evidence of price stickiness in the inflation data. However, this evidence is not that conclusive because, as Bryan and Cecchetti (1999) have shown, there is a small-sample bias that will push for positive correlation between skewness and mean inflation.

<sup>3</sup> By definition, approximately equal to the headline inflation rate.

Table 3  
**CPI Inflation regression on its higher  
order cross-sectional moments**

Dependent variable: CPI inflation (sample adjusted = January 1998–February 2009)

	(1)	(2)	(3)	(4)
Constant	0.17 (5.57) <sup>***</sup>	0.06 (1.03)	0.12 (3.58) <sup>***</sup>	0.03 (0.54)
Lagged CPI inflation	0.40 (4.63) <sup>***</sup>	0.32 (3.58) <sup>***</sup>	0.36 (4.35) <sup>***</sup>	0.30 (3.45) <sup>***</sup>
Cross-sectional variance (CPI)		0.014 (2.43) <sup>**</sup>		0.013 (2.30) <sup>**</sup>
Cross-sectional skewness (CPI)			0.025 (2.42) <sup>**</sup>	0.022 (2.20) <sup>**</sup>
R <sup>2</sup>	0.16	0.21	0.21	0.24
Breusch-Godfrey F-stat (null = no serial correlation)	1.49	0.47	0.90	1.07
Jarque-Bera statistic (null = normality)	0.25	0.38	0.25	0.11

t-statistics in brackets

<sup>\*\*\*</sup> rejection of the null hypothesis at 1% level

<sup>\*\*</sup> rejection of the null hypothesis at 5% level

<sup>\*</sup> rejection of null hypothesis at 10% level

In order to verify the robustness of the sticky price econometric evidence against the small-sample bias suggested by Bryan and Cecchetti (1999), we repeated the exercise using the cross-sectional skewness and variance of wholesale inflation. These two measures also depict the relative price shocks affecting the economy at a given time, and might therefore translate into headline CPI inflation.<sup>4</sup> Table 4 shows that the Mankiw-Ball hypothesis is still valid. This means that if the cross-sectional distribution of prices becomes skewed and very volatile, headline inflation is likely to increase; but also implies that the Phillips curve shifts upwards. This is perhaps the kind of effect that might be making inflationary expectations linger at a higher level than the inflation target, as we shall see in the next sections.

<sup>4</sup> This procedure was first used by Amano and Macklem (1997).

Table 4

**CPI Inflation regression on higher order  
cross-sectional moments of wholesale prices**

Dependent variable: CPI inflation (sample adjusted = February 1999–February 2009)

	(1)	(2)	(3)	(4)
Constant	0.17 (5.57) <sup>***</sup>	0.12 (3.00) <sup>***</sup>	0.17 (5.56) <sup>***</sup>	0.07 (2.06) <sup>***</sup>
Lagged CPI inflation	0.40 (4.63) <sup>***</sup>	0.28 (3.21) <sup>***</sup>	0.33 (3.54) <sup>***</sup>	0.24 (2.64) <sup>***</sup>
Cross-sectional variance (WPI)		0.03 (2.39) <sup>**</sup>		0.054 (4.19) <sup>**</sup>
Cross-sectional skewness (WPI)			0.017 (1.17)	0.035 (3.82) <sup>**</sup>
R <sup>2</sup>	0.16	0.16	0.13	0.22
Breusch-Godfrey F-stat (null = no serial correlation)	1.49	1.43	0.08	1.07
Jarque-Bera statistic (null = normality)	0.25	0.05	0.26	0.11

t-statistics in brackets

<sup>\*\*\*</sup> rejection of the null hypothesis at 1% level

<sup>\*\*</sup> rejection of the null hypothesis at 5% level

<sup>\*</sup> rejection of null hypothesis at 10% level

### Price stickiness

A direct way to gain insight into price stickiness is survey evidence. Back in 2007, following studies performed in Canada, England, Spain and elsewhere, the Central Reserve Bank of Peru conducted a survey of firms in the industrial, trade and service sectors. The main outcome of the survey was that almost 50% of the firms adjust their prices more than once a year.

Table 5

**Price adjustment frequency**

	Total	Industry	Trade	Services
More than once a year	49.0	41.4	70.4	48.4
Once a year	26.4	27.6	20.4	29.0
Less than once a year	24.5	31.0	9.3	22.6
Total	100	100	100	100

In an ideal flexible price world, price adjustments are based on a continuous-time pattern. If prices are adjusted once or less than once a year, then we have an indication of strong price stickiness in price formation and therefore monetary policy can affect output.

### Inflation expectations

The central bank conducts a monthly macroeconomic expectation survey for monetary policy purposes. This survey is designed by economic sector and is conducted monthly in the Lima Metropolitana area to three agent types: 1) non-financial firms, 2) economic analysts, and 3)

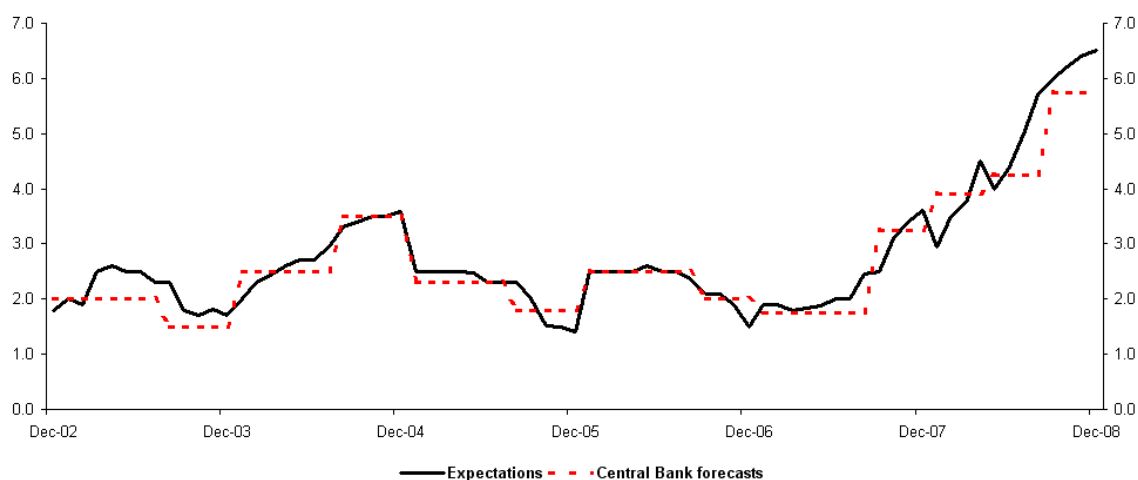
financial institutions. The survey covers current and next-two-years-ahead CPI inflation expectations. The outcome is released during the first week of each month.

Since 2002, the central bank has regularly published an inflation report with official inflation forecasts. Figure 3 compares economic analysts' expectations and central bank current-year forecasts published in each inflation report. On statistical grounds we find a double Granger causality, namely, for short horizons, both the central bank and economic analysts adjust forecasts in the same way, using all available information relevant for short-term forecasts.

Figure 3

**Economic analysts' inflation expectations versus central bank inflation report forecasts**

Expectations for current calendar year



Regarding inflation expectations for next calendar year, we provide evidence that economic analysts' forecasts do follow those of the central bank. The Granger causality test strongly rejects the hypothesis that inflation reports' forecasts do not Granger-cause economic forecasts.

Table 6

**Pairwise Granger causality test between inflation report forecasts for next year calendar and economic analysts' expectations for next year calendar**

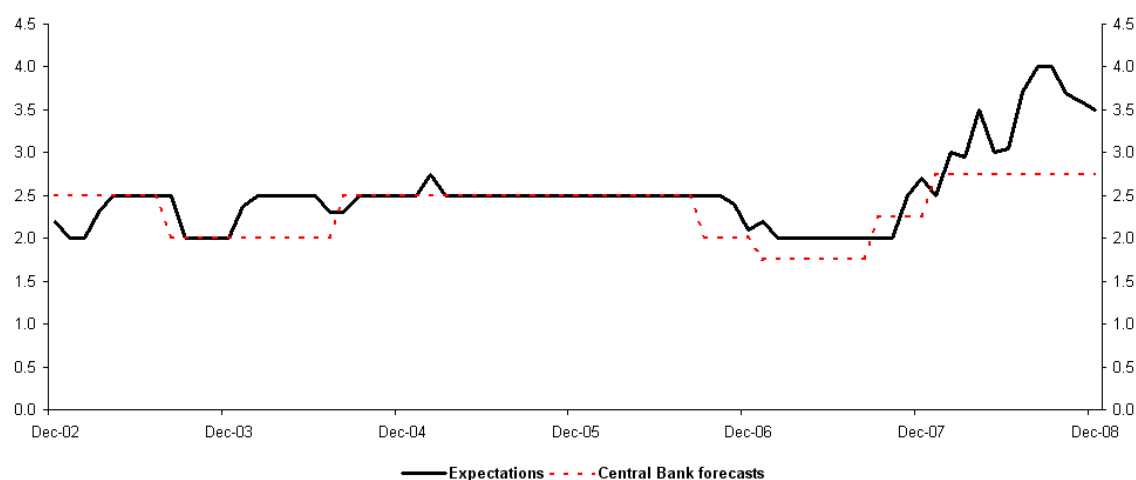
Null hypothesis:	Obs	F-statistic	Prob.
Inflation report forecast does not Granger-cause economist forecast	71	8.02684	0.0008
Economist forecast does not Granger-cause inflation report forecast		0.77263	0.4659



Figure 4

**Economic analysts' inflation expectations versus  
central bank inflation report forecasts**

Expectations for next calendar year



One key observation is the existence of heterogeneous expectations among agent types. This heterogeneity stems from the fact that not all agents process information in the same way. Simple evidence presented in Table 7 shows that non-financial agents' expectations tend to be more persistent than economic analysts' expectations. Furthermore, non-financial agents' expectations have not yet given a statistically significant weight to the numerical inflation target of the central bank. Since price formation is likely to depend more heavily on non-financial agents' expectations, the central bank closely monitors them and seeks to improve communication to anchor those expectations.

Table 7

**Regression of expected year-on-year inflation 18-months  
ahead against possible determinants for non-financial agents  
and economic analysts (HAC standard errors)**

	Non-financial agents	Economic analysts
- Lagged expected inflation	0.94 (25.2) <sup>***</sup>	0.79 (12.1) <sup>***</sup>
- Lagged year-on-year inflation	0.04 (2.7) <sup>***</sup>	0.06 (3.3) <sup>***</sup>
- Inflation target	0.03 (1.0)	0.16 (2.8) <sup>***</sup>
R <sup>2</sup>	0.94	0.79
Breusch-Godfrey F-stat (null = no serial correlation)	2.14	1.03

Notes: t-statistics in brackets

<sup>\*\*\*</sup> rejection of the null hypothesis at 1% level

<sup>\*\*</sup> rejection of the null hypothesis at 5% level

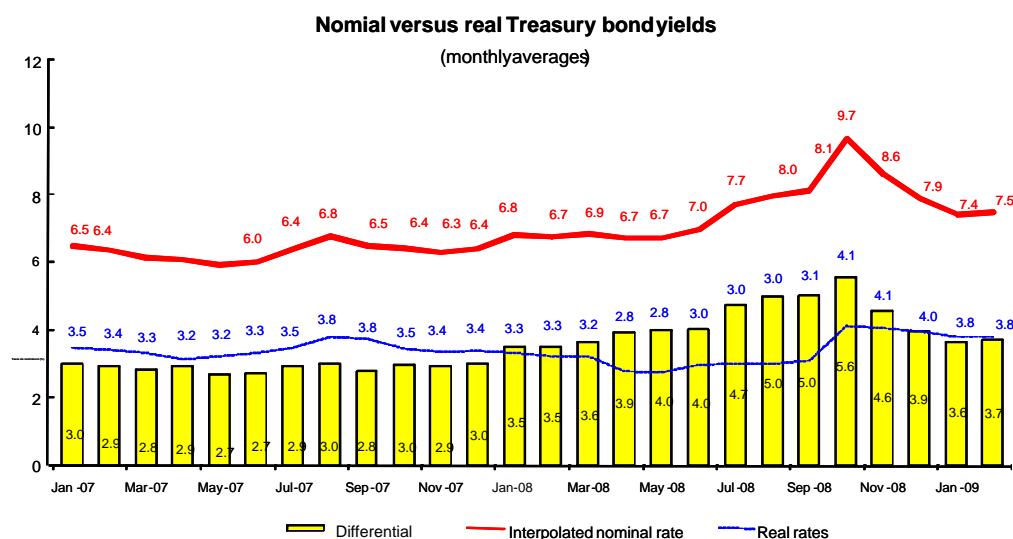
<sup>\*</sup> rejection of null hypothesis at 10% level

Indicators of long-term inflation expectations (up to 15 years) are also estimated on the basis of the difference between nominal and real bond yields. Indexed bonds<sup>5</sup> paying a constant real return were introduced in Peru by 2002. A direct estimate that relies on these data produces the break-even inflation rate ( $\pi^{be}$ ).

$$\pi^{be} = \text{Nominal yield} - \text{real yield} \quad [4]$$

Figure 5

### Nominal versus real treasury bond yields (for 2024) and its differential



This break-even inflation is composed of an unknown expected inflation, an inflationary risk, and a liquidity risk premium for nominal bonds. Precise estimation of expected inflation is hindered by the lack of enough historical series and the illiquidity of CPI-indexed bonds. Figure 5 shows yields and their differential (in bars). We observe that break-even inflation rose to 5.6% in October 2008, partly due to inflation expectations and partly due to higher risk liquidity and inflationary premia.

### 3. Other price indices followed by the central bank

#### National CPI

Since January 2003, the INEI has published a national CPI, defined as the average of consumer price indices calculated for the main 25 Peruvian cities. Like the Lima CPI, the weights also correspond to the ENAPROM survey for 1993–94.

The use of the national CPI as headline inflation indicator for monetary policy purposes is hindered by statistical shortcomings that have yet to be resolved; once these shortcomings vanish, it is likely that the central bank will adopt the national CPI as the benchmark headline inflation to target. So far, the central bank has endorsed the Lima CPI for a variety of reasons:

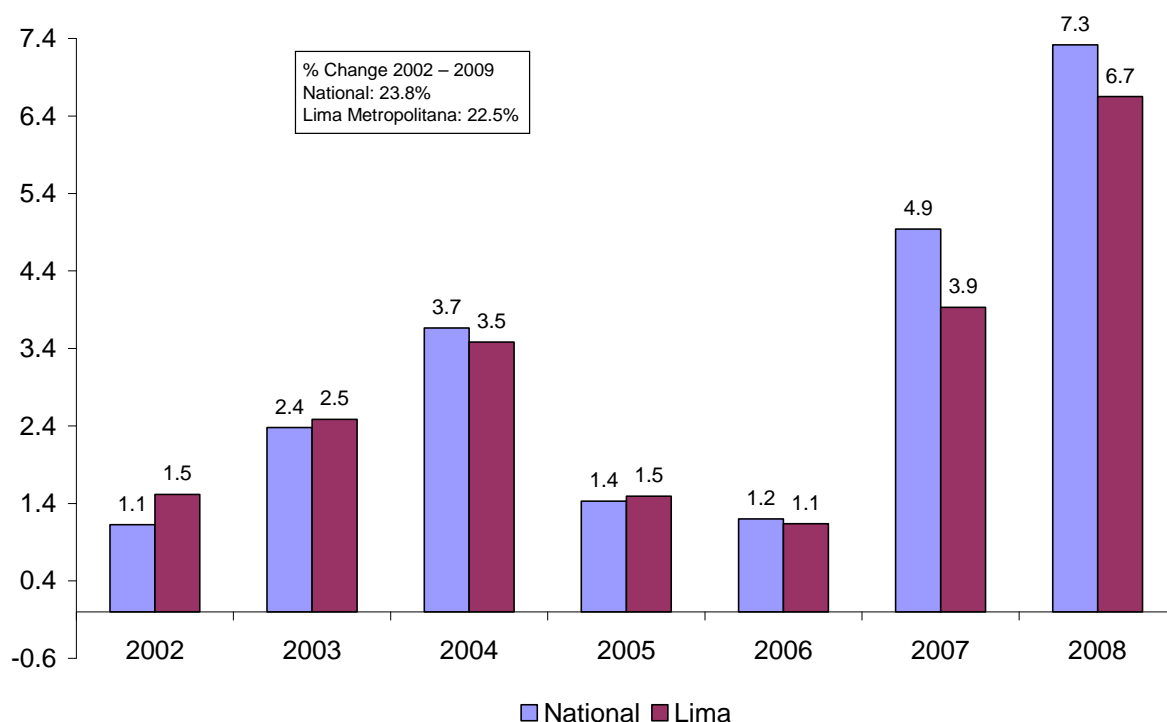
<sup>5</sup> Under the name “constant present value bonds – VAC”

- One of the results of the Lima CPI revision was the reduction of the weight of the food and beverages group. This revision has not been made for the national CPI.
- For the Lima CPI, the INEI gathers more than 36,000 prices each month, whereas for the 24 remaining cities the INEI collects only 1,708 prices on average per city.
- The Lima CPI is published in the official newspaper El Peruano by the first day of every month, whereas the national CPI is available on the INEI website on the 15th of each month.
- The Lima CPI is a good proxy of national inflation since the expenditure of Lima represents the 70% of national expenditure.

A question that arises here is whether all price indices within the national CPI converge with a common trend. This has been tackled in Monge and Winkelried (2004), where panel unit root techniques are used to discover that discrepancies between the 25 CPI aggregates due to idiosyncratic shocks die out in less than a year. One finding of Monge and Winkelried (2004) is that using the Lima CPI for the calculation of the central bank inflation target guarantees an anchor for the whole national CPI.

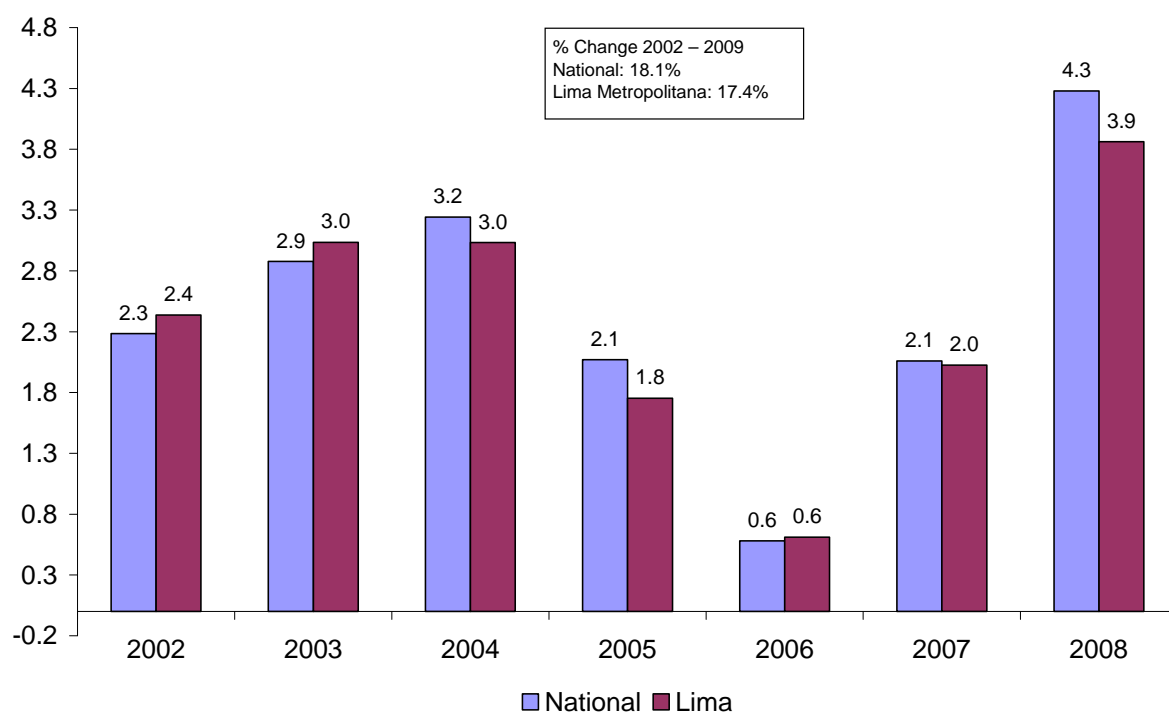
Since the inception of the national CPI, the two inflation rates have moved in close tandem. For example, during 2008, the Lima CPI rose by 6.7% and the national CPI by 7.3%. In the period 2002–08 the Lima CPI accumulated a 22.3% increase while the national CPI accumulated 24.1%.

Figure 6  
National and Lima CPI inflation rates  
Annual percentage change



The higher national inflation in 2007 and 2008 was related to the rise in the food and beverages group. In the rest of the cities, the contribution of this group to inflation was larger due to its considerable weight in the respective CPIs. If we exclude foods and beverages from both inflation measures their difference is further reduced.

Figure 7  
**National and Lima CPI excluding food and beverages**  
 Annual percentage change

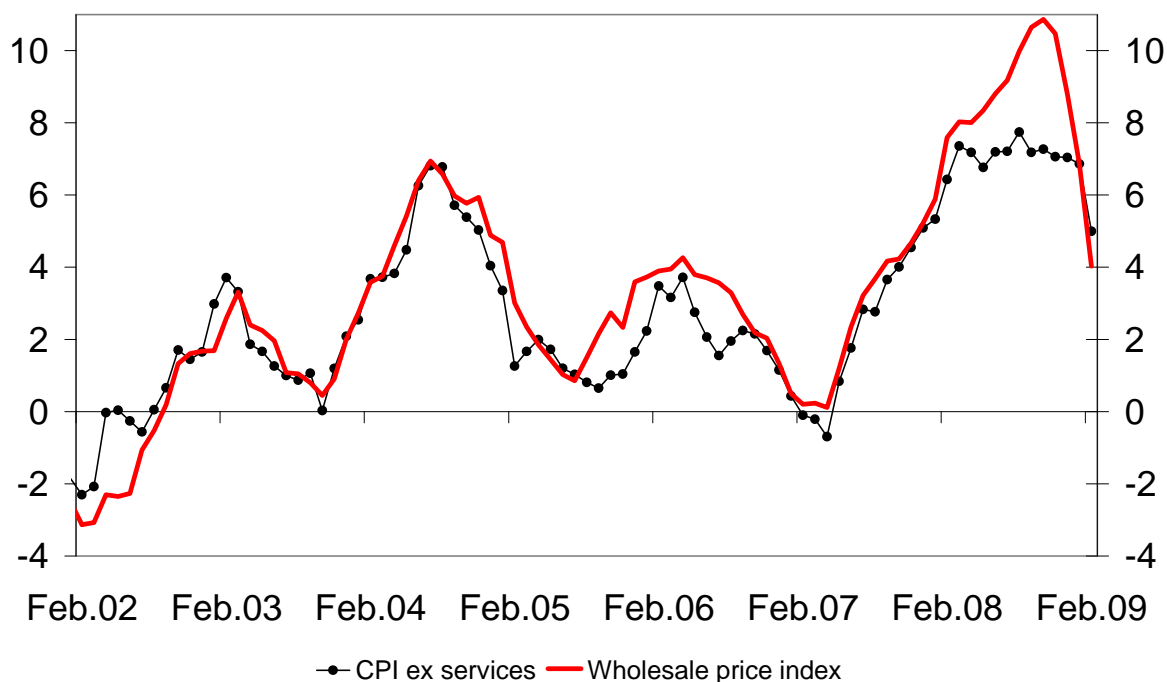


### National wholesale price index

The wholesale price index (WPI) is also compiled by the INEI. It covers the prices of a representative group of goods traded on wholesale markets in 25 major cities. The WPI covers 394 products, classified by sector (agriculture and livestock, fishing, and manufacturing) and by source (domestic and imported). This index could be used as a proxy indicator of producer prices and a leading indicator of the CPI.

Figure 8 shows that both WPI and CPI inflation excluding services provided a similar picture during most of the IT regime. However, an important gap opened during 2008, showing that wholesale prices were more prone to world price movements for food and oil. Importantly, wholesale price moves are usually assumed to represent – although imperfectly – cost-push pressures and affect price-setting decisions relevant for consumers, thereby tending to exert persistent inflationary pressures on the CPI.

Figure 8  
**CPI inflation excluding services and wholesale price index inflation**  
 Year-on-year percentage changes



**Imported CPI**

Imported inflation includes those goods in the CPI basket whose prices depend – to some extent – on international prices. Items such as bread, noodles, oil, cars and medicines are examples of this group.

This measure of inflation is more volatile than headline CPI because it is highly affected by volatile commodity prices that pass through to domestic prices. Even though swings in imported inflation are sizeable, their effect on the overall basket is mild due to the low weight attached to imported components (12.1%).

Figure 9

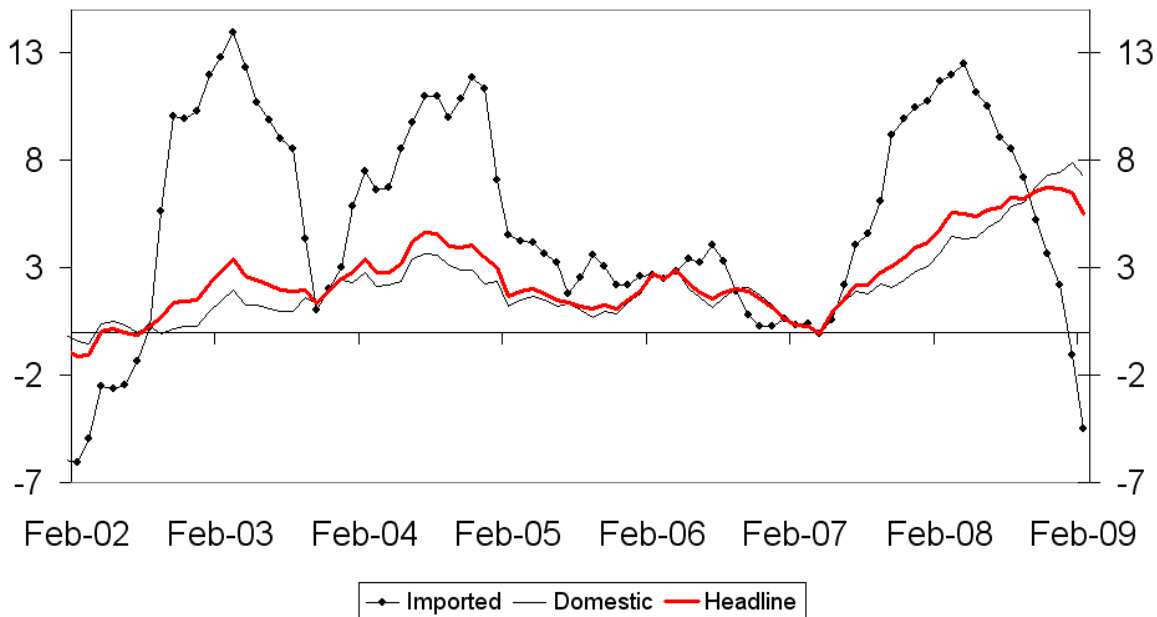
**Headline, imported and domestic CPI year-on-year inflation**

Table 8 shows the domestic and imported drivers of CPI inflation during the inflation-targeting years. The hike in inflation observed over 2007–08 was mainly related to food inflation. In 2007 imported inflation rose to 18.8% while in 2008 domestic food inflation increased by 10.5%. In other words, the effect of rising commodity prices observed from 2007 to mid-2008 first affected the most sensitive components (imported inflation) in 2007, but thereafter it also contaminated domestic components.

For example, a typical chain of reactions from wheat prices is first observed in domestic cereal and bread prices, which after a time lag might translate to restaurant food prices, which is a domestic price.

Table 8

**Headline, imported and domestic CPI year-on-year inflation**

	Weight	2002	2003	2004	2005	2006	2007	2008	Feb-09	2002–09*
<b>Inflation</b>	<b>100.0</b>	<b>1.5</b>	<b>2.5</b>	<b>3.5</b>	<b>1.5</b>	<b>1.1</b>	<b>3.9</b>	<b>6.7</b>	<b>5.5</b>	<b>2.9</b>
Imported	12.1	10.3	3.0	11.3	2.2	0.3	10.5	2.2	-4.5	4.6
Imported food	5.4	10.0	-0.1	10.9	-1.5	2.1	18.8	4.7	0.8	5.8
Imported non-food	6.7	10.6	5.6	11.7	5.0	-1.0	4.3	0.1	-9.1	3.5
Domestic	87.9	0.3	2.4	2.3	1.4	1.3	2.8	7.4	7.3	2.6
Domestic food	42.1	-0.7	2.2	3.0	1.5	1.7	4.1	10.5	9.7	3.3
Domestic non-food	45.8	1.2	2.6	1.6	1.3	0.9	1.6	4.5	5.0	2.0

\* February 2009.

**Tradable and non-tradable CPI**

A related measure of imported inflation is given by the tradable component of CPI inflation. Goods and services in the CPI basket can be arranged by their tradability in the world market; their prices are influenced by international prices, tariffs, transport costs, and the

exchange rate. Tradable CPI amounts to about 41% of the whole basket. In the long run both tradable and non-tradable inflation show a similar evolution.

Table 9

**Headline, tradable and non-tradable year-on-year inflation**

	Weight	2002	2003	2004	2005	2006	2007	2008	Feb-09	2002–09*
<b>Inflation</b>	<b>100.0</b>	<b>1.5</b>	<b>2.5</b>	<b>3.5</b>	<b>1.5</b>	<b>1.1</b>	<b>3.9</b>	<b>6.7</b>	<b>5.5</b>	<b>2.9</b>
Tradable	41.2	1.9	1.3	4.9	1.1	0.8	4.3	4.6	2.1	2.4
Tradable food	18.0	-0.7	0.1	6.7	-0.6	0.9	6.3	7.3	5.4	2.8
Tradable non-food	23.3	3.8	2.2	3.5	2.4	0.6	2.8	2.5	-0.4	2.1
Non-tradable	58.8	1.3	3.3	2.5	1.8	1.4	3.7	8.1	7.9	3.2
Non-tradable food	29.6	1.2	2.9	2.4	2.3	2.2	5.9	11.0	10.0	4.1
Non-tradable non-food	29.2	1.3	3.7	2.6	1.3	0.6	1.4	5.0	5.5	2.2

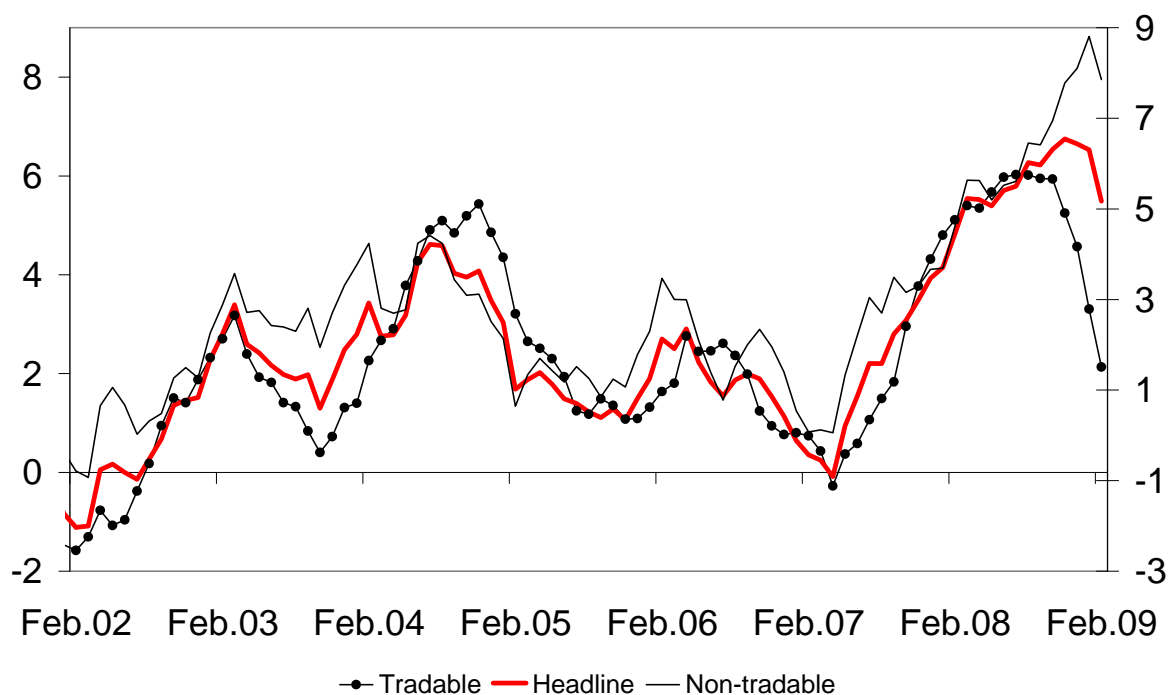
\* February 2009.

Figure 10 shows that there is a drift between both tradable and non-tradable inflation towards the end of 2008. The tradable component started falling due to the drop in world commodity prices, while non-tradable goods became relatively more expensive. This was an indication of possible strong domestic economic growth.

Figure 10

**Headline CPI and its tradable and non-tradable components**

Year-on-year percentage changes



#### 4. Core inflation measures used by the central bank

This paper has shown that headline inflation includes sizeable transitory components driven mainly by food and energy prices. In this environment, a focus on underlying inflationary signals can help improve monetary policymaking and its further assessment.

Nevertheless, economists do not have a generally accepted theoretical definition of core inflation. Eckstein (1981) defines core inflation as the rate of inflation that corresponds to the long-run growth path of the economy. Bryan and Cecchetti (1994) define it as monetary inflation that results from changes in the quantity of money. Reis and Watson (2007) entertain a concept that they dub “pure inflation”, which refers to movements in prices driven by common price movements and not by relative price swings.

Bilke (2006) provides a typology of core inflation measures based on disaggregate and aggregate views of prices. The disaggregated methods take the cross-sectional components of CPI and consider diverse exclusion techniques as well as measures of central tendency and re-weighting. The aggregate methods conform to what Mishkin (2007) calls theoretical approaches because they include dynamic factor models and structural VARs.

Whatever the concept we address, in order to aid policy in terms of monetary policy implementation and communication, a good core inflation indicator must have some desirable properties, for example those outlined in Roger (1998):

- a. It must be easy to understand and to reproduce by both policymakers and the public.
- b. It must be a stable indicator, ie it must have few and non-significant revisions, when new data are added to the series.
- c. It must be a credible indicator, ie its evolution should not systematically diverge from observed inflation. In order to maintain credibility, core inflation should not underestimate headline inflation for long periods.
- d. It must be available at the same time as headline inflation, to help explain monetary policy to the general public.
- e. It must have lower volatility than inflation.
- f. It must have the capacity to predict headline inflation, ie when headline inflation diverges from core inflation, it will probably move back towards core inflation after some time.

##### *Core inflation indicators followed by the Central Reserve Bank of Peru*

In this paper, we update the assessment of some of the core inflation measures posted on the central bank’s website,<sup>6</sup> and include some new measures that were monitored during the 2008 high inflation episode.

**Official core inflation (CORE):** The central bank of Peru publishes a core inflation indicator that excludes about 39.4% of the volatile components of the basket. The excluded items are agricultural foodstuffs, because their prices are affected by weather conditions. Bread, noodles, oil, rice and sugar are also excluded because their prices depend on commodity prices. Finally, fuels, utilities and transport are excluded because their prices depend on the evolution of international oil prices, fiscal policy and regulation. This official core measure is stable since it is not subject to revisions when new data are added to the series of inflation.

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<sup>6</sup> Nota de Estudios No. 11-2006 – 6 April 2006.  
<http://www.bcrp.gob.pe/docs/Publicaciones/Notas-Estudios/2006/Nota-Estudios-11-2006.pdf>



**Other core inflation indicators obtained by excluding items:**

- **CPI ex food:** Excludes food items from the CPI basket.
- **CPI ex food&energy:** Excludes food and energy from the basket.
- **Core ex food:** Excludes food from the core CPI basket.

We also consider three indicators based on limited-influence statistics of the cross-sectional distribution of price changes.

**63rd percentile (PCTL63):** This indicator corresponds to the 63rd percentile of the price change distribution. This percentile is chosen so that the mean core inflation will match mean headline inflation.

**Trimmed mean (TRIM50):** Weighted mean of price changes located between the 34th and 84th percentiles of the price change distribution. The criteria for choosing these percentiles are also set in terms of targeting the mean core inflation rate over a reference sample.

**Rewighted mean (REWEIGHTED):** This is an indicator based on the CPI, recalculated by dividing the weights of each item by the standard deviation of their monthly percentage changes.

Table 10 shows the evolution of year-on-year inflation measures observed during the last months of 2007 and 2008. One particular point to note is that all core inflation indicators almost doubled from December 2007 to December 2008, signalling that overall inflationary pressures are relevant for monetary policy decisions. In fact, the central bank of Peru raised its policy rate by 150 basis points by August 2008.

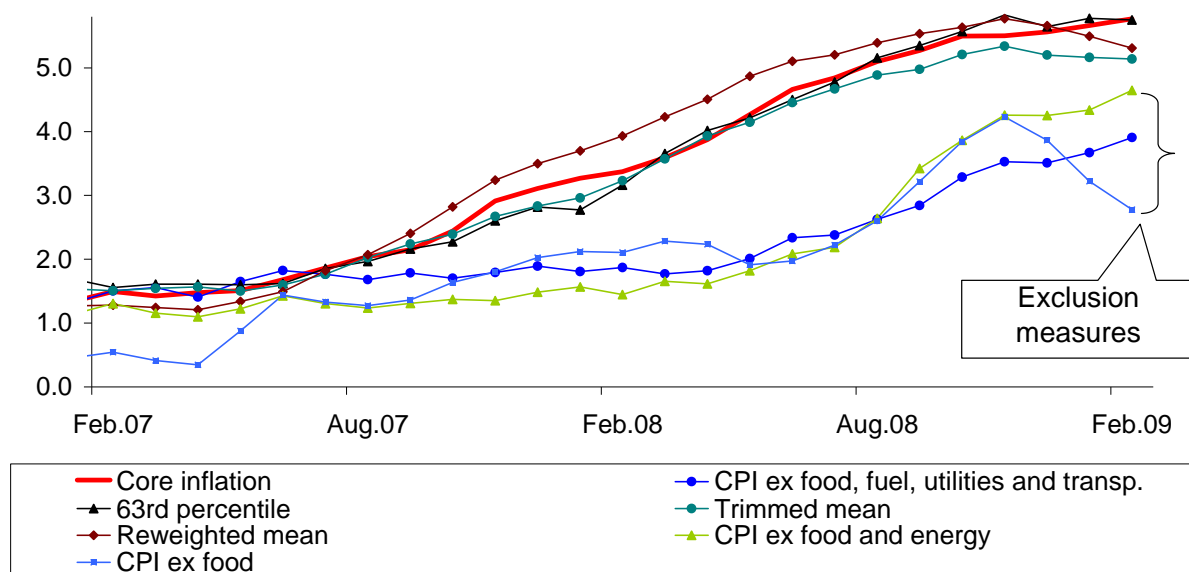
Table 10  
**Core year-on-year inflation measures**

	2007		2008			2009		% change annual avg. 95-09	Std. dev. 95-09	
	Jun.	Dec.	Mar.	Jun.	Sep.	Dec.	Jan.			Feb.
<b>CPI</b>	1.5	3.9	5.5	5.7	6.2	6.7	6.5	5.5	4.4	0.43
Core inflation	1.7	3.1	3.6	4.7	5.3	5.6	5.7	5.8	4.2	0.30
<b>Other core inflation indicators</b>										
CPI ex food	1.4	2.0	2.3	2.0	3.2	3.9	3.2	2.8	4.8	0.44
CPI ex food and energy	1.4	1.5	1.7	2.1	3.4	4.3	4.3	4.6	4.8	0.43
CPI ex food, fuel, utilities and transportation	1.8	1.9	1.8	2.3	2.8	3.5	3.7	3.9	4.5	0.38
63rd percentile: rate corresponding to the 63rd of the price changes distribution	1.6	2.8	3.7	4.5	5.3	5.6	5.8	5.8	4.4	0.3
Trimmed mean (34 to 84): weighted mean of price changes located between the 34th and 84th percentiles of the price change distribution	1.6	2.8	3.6	4.5	5.0	5.2	5.2	5.1	4.4	0.3
Rewighted mean: CPI recalculated dividing the weights by the standard deviation of the monthly percentage changes of the corresponding item	1.5	3.5	4.2	5.1	5.5	5.7	5.5	5.3	4.3	0.3

Figure 9 provides an overall picture of the dynamics of the diverse core inflation indicators since December 2001; the rapid rise in core inflation since mid-2007 is also a remarkable feature. During the period, most food items within the official core inflation that used to have low volatility started showing important and persistent increases due to the rise in food commodity prices. It was in these circumstances that monetary policy turned more attention to core indicators that exclude food and energy prices. This switch of attention was due to the fact that the central bank considered the commodity price hikes only as temporary and believed that a huge reversal was likely to take place sooner or later.

Figure 11

### Core year-on-year inflation rates



It is worth mentioning that the central bank of Peru also estimates core inflation measures based on theoretical approaches following Quah and Vahey (1995) or Reis and Watson (2007). For example, first Grippa and Ferreyros (2000) and then Salas (2009) have developed monetary VAR models to extract permanent and transitory shocks that affect inflation and define core inflation measures driven by demand shocks. However, the applicability of these measures is still under scrutiny. As Mishkin (2007) puts it,

*“... theory-based approaches tend to be rather complex and require faith that the model they are based on is the right one.”*

#### Assessment of core inflation indicators:

The empirical literature has identified some testable features desirable for any core inflation measure. These core inflation tests are outlined, for example, in Smith (2004), Cogley (2002), and Hanson et al (2008), among others. The idea behind the tests lies in the fact that any core inflation measure must capture underlying inflationary pressures in a historic and predictive fashion.

The part that is not captured by core inflation indicators is presumed to represent high-frequency noise components unrelated to demand or monetary policy as a whole.

The word “component” here is key because it refers to the time-series process of headline inflation and not to the cross-sectional pieces that comprise the aggregate headline price index. References to core inflation indicators that exclude some items of the price index are useful only insofar as the non-excluded parts have certain features over time.

Below, we outline the criteria for assessing the relevance of core inflation indicators at the central bank.

#### Core inflation as an indicator of future inflation

Core inflation might hint at future inflationary pressures. In that sense, we can think of different measures of core inflation as forecasts of future inflation h-steps ahead and then assess the accuracy of those forecasts by means of the root mean square forecast error

(RMSE). Following the exercise in Hanson et al (2008) we perform the RMSE statistic according to

$$rmse_h = \sqrt{\frac{1}{T} \sum_t (\pi_{t+h}^{cpi} - \pi_t^{core})^2} \quad [5]$$

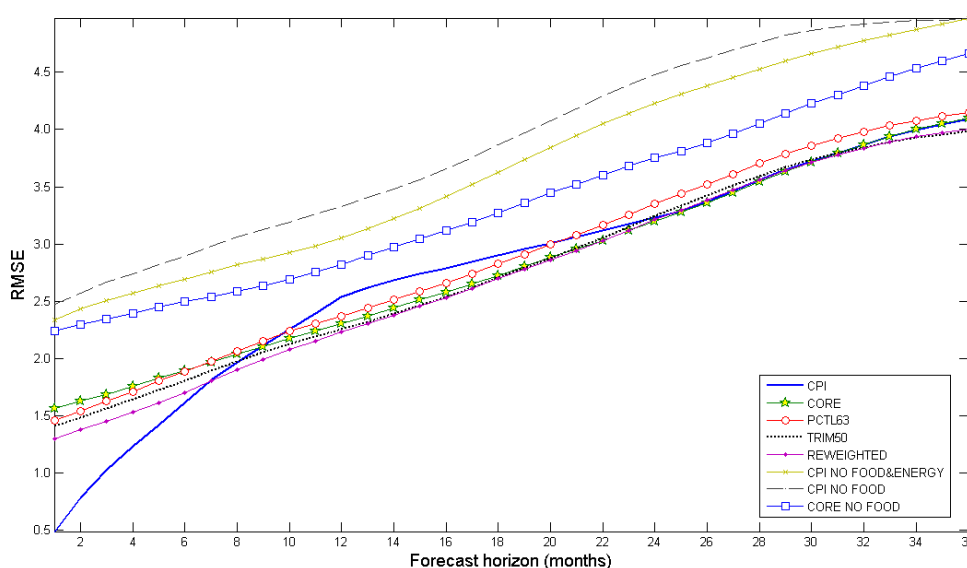
where  $\pi_{t+h}^{cpi}$  is the year-on-year measure of headline inflation in period  $t + h$ ,  $h$  is a forecast horizon that takes values  $h = 1, 2, \dots, 36$ ,  $\pi_t^{core}$  is any particular year-on-year core inflation measured at time  $t$ .

To perform this exercise we used monthly data from December 1995 to December 2008 and consider that the sample size ( $T$ ) to compute the RMSE for each horizon varies from 121 to 156.

In Figure 12 we observe RMSE for different forecast horizons and for different core inflation measures. A forecast model is good if it has a low RMSE, some models are accurate for short horizons, and some are good for medium- to long-term horizons. A particular interesting feature is that up to  $h = 6$ , a “naive” forecast represented by the current CPI inflation outperforms all the core inflation indicators. It is only for horizons  $h = 10$  to  $20$  that a group of core inflation measures outperforms the “naive” forecast. The core measures that belong to this group are the official CORE, PCTL63, TRIM50 and REWEIGHTED. Strikingly, the core inflation measures that exclude food or energy items perform poorly for the whole period 1995–2008.

Figure 12

### RMSE for y-on-y CPI inflation forecasts along horizons



The results provided in Figure 12 give an indication that forward-looking monetary policy should not overlook the group of core inflation measures that fare better than all other core inflation indicators at horizons  $h = 10$  to  $20$ , because it is precisely this forecast horizon that matters most for monetary policy in Peru.

Related to the measures of RMSE, the notion of forecast bias is also important. To show this, Figure 13 measures the signed bias of the core inflation indicators implicit in the RMSE values.

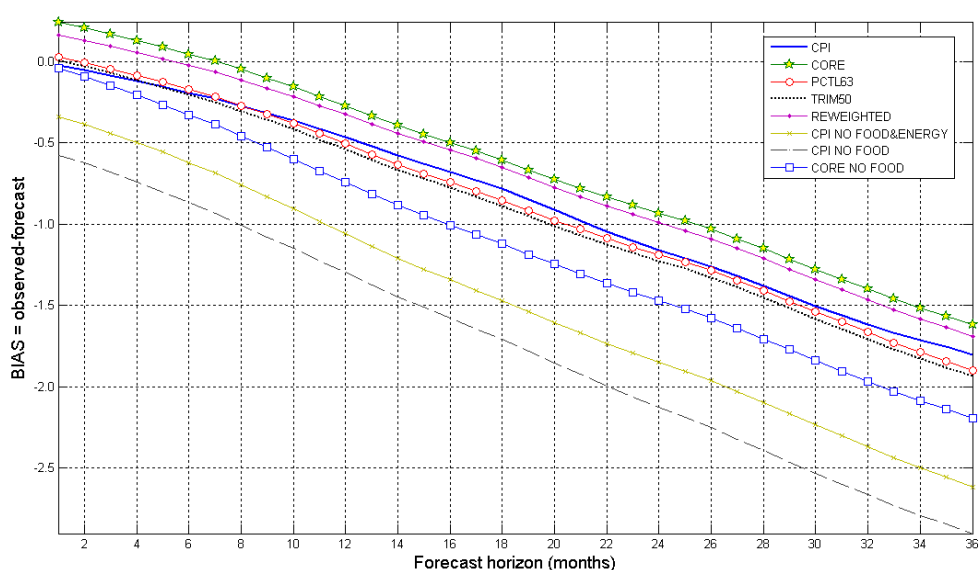
$$bias_h = \frac{1}{T} \sum_t (\pi_{t+h}^{cpi} - \pi_t^{core}) \quad [6]$$

As equation [6] states, the bias is the signed difference between the observed inflation at  $t + h$  and the forecast made  $h$  periods before. A positive bias is a sign of underprediction, meaning that the forecast tends to be lower than the outcome, while a negative bias signals overprediction. A bias of around zero means that all the RMSE is explained by the volatility of the forecast error. For example, in Figure 13 we note that the bias of the official core inflation in indicating headline inflation for horizon  $h = 7$  is approximately zero while Figure 12 indicates that its RMSE for the same horizon is 1.96, this means that in spite of the fact the bias is negligible, the RMSE error is not zero because the variance of forecast errors<sup>7</sup> is relatively large.

As we move up to the best-forecast horizons pertaining to the official CORE inflation, the bias becomes negative, in the range of 0–0.5. It is also important to note that core inflation measures that exclude food and energy items have also a strong negative bias at all horizons.

Figure 13

### Bias for y-on-y CPI inflation forecasts along horizons



In order to ensure robustness we performed this same exercise by omitting the last two years of data (ie before the inflationary hike) and the pictures of RMSE and BIAS maintained the same ordering.

A related measure of forecast ability is the exercise performed in Cogley (2002), which highlights that a good core inflation indicator must have the ability to remove short-run noise from headline inflation. This means that if current headline inflation is above core inflation, it should induce future corrective declines in headline inflation towards core inflation.

$$\pi_{t+h}^{cpi} - \pi_t^{core} = \alpha_H + \beta_H (\pi_t^{cpi} - \pi_t^{core}) \quad [7]$$

In terms of equation [7], the coefficient  $\beta_H$  quantifies the degree of the correction mentioned above. If the core inflation measure is a good indicator, then  $\beta_H$  must be statistically lower

<sup>7</sup> If  $\pi_{t+h}^{cpi}$  and  $\pi_t^{core}$  move together, the variance would be close to zero. However when  $\pi_t^{core}$  is too smooth, the variance of  $\pi_{t+h}^{cpi}$  tends to dominate, rendering huge RMSE values.

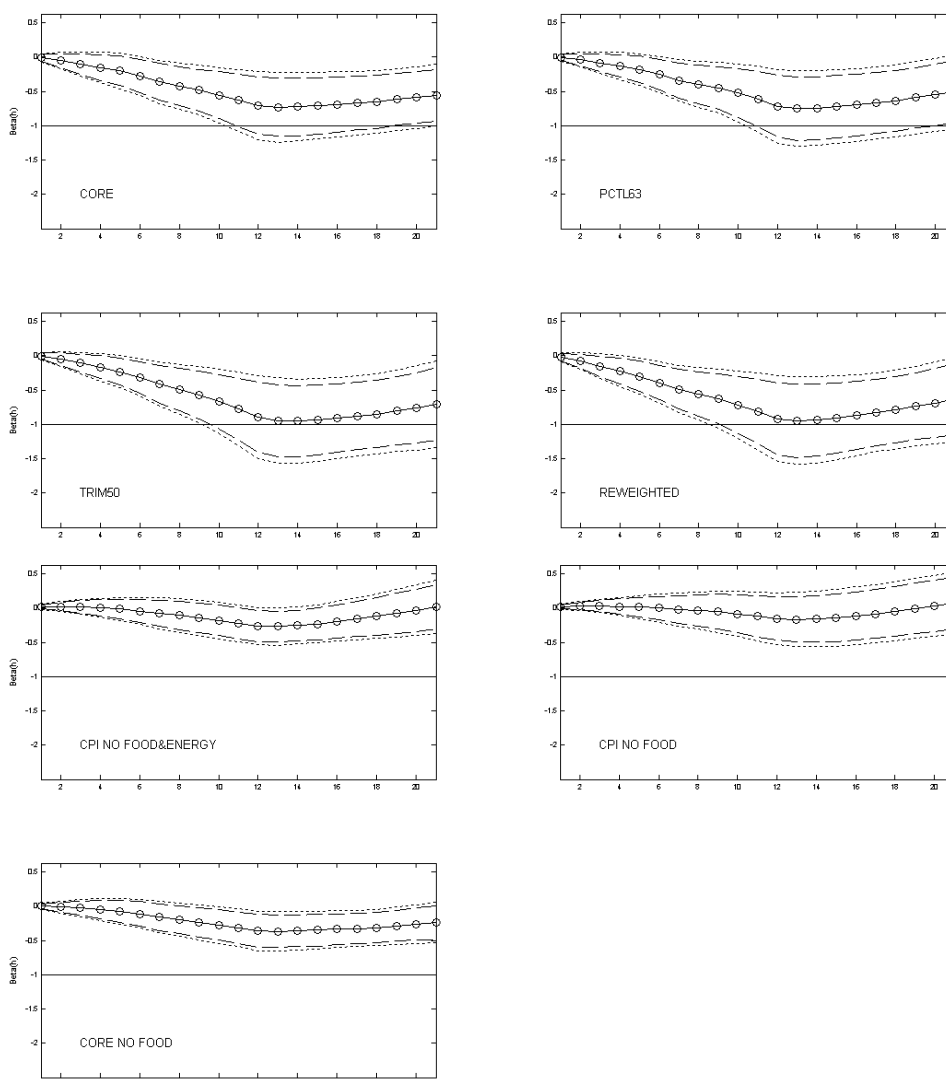
than zero. We can characterise the correction in the following terms: if the coefficient is statistically equal to  $-1$  then the gap between headline and core inflation exactly matches the magnitude of future inflationary corrections, if the parameter is strongly below  $-1$  then the gap underestimates future inflationary corrections, whereas a parameter value above  $-1$  shows that the gap overestimates future corrections.

Figure 14 shows the different values of parameter  $\beta_H$  for the seven core inflation indicators under consideration. Notably, the core inflation indicators that performed well in the RMSE exercise also perform well under this exercise. The official CORE and PCTL63 slightly underpredict future inflationary correction for short horizons, but for longer horizons (more than a year) we cannot reject the possibility that these two indicators predict proportional correction in future inflation. The TRIM50 and the REWEIGHTED measure provide a similar picture; we can be more confident about their ability to indicate longer-term corrections.

A quite different story is provided by the CORE inflation measures that exclude food and energy. The parameter  $\beta_H$  is basically zero for all horizons and therefore they are of no use in guiding future inflationary corrections.

Figure 14

**Values of  $\beta_H$  for each horizon  $h$  and for each core inflation indicator together with HAC confidence bands**



## Core inflation should have the same average as CPI inflation

Using the sample of year-on-year inflation measures from December 1995 to December 2008, we estimated their mean value over the whole period and tested if the respective mean values were different from the CPI inflation mean value.

Table 11 reports the t-test performed and shows that mean Core, CPI no food&energy, CPI no food and reweighted do not have a mean similar to headline inflation, thus rejecting the hypothesis that these core indicators have the same mean as CPI at 10% or 5% significance levels.

These results mean that, even though it signals future inflation movements, the official core indicator has failed to anchor headline inflation completely in the long run.

Table 11  
Mean comparison test (sample: December 1995 to December 1998)

Measure	Mean	Std. rr.	[95% conf. interval]		t-test Pr( T  >  t )
CORE	3.92	0.25	3.42	4.41	0.02**
CORE_NO_FOOD	4.19	0.28	3.64	4.74	0.99
CPI_NO_FOOD_NO_ENERGY	4.49	0.30	3.90	5.07	0.09*
CPI_NO_FOOD	4.72	0.29	4.15	5.29	0.00***
PCTL63	4.15	0.23	3.69	4.61	0.71
REWEIGHTED	3.99	0.24	3.51	4.47	0.05*
TRIM50	4.13	0.25	3.64	4.62	0.61
CPI	4.19	0.26	3.67	4.70	

Ho: mean(diff) = 0 Ha: mean(diff) different from 0

\*, \*\* reject the null hypotheses at 10% and 5% significance, respectively.

## Persistence of core inflation

Knowledge about the persistence of core inflation measures is also relevant for monetary policy purposes. As shown in Figure 15, the official CORE REWEIGHTED, TRIM50 and PCTL63 have the most persistent responses to a shock that drives them away from their baseline values. The core-inflation shocks die away only after approximately two years. The core measures that exclude food and energy components have responses that disappear after about 15 months. In order to compute the responses, we estimated a simple VAR equation

$$\begin{bmatrix} \pi_t^{cpi} \\ \pi_t^{core} \end{bmatrix} = A(L) \begin{bmatrix} \pi_t^{cpi} \\ \pi_t^{core} \end{bmatrix} + \varepsilon_t \quad [8]$$

where  $A(L)$  is a matrix polynomial that considers at least 13 lags and  $\varepsilon_t$  is a vector of corresponding reduced-form shocks. The impulses are computed with standard Cholesky representations.

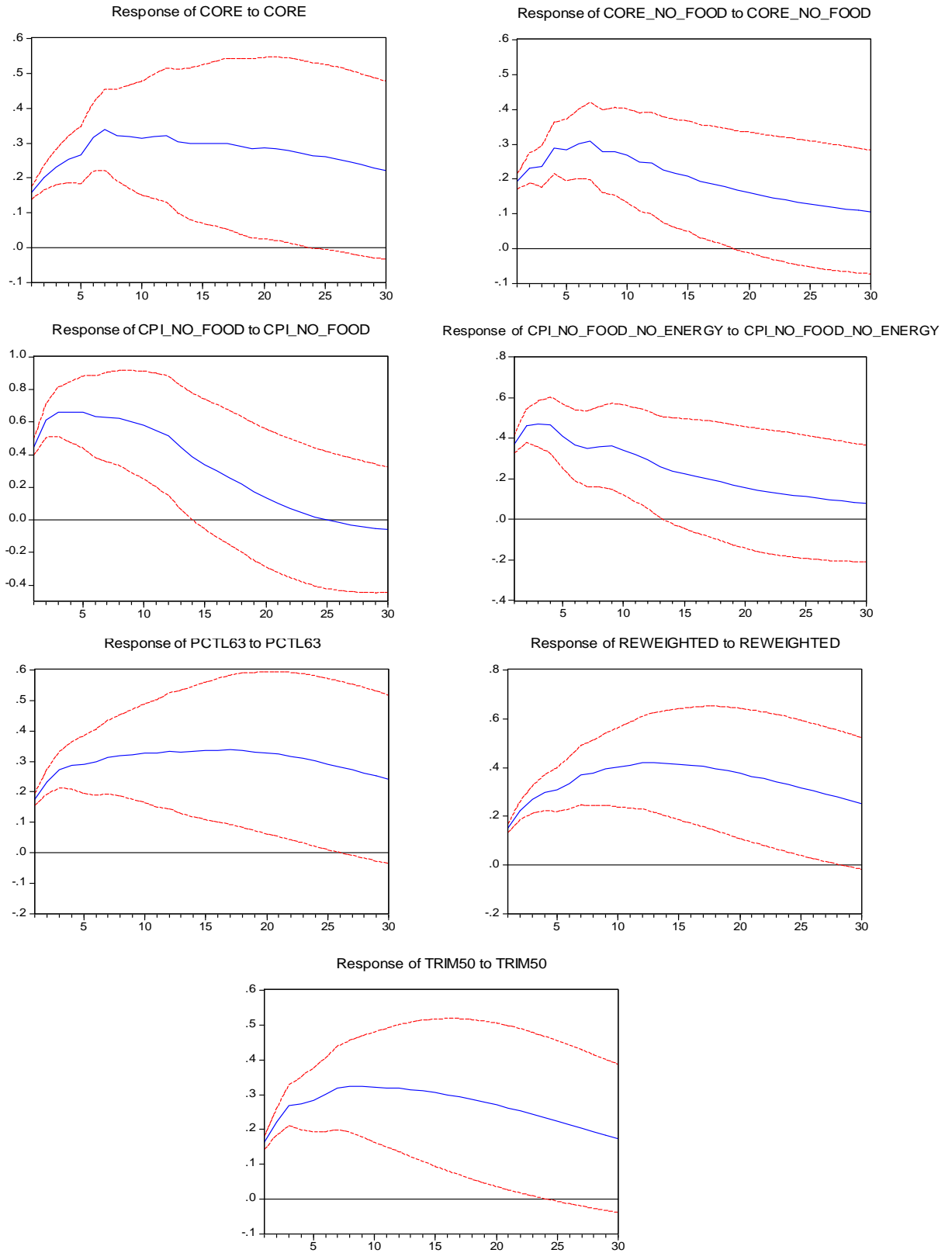
The results provided here are broadly in line with what we should expect about core inflation movements. Mishkin (2007) is clear about this feature:

*“Thus, relative to changes in headline inflation measures, changes in core measures are much less likely to be reversed, provide a clearer picture of the underlying inflation pressures, and so serve as a better guide to where headline inflation itself is heading. Of course, if a particular shock to non-core prices is not temporary but, rather, turns out to be more persistent, then the higher costs are*

likely to put some upward pressure on core prices. Central bankers must always be aware of this risk.”

Figure 15

**Impulse-response of different measures of core inflation to 1 standard deviation shock**



Note: x-axis: months; y-axis: percent deviation from baseline

## Do measures of core inflation Granger-cause headline inflation?

Table 12 shows that the official CORE and PCTL63 reject the null hypothesis that they do not Granger-cause headline inflation. This means that present and/or past values of these core inflation measures are useful in explaining the current behaviour of headline inflation.

Table 12

### Granger causality tests

<u>Measure</u>	<u>Null hypothesis</u>	<u>Prob</u>
<b>CORE</b>	CPI does not Granger-cause CORE	0.671
	CORE does not Granger-cause CPI	0.0587*
<b>CORE_NO_FOOD</b>	CPI does not Granger-cause CORE_NO_FOOD	0.0175**
	CORE_NO_FOOD does not Granger-cause CPI	0.215
<b>CPI_NO_FOOD_NO_ENERGY</b>	CPI does not Granger-cause CPI_NO_FOOD_NO_ENERGY	0.0136**
	CPI_NO_FOOD_NO_ENERGY does not Granger-cause CPI	0.905
<b>CPI_NO_FOOD</b>	CPI does not Granger-cause CPI_NO_FOOD	0.0685*
	CPI_NO_FOOD does not Granger-cause CPI	0.836
<b>PCTL63</b>	CPI does not Granger-cause PCTL63	0.0989*
	PCTL63 does not Granger-cause CPI	0.0614*
<b>REWEIGHTED</b>	CPI does not Granger-cause REWEIGHTED	0.361
	REWEIGHTED does not Granger-cause CPI	0.324
<b>TRIM50</b>	CPI does not Granger-cause TRIM50	0.433
	TRIM50 does not Granger-cause CPI	0.432

\*, \*\* reject the null hypotheses at 10% and 5% significance, respectively.

## 5. Concluding remarks

The Central Reserve Bank of Peru conducts monetary policy in terms of CPI headline inflation but due to sizeable noise and fluctuations in this variable, it is necessary to follow up other price indices and core inflation indicators in order to have better guides for monetary policy.

During the inflationary pressures of 2007–08 in particular, we observed an increasing instability of standard core inflation measures that have clouded their use in monetary policy. This feature has been predominantly acute in an environment characterised by the high weight attached to food prices within the overall basket.

The standard core inflation measure published by the central bank of Peru still remains a good indicator for future headline inflation changes. Even though the core inflation measure that excludes food items did not fare well in analysis of the whole sample, it does not mean that it should be overlooked. In fact, if food price shocks are transitory – as indeed they were in the 2007–08 episode – then its importance for monetary policy purposes is still justified.



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# Measurement of inflation and the Philippine monetary policy framework

Diwa C Guinigundo<sup>1</sup>

For an inflation-targeting central bank, the choice of price index should reflect the most informative price level in the decision-making process of economic agents. Ideally, it should also be an index that responds strongly to the instruments of monetary policy. It is expected that each agent will accord different levels of importance to different price indices. However, for purposes of policy setting, the inclusion of prices that are not sensitive to monetary policy or those that largely reflect relative price changes may lead to an unnecessary monetary policy reaction that only makes anchoring of price expectations more difficult.<sup>2</sup>

## A. Operational aspects of inflation targeting in the Philippines

The inflation target-setting in the Philippines is based on the existing framework for coordination between government economic agencies under the Development Budget Coordinating Committee (DBCC).<sup>3</sup> The national government, through the DBCC, sets the inflation target based on the consumer price index (CPI) two years ahead in consultation with the Bangko Sentral ng Pilipinas (BSP). The BSP has full powers over and responsibility for the announcement of the inflation target and the determination of appropriate monetary policy to achieve the target.

The monetary policy framework provides for exemption clauses to recognise the fact that there are limits to the effectiveness of monetary policy and that there may be occasional breaches owing to factors beyond the control of the central bank. These exemptions include price pressures arising from: (1) volatility in the prices of agricultural products; (2) natural calamities or events that affect a major part of the economy; (3) volatility in the prices of oil products; and (4) significant government policy changes that directly affect prices, such as changes in the tax structure, incentives and subsidies. Thus, the communications strategy will need carefully to specify the reasons, plan of action and length of time involved to bring inflation back to target.

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<sup>1</sup> Deputy-Governor, Bangko Sentral ng Pilipinas.

<sup>2</sup> Measurement of inflation has long been the subject of empirical debate. The use of different indices has varying implications on inflation. Consumer price index (CPI) inflation is an indicator of how much the cost of a typical market basket of goods and services commonly purchased by households behaves over a specific time period. The advantage is that it includes imported components. However, it does not capture the substitution effects that happen between periods unless the basket is modified accordingly. There are also arguments that the CPI basket does not take into account the different consumption baskets across income class.

<sup>3</sup> A government interagency body responsible for setting the annual government targets for macroeconomic variables used in the formulation of the fiscal programme. Nonetheless, the jurisdiction over inflation forecasting and setting of appropriate inflation target that is consistent with the macroeconomic targets remains with the BSP. For a complete account of the Philippines' monetary policy framework, see DC Guinigundo (2005), "Inflation targeting: the Philippine experience," in *The Bangko Sentral and the Philippine Economy*, (ed Vicente B. Valdapeñas, Jr), Manila, Bangko Sentral ng Pilipinas, pp 346–91.

The decision-making process of the Monetary Board (MB) is supported by the Advisory Committee (AC).<sup>4</sup> The meetings of the Advisory Committee provide for a more in-depth, comprehensive, broad-ranging assessment of monetary conditions, economic outlook, inflationary expectations and the forecast inflation path. The recommendations to the MB are voted on by AC members via majority vote.

There are a number of disclosure and accountability mechanisms to help the public better monitor the BSP's commitment to achieving the inflation target. These include regular reports, publications, press statements, seminars and conferences, and highlights of the MB meetings on monetary policy, among other things. In cases when the BSP fails to achieve the inflation target, the BSP Governor issues an open letter to the President outlining the reasons why actual inflation did not fall within the target, along with the steps that will be taken to bring inflation back towards the target.<sup>5</sup>

## **B. Relevant price index for setting the inflation target in the Philippines**

As mentioned above, the price index used as the basis for determining the inflation target is the CPI. Consumer prices for a representative basket are compared to a base year and weighted by the appropriate consumption pattern. Hence, the determination of the base year and the composition of the basket are important, lest the CPI become irrelevant.

The survey, generation, and rebasing of the CPI are undertaken by the independent National Statistics Office (NSO). The CPI has been rebased seven times, most recently in 2000. The NSO is currently processing the commodity outlet survey, which will be the basis for determining the revised market basket of commodities.<sup>6</sup>

Rebasing an index is necessary to ensure that this barometer of economic phenomena is truly reflective of the current situation. Consumer tastes and technology change over time, causing the fixed market basket of goods and services to become outmoded. To capture such changes for a more meaningful price comparison, revision or updating of the fixed market basket, the sample outlets, the weights and the base year have to be undertaken periodically. The market basket used in the construction of the 2000 CPI was drawn from the results of the updating activity of the 1994 market basket for the provinces and selected cities.<sup>7</sup>

The consumer items that constitute the CPI basket are determined by the nationwide Family Income and Expenditure Survey (FIES) conducted every three years by the NSO. The latest rebasing exercise used 2000 as the base year to coincide with the FIES conducted on the

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<sup>4</sup> The Advisory Committee is composed of the following members: (1) the BSP Governor, who serves as Chair; (2) the Deputy Governor for Monetary Stability; (3) the Deputy Governor for Supervision and Examination; (4) the Managing Director of the Monetary Policy Sub-Sector; and (5) the Managing Director of the Treasury Department. The technical secretariat consists of staff from the BSP's Department of Economic Research, Center for Monetary and Financial Policy and the Treasury Department (monetary operations).

<sup>5</sup> Open letters to the President have been issued on 16 January 2004, 18 January 2005, 25 January 2006, 19 January 2007 and 14 January 2008.

<sup>6</sup> NSO hopes to start computing the weights by 2009 and possibly start the rebasing of the CPI with 2006 as the new base year by 2010.

<sup>7</sup> The number of items in the 2000 market basket was almost identical to the 1994 market basket. Market baskets for Guimaras, Biliran, Sarangani, Cagayan de Oro City and Apayao were added to the existing 84 provincial/selected city market baskets. Source: National Statistics Office, <http://www.census.gov.ph>.

same year, which covered 41,000 households. The year 2000 was also perceived to be a more politically, economically and socially stable year. To account for the geographical differences in consumption patterns, weights were generated for each province or city. The basket weight for each item of expenditure is a proportion of that item to total national expenditure. Likewise, geographical weights were also determined where the weight of a region is equal to the sum of the weights of the provinces belonging to that region. The sum of the weights for the region is equal to the national weight.

The use of the CPI as the basis for policy setting under inflation targeting is largely governed by pragmatic considerations. The frequency with which it is published and the fact that it is an index readily understood by the public rendered its adoption appealing. The GDP deflator, while output-based, is available only on a quarterly basis and is subject to periodic revisions in the national income accounts. This makes it less reliable for target-setting purposes.

As part of a new framework that rests on anchoring inflation expectations towards the desired inflation path of the BSP, the inflation target naturally has to be based on a price index with which the public is familiar. This aids in the explanation of the underlying factors that affect inflation performance. In this regard, building a constituency of support for the price stability objective of monetary policy will be facilitated. Given the usual asymmetry in perception about relative price changes and overall price changes, public understanding of the price index used for target-setting could be nuanced as well. In this regard, the CPI has an inherent advantage.

CPI inflation also tends to be affected by the transitory effects of volatile price movements of certain commodities. Temporary shocks or disturbances that are due to factors outside the direct control of economic policy (eg oil price shocks) may cause fluctuations in CPI inflation that may not necessarily require a monetary response. As such, the BSP also monitors “core” inflation to supplement its analysis of the appropriate stance of monetary policy. When the impact of such disturbances on price data is eliminated, core or underlying inflation serves as a useful alternative indicator of the path of inflation. Core inflation is computed by excluding selected unprocessed food and energy-related items from the CPI basket. Excluded items account for 18.5% of the CPI.<sup>8</sup> Despite the reduction in the share of food over the years, it still accounts for a large part of the CPI.

**Table 1. Comparison of CPI Weights for all Income Households**

	2000	1994	Difference
Food, beverages and tobacco	50.03	55.12	-5.09
Food	46.58	50.98	-4.39
Non-food	49.97	44.88	5.09
Clothing	3.00	3.66	-0.66
Housing and repairs	16.80	14.69	2.11
Fuel, light and water	6.95	5.74	1.21
Services	15.89	12.28	3.61
Miscellaneous	7.33	8.51	-1.18

Source: National Statistics Office

<sup>8</sup> Excluded items are rice (9.4%); corn (0.9%); fruit and vegetables (5.3%); LPG (1.3%); kerosene (0.3%); and oil, gasoline and diesel (1.3%).

Simple tests for equality of means and variances of quarterly series for CPI inflation and CPI core inflation were conducted for three sample periods: 1995–2001, 2002–2008Q2 and 2002–08. The results failed to reject the null hypothesis of equal means and variances for the sub-sample periods at 1% level of significance.<sup>9</sup> Furthermore, the correlation between headline and core CPI inflation is at a high 0.91. Hence, there appears to be no added benefit to using core as the basis for target setting.

**Table 2. Tests for Equality of Means and Variances of CPI Inflation and CPI Core Inflation (p-values)**

	1995-2001	2002-2008.Q2	2002-2008
Test for equality of means (t-test)	0.87	0.52	0.33
Test for equality of variances (F-test)	0.86	0.19	0.04

Estimates for different sub-periods after the adoption of inflation targeting in 2002 fail to reject the null of equal means and variances between CPI inflation and CPI core inflation at 1% level of significance.

Excluding asset price components from headline inflation also has little effect. Currently, the CPI includes only rent and minor repairs. The rent component of the CPI is, however, not reflective of the market price because of rent control legislation. The absence of a real estate price index (REPI) reflects valuation problems, owing largely to the institutional gaps in property valuation and taxation.<sup>10</sup> While the price deflator derived from the gross value added from ownership of dwellings and real estate could represent real property price, it is also subject to frequent revisions, making it difficult to forecast inflation.<sup>11</sup>

The volatility of inflation using CPI core and PGDP has narrowed since the adoption of inflation targeting in 2002. Headline CPI inflation, on the other hand, exhibits greater volatility. This is not surprising since headline CPI inflation encompasses even the volatile components.

<sup>9</sup> If the last two quarters of 2008 are included, the level of significance at which the null of equal variance can be rejected dropped significantly to 4%. This implies greater volatility in the components of headline inflation.

<sup>10</sup> E Domingo and R Fulleros (2005), "Real estate price index: a model for the Philippines", BIS Papers no 21, Proceedings of a joint conference organised by the BIS and the IMF in Washington, D.C.

<sup>11</sup> Used imputed rents for owner-occupied housing. The benchmark estimates for the number of owner-occupied dwelling units and the average rent are derived from the Census Population and Housing, and the Family Income and Expenditure Survey, respectively. The average rent is updated using the rental index from the consumer price index (CPI). The gross value added (GVA) is the difference between the imputed rent and intermediate inputs, which are basically the cost of repairs and maintenance of dwelling units. Source: <http://www.nscb.gov.ph>.

**Table 3. Moments of Year-on-Year Inflation Rates in the Philippines**

Sample period: 1995-2001	CPI Inflation	CPI Core Inflation	GDP Deflator Inflation
Mean	6.55	6.63	7.53
Median	6.24	6.40	6.80
Maximum	10.18	10.18	11.56
Minimum	2.51	3.26	4.88
Std. Dev.	1.93	1.87	1.89
Skewness	0.06	0.04	0.65
Kurtosis	2.43	2.29	2.42
JB Probability	0.82	0.74	0.31
Observations	28	28	28
Sample period: 2002-2008	CPI Inflation	CPI Core Inflation	GDP Deflator Inflation
Mean	5.49	4.90	5.22
Median	4.74	4.74	4.77
Maximum	12.18	8.02	10.08
Minimum	2.35	2.42	2.03
Std. Dev.	2.66	1.78	1.90
Skewness	0.69	0.21	0.58
Kurtosis	2.57	1.72	2.98
JB Probability	0.30	0.35	0.46
Observations	28	28	28

GDP deflator series has been rebased to 2000=100 to make it comparable with the CPI and CPI core series.

It may be important to note that the early period of inflation targeting has been characterised by disinflation and greater productivity gains. While the indicative estimates of productivity (Table 4) are not disaggregated into tradable and non-tradable sectors, it is possible that given the structural shift of the economy towards the largely non-tradable services sector (both in terms of share to GDP and growth rate), the estimated productivity gains could have translated into lower inflation.

**Table 4. Indicative Productivity Estimates for the Periods  
1994-2001 and 2002-2007**

	$\alpha^* \Delta L/L$	$(1-\alpha)^* \Delta K/K$	TFP
1994-2001	0.41	2.89	0.45
2002-2007	0.67	1.88	3.10

Source: Author's own estimates using the simple growth accounting method where the residual is taken as the total productivity (TFP) growth rate. Assumes labor share of 25% ( $\alpha = 25$ ). For labor, full-time equivalent employment (L) was used. Capital stock (K) series was derived using the perpetual inventory method with 20% annual rate of depreciation.

### C. Comparison of different measures of inflation

Tests on the stationarity of residuals confirm the presence of cointegrating relationship between CPI and CPICORE, using the following autoregressive distributed lag (ARDL) specification,  $LCPI_t = \beta_0 + \beta_1 LCPICORE_t + \beta_2 LCPICORE_{t-1} + \beta_3 LCPI_{t-1} + \varepsilon_t$ . The results are as follows:



$$LCPI_t = -0.04 + 1.21LCPICORE_t - 1.09LCPICORE_{t-1} + 0.89LCPI_{t-1}^{12}$$

*Adjusted R*<sup>2</sup> = 0.99      *Durbin Watson* = 1.79

**Table 5. Summary of Stationarity Tests on the Residuals ( $\varepsilon_t$ ) of CPI Equation**

	<b>Augmented Dickey Fuller</b>	<b>Elliot-Rothenberg-Stock DF-GLS</b>	<b>Phillips-Perron</b>	<b>Kwiatkowski-Phillips-Schmidt-Shin <sup>1/</sup></b>
FULL SAMPLE (1995-2008)	-6.52	-6.26	-6.44	0.14
Inflation Targeting (2002-2008)	-4.61	-4.40	-4.58	0.14

Unless otherwise stated, all reported test statistics are significant at 1% level of significance.

<sup>1/</sup> Null is that residuals are stationary. Unlike ADG, PP and DF-GLD tests which compare t-stat with McKinnon critical value, KPSS test uses LM stat vis-a-vis asymptotic critical values.

The same ARDL specification for CPI against GDP deflator (rebased to 2000=100) was also tried. Stationarity tests on the residuals of the specification given below also indicate a cointegrating relationship between the two price indices (results not reported). However, the impact multiplier of GDP deflator is much smaller than the CPICORE. This is expected because of lags in the release of GDP data.

$$LCPI_t = 0.15LPGDP_t - 0.14LPGDP_{t-1} + 1.48LCPI_{t-1} - 0.49LCPI_{t-2}$$

*Adjusted R*<sup>2</sup> = 0.99      *Durbin Watson* = 1.68

In addition, the table below shows that the three commonly considered measures of inflation, namely headline CPI inflation, core CPI inflation and PGDP inflation, are highly correlated.

**Table 6. Correlation of Different Measures of Inflation (1995-2008)**

	<b>Headline CPI inflation</b>	<b>Core CPI inflation</b>	<b>GDP Deflator inflation</b>
<b>Headline CPI inflation</b>	1.00	0.91	0.82
<b>Core CPI inflation</b>	0.91	1.00	0.84
<b>GDP Deflator inflation</b>	0.82	0.84	1.00

Sources of basic data: NSO and National Statistical Coordination Board (NSCB)

Note: GDP deflator from the National Income Accounts has been rebased to 2000=100 to make it comparable with the CPI and Core CPI.

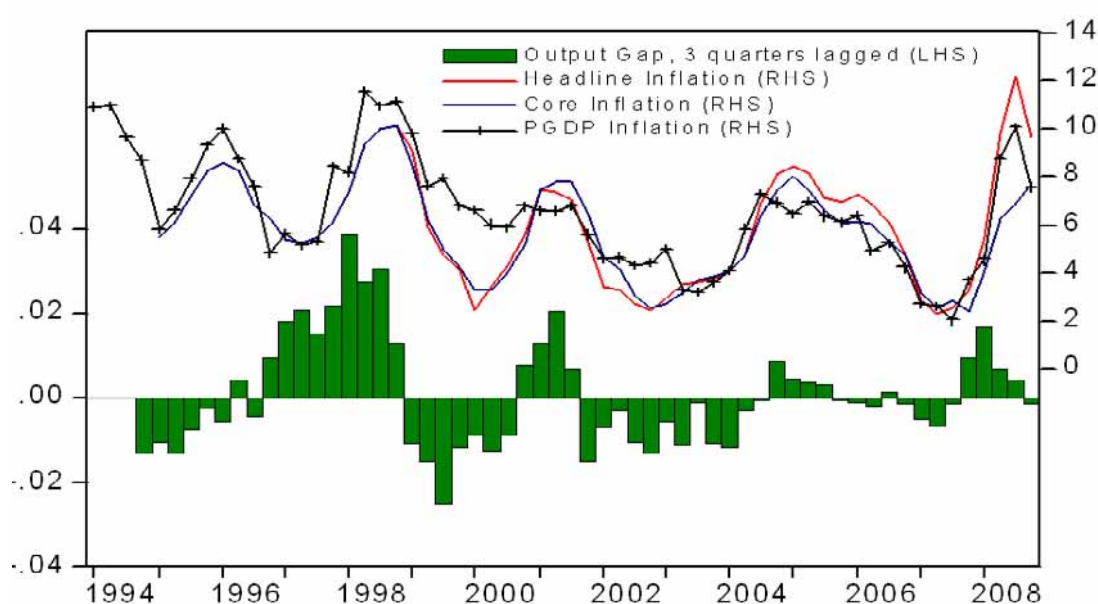
<sup>12</sup> All regressors are significant at 1% level of significance.



However, the three measures of inflation deviate significantly from each other during the pre-inflation targeting period and earlier phase of inflation targeting (see Figure 1). In the periods 1997Q4–2000 (Asian financial crisis), and 2002 (lagged effects of the dot-com bubble and US terrorist attacks), PGDP inflation exceeded both headline and core inflation rates. These periods were characterised by unfavourable external developments coinciding with constrained production capacity of the domestic economy. The gap was more pronounced during the Asian financial crisis when output gap was at its highest.

The trend reversed in 2005–06 with a marked increase in headline and core inflation relative to PGDP inflation. This trend largely reflected the second-round effects from continued increases in global oil prices, which led to higher domestic pump prices, minimum wage adjustments throughout the country, and hikes in transport fares and utility charges, the El Nino phenomenon and the two-percentage point increase in the value-added tax.

**Figure 1. Performance of Different Measures of Inflation (1995-2008)**



Output gap is calculated as the difference between actual GDP and trend GDP, derived using the Hodrick-Prescott filter.<sup>13</sup>

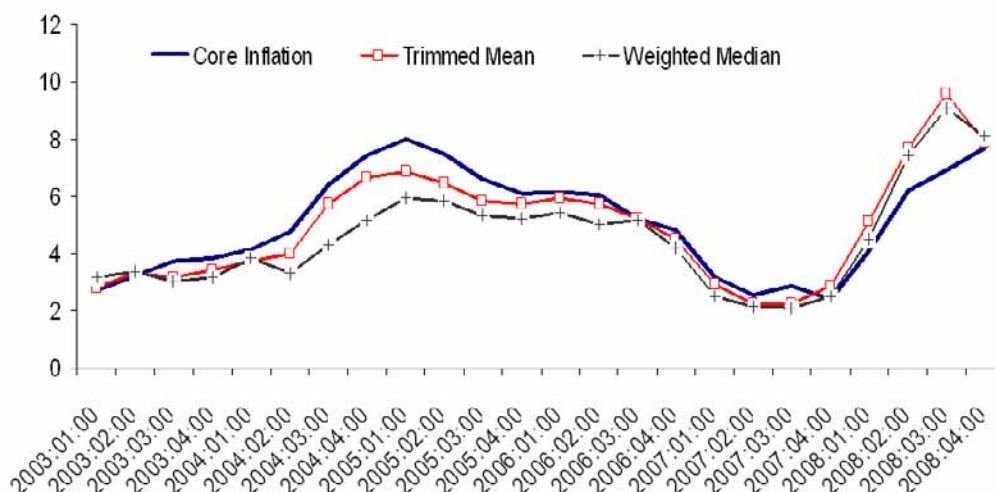
Near convergence was realised in 2007, the year when the economy registered the best growth performance, lowest inflation and high external payments surplus. This growth performance was made possible by major structural reforms in the fiscal and financial sectors that restored confidence in the economy.

However, the disinflation record was adversely affected in 2008 by the extraordinary increases in global commodity prices, as shown by the rise in inflation. Figure 2 shows the discernible spike in the alternative trimmed mean and weighted median measures of core inflation in 2008, an indication of stronger underlying demand pressures.

<sup>13</sup> The use of three-quarters lagged output gap is based on the estimated lags of monetary policy in the book by V Bayangos (2007), *Inflation targeting and exchange rate uncertainty*, Shaker Publishing BV, (Dissertation for the degree in Doctor of Philosophy in development studies, Institute of Social Studies, the Hague, the Netherlands).

Monetary policy responded by raising the policy rate by 100 basis points over the period June to August 2008. A neutral stance was adopted until November as the risks surrounding the inflation outlook over the policy horizon were assessed to have moderated. By December 2008, it was recognised that the near-term inflation outlook was supported by the downward shift in the balance of risks following the easing of commodity prices, the moderation in inflation expectations, and the expected slowdown in economic activity. These developments provided latitude for monetary easing to support growth and help the country ride out the global financial turmoil.<sup>14</sup>

**Figure 2. Core Inflation, Trimmed Mean Inflation and Weighted Median Inflation (1995-2008Q2)**



Source: BSP-Department of Economic Research

Notes:

1. Trimmed mean represents the average weighted inflation rate of the middle 70 percent in the lowest-to-highest ranking of year-on-year inflation rates for all CPI components.
2. The weighted median represents the middle inflation rate (corresponding to a cumulative CPI weight of 50 percent) in a lowest-to-highest ranking of year-on-year inflation rates

## D. Shift to point target with wider band

When inflation targeting framework was adopted in 2002, the inflation target was defined in terms of a range with one percentage point intervals. This range target was deemed to be stringent for a new inflation targeter. In 2008, the Government's inflation target was re-specified from a range target to a point target with a tolerance interval of  $\pm 1$  percentage point. The point target currently stands at 4.0%  $\pm 1$  percentage point for 2008 (or equivalent to a range of 3–5%), and 3.5%  $\pm 1$  percentage point for 2009. The shift is consistent with standard practice among inflation-targeting central banks.

For the period 2002–07, the average inflation outturn was within the average of the lower and upper bounds of the target (which can be loosely interpreted as the implied long-run target). The average inflation was actually just 0.10 percentage point off the midpoint average for the

<sup>14</sup> Highlights of 2008 Monetary Board Meetings on Monetary Policy Issues (5 June, 17 July, 28 August, 6 October, 20 November, and 18 December).

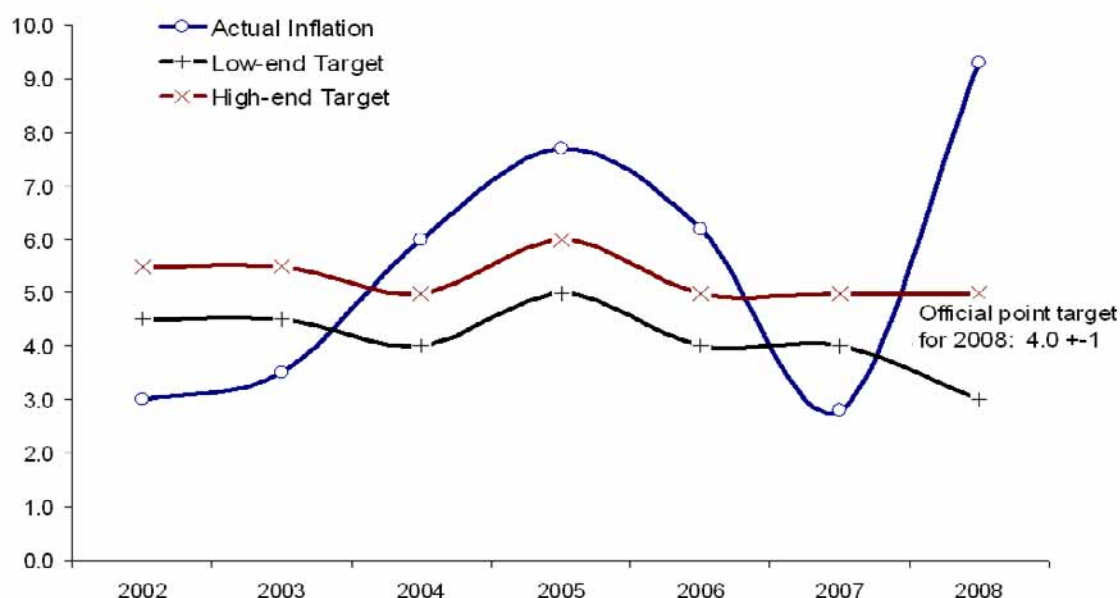
same period. The same scenario continues until the second quarter of 2008. It reversed and exceeded the upper-bound target.

**Table 7. Average Inflation vis-à-vis the Average Inflation Target 2002-2008**

	Average actual inflation	Inflation Target		
		Midpoint of average target range	Average lower bound of target	Average upper bound of target
2002-2007	4.9	4.8	4.3	5.3
2002-2008	5.5	4.7	4.1	5.3

However, when the inflation performance is analysed on a yearly basis, the overall picture points to continuous breaches (Figure 3). Hence, the shift from a range target to a point target with a tolerance interval effectively widened the BSP's target band. A broader target band is seen to provide added flexibility to monetary authorities in steering inflation. It helps ensure that the design of the inflation target is more consistent with the country's economic circumstances, and safeguards the credibility of the inflation-targeting framework. It also helps align monetary policy practices in the Philippines with those in other inflation-targeting countries.

**Figure 3. Comparison of Annual Actual Inflation and Inflation Target Range**



Under the inflation-targeting framework, we distinguish between the inflation target and the inflation forecast. The inflation target represents policymakers' desired inflation rate, which they commit to achieving over the policy horizon. Inflation targets, because of their institutional nature, tend to be less susceptible to revisions. Countries with a history of high inflation like the Philippines are more inclined to set a decelerating path for inflation targets across a period of several years instead of having a long-term point target.

The inflation forecast, meanwhile, represents the expectation or prediction of the inflation rate over the policy horizon, given the current information set. The inflation forecast changes over time as new information is incorporated into the assessment of future inflation. The forecast is a major factor considered by monetary authorities when deciding whether monetary policy instruments should be adjusted to attain the inflation target.

In conveying to the public the views of BSP, the balance of supply and demand conditions is presented along with forecast of inflation conditional on available set of relevant information. In this manner, the inflation forecast that underpins the monetary policy decision towards the achievement of the inflation target is clearly specified.<sup>15</sup>

## E. Concluding remarks

Despite the conceptual appeal of various price indices, headline CPI still has conceptual, operational and practical advantages over other price indices to be used as basis for inflation targeting in the Philippines. This is particularly important given the relatively short period of experience of inflation targeting. Furthermore, recent study on inflation expectations indicates that agents are still largely backward-looking, as evidenced by the considerable inertia in how inflation expectations are formed.<sup>16</sup> Hence, an introduction of other price indices as basis for inflation target-setting may create confusion among the public, making the goal of anchoring of inflation expectations more difficult. However, this does not preclude efforts to broaden understanding of the relative importance of various price indices in analysing inflation dynamics for monetary policy decision-making, albeit not necessarily for setting the inflation target.

Going forward, given the high income disparity in the Philippines, it may be worthwhile to examine and perhaps eventually develop a CPI based on income class. Consumption patterns differ across various income classes. When prices of necessities such as food rise much faster than luxuries, the poor who tend to spend more of their budget on necessities suffer more than the non-poor households.

Son and Kakwani (2006) have proposed a method for establishing a more direct link between poverty measure and price index via the so-called price index for the poor (PIP). This PIP is derived using the price elasticity of poverty as weights. The percentage change in poverty is decomposed into two components, namely, the income and distribution effects. The income effect measures the change in poverty when all prices increase uniformly while the distribution effect captures the change in poverty when relative price changes. It is the latter that determines whether the price changes are pro-poor or not.<sup>17</sup>

Even if monetary policy ought to respond to general price changes and not to relative price changes, knowledge of PIP would nonetheless aid the BSP in coordinating and communicating to concerned government agencies the policy gaps that need to be addressed to stabilise prices. This is in recognition of the fact that price stability is best achieved when the purchasing power of the poor, who do not have adequate assets to be used a hedge against inflation, is protected.

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<sup>15</sup> The BSP, under its inflation-targeting framework, also assesses the inflation expectations, evidence of second-round effects, the yield curve, among a host of critical factors during the inflation process.

<sup>16</sup> V Bayangos, J Basilio, D Floro and E Glindro (2008), "Quantifying the inflation expectations channel in the Philippines: some preliminary results", BSP WP 2008-2, Bangko Sentral ng Pilipinas (forthcoming).

<sup>17</sup> H Son and N Kakwani (2006), "Measuring the impact of price changes on poverty", Working Paper no 33, International Poverty Centre, United Nations Development Programme.

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# To what extent can we trust core inflation measures? The experience of CEE countries

Piotr Wiesiołek<sup>1</sup> and Anna Kosior<sup>2</sup>

## 1. Introduction

The notion of core inflation is one of the most important concepts for the conduct of monetary policy. Core inflation measures are frequently referred to in discussions about monetary policy decisions because of their usefulness as analytical tools and as guides for these decisions. They are also commonly used to communicate and explain monetary policy decisions to the public. Finally, core inflation measures are also sometimes used to specify inflation targets. The usefulness of core inflation measures for monetary policy stems from the fact that they should in principle distinguish between permanent and transitory price movements, or between generalised inflation and relative price movements.

However, despite the widespread presence of core inflation in monetary policy conduct, its measurement is not unproblematic. There are a plethora of different methods for computing core inflation and of different criteria that may be used to evaluate the core inflation measures. Moreover, different core inflation measures can show a varying degree of usefulness for distinct policy purposes. In addition, their usefulness can vary over time, with the changes in the nature of inflationary developments. A question can therefore be posed: to what extent can the central bankers trust the core inflation measures?

This paper examines problems related to measuring core inflation and using core inflation measures in monetary policy conduct, from the point of view of three Central European inflation targeting central banks: the Czech National Bank (CNB), the Magyar Nemzeti Bank, Hungary (MNB), and the National Bank of Poland (NBP). The paper is structured as follows: first, Section 2 introduces some general issues connected to the core inflation concept and measurement of core inflation. Next, Section 3 examines the experience of the CNB, MNB and NBP with respect to the use of core inflation measures in the conduct of monetary policy. Section 4 concludes.

## 2. Monetary policy and core inflation measures

### 2.1 Core inflation as a measure for policy purposes

Core inflation measures are commonly used in the conduct and formulation of monetary policy owing to their usefulness as analytical tools, communication tools and – under some circumstances – viable targets for monetary policy.<sup>3</sup>

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<sup>3</sup> Johnson (1999) provides a different outline of core inflation's policy purposes. In her work she stresses the role of core inflation as an indicator of current and future trends in inflation, a measure of inflation for empirical

### 2.1.1 Core inflation measures as analytical tools

Despite the widespread use of core inflation measures, no single concept of core inflation exists. Although most economists would agree that core inflation should reflect the part of inflation that is relevant for monetary authorities, there is no consensus on what should be understood as “relevant”. Different answers to that question may result in the development and application of alternative measures of core inflation<sup>4</sup>. Roger (1998, p 1) argues that “virtually all practical efforts to measure core inflation can be seen as trying to quantify one of the two broad concepts”: core inflation as persistent inflation, and core inflation as generalised inflation.

First, it may be argued that it is crucial for policymakers to distinguish between permanent and transitory price movements, as the appropriate prescription for monetary policy relies heavily on this distinction. Due to the long and variable lags in the monetary policy transmission mechanism, responding to temporary price shocks may result in unwarranted output variability, whereas failing to detect the growth in underlying inflation trend at the onset may lead to a sustained rise in inflation and ultimately require a more prolonged period of policy tightening (Rich and Steindel (2007), p 19). Therefore, to the extent that core inflation measures provide information on the nature of price changes, they are useful in guiding monetary policy decisions.

Moreover, by reflecting the persistent component of headline inflation, core inflation helps to analyse not only the current inflation developments but also future outlook for inflation, which makes it an appropriate tool for the forward-looking monetary policymaker. In addition, if core inflation measures represent the component of price changes that is expected to persist over medium-run horizons of several years (Bryan and Cecchetti (1994)), they may be useful for near-term to medium-term inflation forecasting (Clark (2001), p 6).

Although the concept of core inflation as persistent inflation is vague as regards the determinants of inflation, the underlying trend is usually identified as being shaped by the pressure of aggregate demand against the capacity of the economy, and the transitory component may be viewed as resulting mostly from supply shocks.

Second,<sup>5</sup> core inflation may be defined as reflecting the part of price changes that is common to all items. This concept of core inflation is based on the division of the inflation measured into a component representing generalised inflation and a non-core component reflecting changes in relative prices of goods and services. The generalised inflation is sometimes associated with the monetary expansion in line with the belief that in the long run inflation is a monetary phenomenon (Bryan and Cecchetti (1994); Wynne (2008)). Underlying this concept is the assumption that relative price movements should have no long-run effect on the aggregate price level or aggregate inflation rate. Hence, they should not require a monetary policy response<sup>6</sup>.

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work and a viable target for monetary policy. The first two policy purposes distinguished by Johnson (1999) correspond with the purpose of using core inflation measures as analytical tools, as this study shows.

<sup>4</sup> However, it may be argued that in practice core inflation measures are often defined in terms of the particular method used for their computation and not in terms of what they are trying to capture (Roger (1998), p 1).

<sup>5</sup> Those two concepts of core inflation are not mutually exclusive and they may be used to justify derivation of the same measures of core inflation. For example, core inflation excluding food and energy prices may be derived on the assumption that changes to these prices represent high-frequency noise to inflation, as well as assuming that the markets for these goods are often hit by idiosyncratic shocks. Moreover, both concepts may be viewed as pointing to the similar determinants of inflation, namely predominantly supply shocks.

<sup>6</sup> See Roger (1998) and Manikar and Paisley (2004) for discussion of why relative prices might affect the rate of inflation over an extended period.



According to this concept, price changes that ought to be systematically filtered out from the headline inflation may result from market- or firm-specific supply and demand shocks, specific events such as changes in indirect taxes, or one-time shifts of exchange rate due to non-monetary sources (Johnson (1999), p 3). By excluding these price changes, we obtain the measure that is most closely related to monetary policy and can be used, for example, to assess its effectiveness.

### **2.1.2 Core inflation measures as inflation targets**

Although the majority of inflation targeting central banks have specified their targets in terms of headline inflation, there may be important reasons for using core inflation measures as inflation targets. One of the advantages of targeting core inflation over targeting headline inflation is greater controllability of the former. Since inflation targeting strategy implies ex post accountability of monetary authorities with regard to the achievement of the specified target, it might be sensible to define the target in terms of the measure of inflation over which the central bank has sufficient ex ante control (Hogan, Johnson and Laflèche (2001), p 3). Assuming that core inflation measures are derived by excluding price fluctuations from non-monetary sources and may thus be regarded as pointing directly to the outcome of monetary policy, they are better suited for assessing the central bank's performance.

Moreover, by specifying inflation targets in terms of core inflation, central banks may be able to achieve greater alignment of inflation expectations with the medium-term focus of monetary policy. Core inflation may draw the public's attention to the more persistent movements in inflation. And, if the public based its wage- and price-setting behaviour on persistent trend in inflation rather than on the temporary price shocks, the variability of the overall inflation might be reduced (Hogan, Johnson and Laflèche (2001), p 3).

### **2.1.3 Core inflation measures as useful tools for communicating monetary policy**

Core inflation measures can be very useful communication tools, even if they are not directly applied as a specification of a policy target. Regardless of the monetary policy strategy pursued, central banks may find it desirable to explain past inflation performance by indicating the parts in inflation that can be attributed to the factors not directly controllable by monetary policy. Bringing forth the impact of such factors may be conducive towards strengthening a central bank's credibility. For example, headline inflation targeting central banks may use core inflation for backward-looking accounting for deviations of overall inflation from the target due to, eg the supply-side shocks (Roger (1998), p 9). By highlighting the impact of these shocks, core inflation helps to explain that such deviations are not indicative of the central bank's faltering commitment to achieving the target.

In addition, core inflation measures can be useful in making monetary policy more transparent to the public. They may be applied to describing the inflation process and bringing forth the origin of shocks impacting price developments, which is important in making the public understand current decisions by monetary authorities.

## **2.2 Typology of core inflation measures**

A large number of core inflation measures that are developed and applied for monetary policy purposes can be divided into two broad groups derived using one of two approaches: the statistical approach and the model-based approach (Mankikar, Paisley 2004).

The statistical approach yields core inflation measures that are most frequently used by central banks. A common feature of these measures is that they use information from an existing aggregate price index and its subcomponents only. Different operations are performed on these indices to obtain the desired measure of core inflation. Such operations may involve:

- 1) excluding certain items from the overall consumption basket, either permanently or on a period-by-period basis;
- 2) reweighting the subcomponents of the overall consumer price index with weights implied, for example, by the volatility of prices, persistency of price changes or dynamic factor analysis;<sup>7</sup>
- 3) applying statistical methods to extract persistent component of inflation (eg estimating trend using moving averages or band-pass filters).

The measures that are most widely used by central banks – mainly because they are relatively easy to compute and to understand – are those derived by excluding certain prices from the aggregate price index. Such exclusion may be justified on various grounds, of which the following may be mentioned:

- a priori assumed or identified empirically on a period-by-period basis volatility of certain prices;
- lower informational content regarding underlying inflation pressures of extreme price changes (as in the case of trimmed means);
- one-off character of certain shocks leading to changes in the price level (such as changes to indirect taxes, abandoning tariff barriers, erratic movements in the exchange rate etc (Silver (2007), pp 168–9);
- lack of relation between particular price changes and the current demand pressures (as in the case of measures excluding regulated and administrative price changes);
- poor controllability of some price changes by monetary policy instruments, eg of non-domestically produced goods and services.

The model-based approach derives core inflation measures by using multivariate econometric analysis directed by economic theory.<sup>8</sup> The main advantage of this approach is that it explicitly takes into account the determinants of inflationary developments. However, the model-based measures of core inflation play a less significant role in the conduct of monetary policy than measures derived by the statistical approach, which is due to several factors (Johnson (1999), pp 5–6). First, in the case of measures derived from structural models (especially SVAR models), there may be controversies regarding the model specification or employed identification schemes and the imposed restrictions, which limits the routine use of such measures by policymakers. Second, underlying for the design of such measures are concepts that are abstract and may be therefore too complicated for the public to understand, which makes such measures inappropriate tools for monetary policy communication. Third, newly incoming data could change the past estimates of core inflation, which could hamper their use both in policy conduct and communication.

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<sup>7</sup> Bryan and Cecchetti (1993) construct a dynamic factor index in which a measure of aggregate price level is formed by weighting its subcomponents by the strength of a common inflation signal present in those price changes.

<sup>8</sup> A well-known example of such an approach to core inflation measurement is the work by Quah and Vahey (1995). The authors define core inflation as the component of measured inflation that has no medium to long-term impact on real output and imposed respective long-run restrictions in their SVAR model.

### **2.3 Desirable properties of core inflation measures**

Different authors point to distinct properties that they believe measures of core inflation used by central banks should ideally possess.<sup>9</sup> Core inflation measures used to specify inflation target and to communicate policy decisions should both be credible. Their credibility may be enhanced if they are calculated by an external agent or – when the central bank is the provider of core inflation measures – if they are at least easily externally verified (Roger (1998), p 10). Such measures should also be understandable by the public and not be subject to significant revisions (Wynne (1999), p 16). It should be possible to explain their deviations from headline inflation without considerable communication effort. Moreover, such measures should be timely or computable in real time. The last property is also expected from the measures that are to provide guidance for monetary policy decisions.

A desirable property of core inflation measures, especially if they are used as analytical tools, is their robustness in the sense that they do a good job of distinguishing persistent and temporary movements in inflation (Roger (1998)). Core inflation measures relevant for guiding monetary policy decisions may also be expected to be forward-looking in some sense (Wynne (1999)). This may mean that they should exhibit good predictive abilities as regards the future inflation trend. If core inflation measures are to be useful in assessing current inflation developments, they cannot exhibit a trend that would systematically diverge from the headline inflation trend, ie they should not be significantly biased relative to the headline inflation measure. Moreover, headline inflation should in the long run converge with core inflation, but the opposite should not hold if core inflation is to be helpful in anticipating the likely future path of inflation (Marques, Neves and Sarmento (2003)). Sometimes, core inflation measures are also evaluated on the basis of the information they contain regarding future values of headline inflation, on the basis of their smoothness or volatility relative to the overall consumer inflation.<sup>10</sup> Finally, core inflation measures may be expected to have some sort of track record (Wynne (1999)), ie their properties should be thoroughly examined and their performance evaluated.

## **3. Core inflation measures and the monetary policy of the Czech National Bank (CNB), the Magyar Nemzeti Bank (MNB) and the National Bank of Poland (NBP)**

### **3.1 Core inflation measures used by the CNB, MNB and NBP**

Core inflation measures usually play a very prominent role at the inflation targeting central banks. It may even be argued that the interest in core inflation measurement has grown precisely because of inflation targeting (Smith (2005)). Core inflation has tended to be an important concept also for the CNB, MNB and NBP, all of which have adopted an inflation targeting strategy.

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<sup>9</sup> Silver (2007) provides an extensive review of the criteria proposed for the assessment of core inflation measures.

<sup>10</sup> These criteria are not, however, universally accepted. For a critique regarding the use of some of these criteria see, eg Marques, Neves and Sarmento (2003, p 765).

Table 1

**Core inflation measures used by the CNB, MNB and  
NBP in monetary policy communication**

Czech National Bank	Magyar Nemzeti Bank	National Bank of Poland
<ul style="list-style-type: none"> <li>• Monetary-policy relevant inflation [100%]</li> <li>• Adjusted inflation excluding fuels [55.12%]</li> <li>• Net inflation [83.6%]</li> </ul>	<ul style="list-style-type: none"> <li>• Trend (underlying inflation)</li> <li>• Core inflation [71.1%]</li> </ul>	<ul style="list-style-type: none"> <li>• Core inflation net of food and energy prices [60.1%]</li> <li>• Core inflation net of most volatile prices<sup>11</sup> [80.0%]</li> <li>• Core inflation net of administered prices<sup>12</sup> [87.6%]</li> <li>• 15% trimmed mean [70.0%]</li> </ul>

Source: CNB, MNB, NBP.

The weights of core inflation baskets in the CPI baskets are given in brackets.

In the case of the CNB the most important core inflation measure in monetary policy conduct and communication is currently the monetary-policy relevant inflation,<sup>13</sup> which is defined as headline inflation adjusted for first-round effects of changes to indirect taxes.<sup>14</sup> Excluding the impact of changes to indirect taxes from the overall inflation rate is consistent with so-called escape clauses, ie exceptions from achieving the inflation target as stated in *The CNB's inflation target from January 2006*. The CNB does not respond to the immediate impact of changes in the level and structure of indirect tax rates because they constitute a specific type of exogenous shocks.<sup>15</sup> In this context, the CNB stresses that it "reacts so that the monetary-policy relevant inflation is close to the inflation target at the monetary policy horizon, taking into account developments in real economic activity and stability on the financial markets".<sup>16</sup> Therefore, although the official target of the CNB is stated in terms of CPI inflation, monetary-policy relevant inflation is an important operational guide for the CNB's monetary policy decisions. The *Minutes of the Board Meeting* confirm that the assessment of the balance of risk to monetary-policy relevant inflation constitutes one of the premises on which interest rate decisions are taken.<sup>17</sup> Monetary-policy relevant inflation is also used extensively in

<sup>11</sup> The most volatile prices are determined at the beginning of each year based on the standard deviation of the year-on-year growth of prices of basic categories of goods and services. The items with the most volatile prices usually include food, energy, Internet services, and public administration services. More on the methodology of calculating core inflation measures at the NBP can be found at: <http://www.nbp.pl/statystyka/bazowa/metodologia.pdf> (in Polish only).

<sup>12</sup> Administered prices were determined basing on the definition used by the European Central Bank. The excluded items include gas, electricity, heat energy, water supply, waste collection, postal services, actual rent for housing, social protection services, and public transport.

<sup>13</sup> Until July 2007 this core inflation measure was referred to in the CNB's *Inflation Reports* as inflation excluding first round impacts of indirect taxes. The effects of indirect taxes have been subtracted from the headline inflation rate since January 2003 (*CNB Inflation Report*, April 2007).

<sup>14</sup> The first round impact of changes to indirect taxes is calculated as the "price change corresponding exactly to the accounting increase in tax" (*CNB Inflation Report*, July 2003).

<sup>15</sup> Such changes are primarily related to the necessity to harmonise indirect taxes resulting from the Czech Republic's membership of the EU (eg gradual harmonisation of excise duties on tobacco products).

<sup>16</sup> Czech National Bank, [http://www.cnb.cz/en/faq/faq\\_mp/mp\\_relevant\\_inflation.html](http://www.cnb.cz/en/faq/faq_mp/mp_relevant_inflation.html).

<sup>17</sup> See for example *Minutes of the Board Meeting on 27 September 2007*.

monetary policy communication, including communicating current inflation developments, the assessment of the fulfilment of the inflation target, and the outlook for inflation.<sup>18</sup>

Until the end of 2001 the most important core inflation measure for the CNB had been net inflation, ie consumer price inflation net of regulated prices and adjusted for first-round effects of changes to indirect taxes. The CNB inflation targets used to be set in terms of this core inflation measure. After switching to targeting headline inflation in 2002, the CNB used net inflation mostly for analytical purposes. Net inflation had also been applied for communicating the CNB's monetary policy decisions.<sup>19</sup> However, it seems that this core inflation measure no longer belongs to the set of the CNB's communication tools.<sup>20</sup> The monetary-policy relevant inflation and adjusted inflation excluding fuels are used for communication purposes. The latter measures the increase in prices of non-food items of the consumer basket excluding items with regulated prices, indirect tax changes and fuels.

Core inflation measures play an important role also at the MNB. They appear (to varying degrees of intensity) in the MNB Council's *Minutes*, in both the part devoted to the description of macroeconomic and financial developments and the Council's assessment of current economic conditions. They are also used in press releases explaining the Council's interest rate decisions. The description of current inflation developments in the MNB's *Report on Inflation* regularly refers to two measures of core inflation: core inflation as calculated by the Hungarian Central Statistical Office (HCSO) and trend (underlying) inflation computed by the MNB.<sup>21</sup> The HCSO core inflation is derived by eliminating unprocessed food, fuels, energy and products with regulated prices from the CPI basket. The exclusion of all these items is justified by the assumption that their prices are not shaped by the supply and demand relations of the economy but by weather conditions, world market developments, or administrative measures.<sup>22</sup> Trend inflation is derived by seasonally adjusting the core inflation index. Trend inflation is viewed by the MNB as "typically a better indicator of inflationary processes" than core inflation measure (MNB *Report on Inflation*, August 2008).

Starting from 2009, the National Bank of Poland computes and publishes four measures of core inflation. Three of them – *15% trimmed mean*, *core inflation net of administered prices* and *core inflation net of most volatile prices* – were introduced in 2001, but the last two were subject to significant methodological revisions at the beginning of 2009. Core inflation net of food and energy prices was introduced only recently, in June 2008.<sup>23</sup>

Core inflation measures have been used by the NBP as an analytical and communication tool. The usefulness of core inflation measures for the analysis of inflationary developments was emphasised by the Monetary Policy Council in its *Monetary Policy Strategy beyond 2003* (p 13). The *Strategy* states that, in addition to headline inflation measures, the Council will also focus on core inflation measures since the former have the disadvantage of being susceptible to shocks that are beyond the capacity of monetary policy. Also, in the *Monetary*

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<sup>18</sup> The presentation of the results of the CNB's macroeconomic forecasts involves publishing a fan chart for the monetary-policy relevant inflation. This core inflation measure appears regularly in the *Inflation Reports*.

<sup>19</sup> Until April 2006 its changes had been regularly analysed and presented in CNB's *Inflation Reports* and it was also referred to in the *Minutes of the Board Meeting*.

<sup>20</sup> For example, it is no longer discussed in the *Inflation Reports* or mentioned in the *Minutes*.

<sup>21</sup> Occasionally, the MNB also used some additional measures of underlying inflation trends to explain the inflationary developments to the public. For example, in May 2005 the trimmed mean and the Edgeworth type price index, which weights the prices by their past variance, were presented in the *Report on Inflation*. The advantages and disadvantages of using such measures were also briefly discussed. However, the bank had not included those measures in its standard set of communication tools.

<sup>22</sup> Magyar Nemzeti Bank, [http://english.mnb.hu/engine.aspx?page=mnb\\_en\\_pressreleases\\_2001&ContentID=6072](http://english.mnb.hu/engine.aspx?page=mnb_en_pressreleases_2001&ContentID=6072)

<sup>23</sup> In connection with the introduction of this new measure, in January 2009 the NBP stopped publishing net inflation, ie core inflation net of food and fuel prices.

*Policy Guidelines*<sup>24</sup> the Council frequently emphasises that core inflation measures play an important role in the assessment of inflationary developments and allow temporary effects to be distinguished from permanent changes in inflationary pressures, at least roughly. The use of core inflation measures as guides for monetary policy decisions is also confirmed by the *Minutes of the MPC decision-making meetings*, which show that core inflation measures are frequently referred to in the discussions about interest rate decisions. Core inflation measures are also regularly used by the NBP to explain the current inflationary developments to the public (see NBP's *Inflation Reports*). They were also used (to varying degrees of intensity in different periods) to communicate the interest rate decisions as the analysis of the press releases published after the Council's decision-making meeting indicates.

### 3.2 Core inflation as inflation target – the experiences of the CEE countries

The inflation targeting central banks have to decide which price index to use to specify their inflation targets. All three central banks analysed currently target headline inflation. However, in the 1998–2001 period, the CNB targeted net inflation (for definition see Section 3.1). The case of re-specifying the inflation target by the CNB is worth analysing in depth, as it highlights some of the intricacies of having the inflation target specified in terms of the core inflation measure.

Having the inflation target set in terms of core inflation, the CNB had to face some challenges, which are intrinsic to core inflation targeting. Core inflation measures do worse than headline inflation in reflecting changes of a typical household's cost of living. Since the cost of living is of primary concern to the public, the central bank's focus on the limited part of the reported inflation rate may not be understood or accepted. There may be such a situation especially if the expenditures on the items that are excluded from the core inflation basket represent a significant part of overall consumption expenditures, and/or if core inflation deviates significantly from headline inflation for an extended period of time. Moreover, the public is usually more familiar with headline than with core inflation, and the former is often the benchmark used by employers and employees in wage negotiations, or to index public sector wages, pensions, government debt or tax tables. Therefore, the public's inflation expectations may be shaped by headline inflation developments even if the target is set in terms of core inflation.

At the onset of inflation targeting in the Czech Republic, the core inflation basket excluded about 18% of the consumer basket. The excluded items (water supply and heating, electricity, gas, telephone, costs and rents, insurance fees and charges, among others) were important for the households' inflation perceptions. Moreover, net and CPI inflation diverged substantially. In addition, net inflation was a newly created index, with which the public was not familiar. Therefore, the CNB ran the risk that net inflation would not be credible and effective as a nominal anchor for the public's inflation expectations. Being aware of these risks (Hrnčíř and Šmídková (2000), p 533), the CNB stressed that the decision to target the net inflation was connected to the ongoing transformation of the economy, in which major changes in relative prices, especially in the group of items with regulated prices or affected by administrative measures, were expected to proceed. The choice of net inflation was also motivated by uncertainty about the schedule for regulated and managed price adjustments and for changes in indirect taxes and fees.<sup>25</sup> Moreover, it was emphasised that the

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<sup>24</sup> See, for example, the *Monetary Policy Guidelines for the year 2008 or 2009*.

<sup>25</sup> The *CNB Monetary Strategy* document (April 1999) stated that “the ongoing transformation, particularly the non-linear distribution of the effects of the fundamental correction of regulated prices and adjustment of indirect taxes (for which a medium-term programme has not yet been specified), requires that the long-term inflation target be specified in the form of net inflation.”

divergence between CPI inflation and net inflation would continue for only a few years, as the convergence of regulated prices with their competitive levels would proceed gradually over medium term. The fact that since February 1998 net inflation estimates have been produced by the Czech CSO was also conducive to enhancing the credibility of net inflation.

The gradual shift from targeting net inflation to targeting CPI inflation was announced in April 2000 in the document *The setting of the inflation target for 2001*. The CNB declared that in addition to announcing targets for net inflation it would in parallel announce targets for the CPI inflation. According to the CNB this shift was primarily motivated by the change in the government's strategy on adjusting regulated prices and indirect taxes.<sup>26</sup> It was anticipated that this move would further influence expectations of inflation, which were shaped rather by headline rather than net inflation developments.<sup>27</sup> As a result, parallel stating of the target in terms of headline inflation brought the CNB's monetary policy more into line with households' actual decision-making process, and increased monetary policy transparency. The CNB expected that this shift would make the inflation targeting regime more effective. Eventually, in April 2001, a change towards targeting inflation measured by the CPI was declared.

### **3.3 Core inflation measures as analytical and communication tools**

#### **3.3.1 Statistical properties of core inflation measures used by the NBP, CNB and MNB**

As discussed above, particular criteria have been proposed in the literature to evaluate the potential usefulness of different core inflation measures in guiding monetary policy decisions. Some of these criteria have been applied to evaluate the core inflation measures used by the NBP, CNB and MNB.

First, the volatility of core inflation indices was examined. Since the derivation of core inflation measures is often justified on the grounds that the excluded items are more volatile than others, the core inflation measures should be less volatile than CPI (see Appendix 1 for detailed results). In the full sample period (January 1998–March 2009) measures used by the CNB and MNB have taken this desired property as assessed by the standard deviations of year-on-year monthly inflation rates. This criterion is also satisfied by the MNB's core inflation and the NBP's 15% trimmed mean. It is interesting that the NBP's core inflation net of food and energy prices exhibited greater volatility than CPI inflation in the full sample period. Food and energy were less volatile than other CPI components. Hence, it could be argued that they should not be excluded from the CPI. However, this picture changes significantly when a shorter sample period is considered. Since January 2004 this core inflation measure has been much less volatile than CPI inflation, which is in line with the procedure of excluding food and energy from the CPI basket.

It may also be argued that not only the core inflation rate but also changes to core inflation rate should be less volatile than changes to headline inflation rate. Applying standard deviation to the first difference of the core inflation series, one can show that this criterion is satisfied by all analysed measures in the full sample period, whereas in the shorter sample period the NBP's core inflation net of administered prices fails to meet this requirement.

Sometimes, core inflation measures are also evaluated on the basis of their variability relative to the variability of headline inflation (Johnson (1999)). Measured by the coefficient of

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<sup>26</sup> In February 2000, the Czech Ministry of Finance announced a medium-term scenario for changes in regulated prices, taxes and fees (in the form of the *"Outlook for Changes in Regulated Prices up to 2002"*).

<sup>27</sup> Headline inflation was referred to in the wage bargaining process. It was also used in the government's budget projections.

variation, in the full sample period only the 15% trimmed mean used by the NBP has slightly lower variability than CPI inflation. In shorter sample periods, the CNB's monetary-policy relevant inflation and adjusted inflation excluding fuels have also met this criterion, as have the NBP's core inflation net of most volatile prices.

Second, the ability to track the inflation trend was assessed. Two approaches to evaluate how well core inflation tracks the inflation trend were applied following Rich and Steindel (2007). First, the long-run means of core inflation and headline inflation were compared (see Appendix 1 for details). All core inflation measures analysed had means lower than that of CPI inflation. Formal statistical tests showed that these differences are statistically significant for two out of three CNB's core inflation measures and for the MNB's core inflation measure. The understating of the long-run growth rate of CPI by these measures appears to be stable in time. In the case of the NBP's measures the differences between means are significant only for core inflation net of food and energy prices, and only in the shorter sample period.

Next, the extent to which the core inflation measures match the movements in the inflation trend over time was examined (see Appendix 2 for details). The results vary slightly depending on the trend estimates, the deviation metric and the sample period. However, in the Czech Republic monetary-policy relevant inflation clearly dominates the remaining core inflation measures in terms of the ability to track the inflation trend, while net inflation usually performs worse. In Poland, in the majority of cases, core inflation net of administered prices deviates most from the inflation trend. The deviations are statistically significant in most cases. The smallest deviations are reported for the 15% trimmed mean measure in case of the short-term inflation trend estimates, and for the core inflation net of most volatile prices in case of longer-term inflation trend estimates.

Third, the core inflation measures were evaluated on the basis of so-called "Marques et al criteria". The first of the three criteria (see Appendix 3 for formal representation and detailed analytical results) essentially requires that headline inflation and core inflation should not exhibit systematically diverging trends. The second criterion is based on the idea that headline inflation should converge with core inflation in the long run (ie core inflation should act as an "attractor" of headline inflation). If this condition is satisfied, one can reasonably expect that headline inflation, which at some point is below (above) the core inflation will increase (decrease) to the level of core inflation. The third criterion ensures that this does not happen the other way round, ie core inflation does not converge with the headline inflation. Only if these three criteria are satisfied can core inflation measures be assessed as providing adequate signals to monetary authorities.

The analysis of core inflation measures used by the CNB, MNB and NBP reveals that these measures do not generally possess the properties formulated by Marques et al (2003). In the full sample period, only the 15% trimmed mean measure computed by the NBP satisfied all three criteria.<sup>28</sup> Among the remaining measures, the NBP's core inflation net of the most volatile prices satisfied the first two criteria, whereas all other measures failed to satisfy at least one of the criteria. It seems that the failure to meet the reviewed requirements is the price paid for the relative simplicity of the measures used to communicate to the public. The measures that are easiest to understand and derive perform worse in terms of the "Marques et al criteria".

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<sup>28</sup> Fulfilment of the Marques et al criteria by different core inflation measures has previously been examined in Poland, eg by Woźniak (2002). The author conducted the tests for six-year rolling samples and for cumulated samples (with the first sample starting in January 1991) for a set of eight measures, four of which were the NBP's measures. He showed that the only NBP measure that satisfied all Marques et al criteria for the majority of the analysed samples was core inflation net of the most volatile prices. Core inflation net of administered prices and net inflation were biased in most cases, whereas core inflation net of most volatile prices and fuels did not attract headline inflation most of the time.



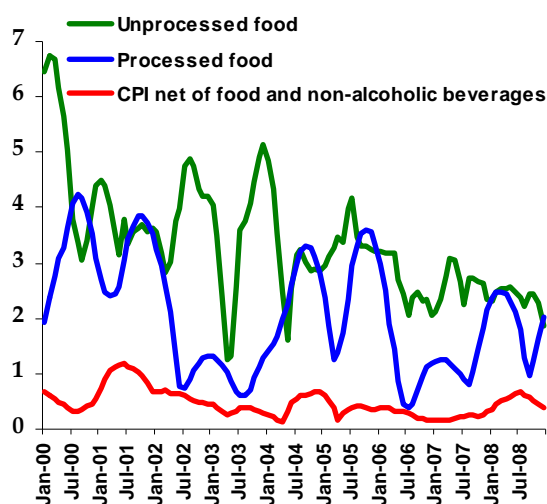
### 3.3.2 The interpretation of core inflation measures based on the “exclusion approach” in the context of the global food and energy price shock

In their communication with the public, most central banks focus on the measures that are computed by permanent exclusion of certain goods from the consumption basket. For example, the CNB frequently communicates by the means of adjusted inflation excluding fuels, the MNB using *core inflation* and the NBP using core inflation net of food and energy.<sup>29</sup> Measures of this type are so widely used mostly because they are simple to explain and to understand. However, under some circumstances the usefulness of those measures for guiding policy decisions and discussing these decisions with the public may be questionable.

#### Processed and unprocessed food price changes and core inflation measures

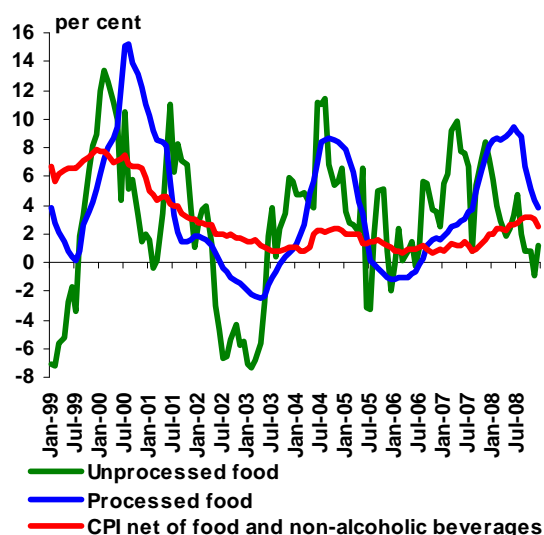
The most popular core inflation measures derived by permanently excluding certain items from the consumer basket are those that exclude food and energy prices. These prices are usually excluded on the grounds of their high volatility. However, it may be argued that not all food and energy prices are excessively volatile. For example, processed food prices may be viewed as being less prone to supply shocks and demand-driven to a greater extent than unprocessed food prices. Therefore, some central banks exclude only unprocessed food from the core inflation basket. For example, the core inflation index used by the MNB excludes only unprocessed food prices. Such approach is supported by the micro-level data analysis showing different behaviour of unprocessed and processed food prices in the Hungarian economy. The former change relatively frequently, on average by large amounts, whereas the price change frequencies are relatively small in case of the latter. Unprocessed food prices also show very high volatility relative to the processed food prices (Gabriel and Reiff (2008)). In Poland, both the processed food and unprocessed food prices have shown significant volatility relative to the remaining part of the CPI basket (Charts 1 and 2), which supports their exclusion from NBP’s net inflation and core inflation net of food and energy prices.

Chart 1. The 12-month rolling standard deviation of year-on-year growth of Polish CPI and the food subcomponent



Source: Polish CSO data, NBP calculations.

Chart 2. Unprocessed and processed food price inflation in Poland (y/y)



Source: Polish CSO data, NBP calculations.

<sup>29</sup> For example, the changes of the NBP’s core inflation net of food and energy prices are analysed in the *Inflation Reports* in greater detail than the changes of other NBP’s core inflation measures. Since its introduction it is the main measure to which the MPC members refer in the discussions at the decision-making meetings described in the *Minutes* as well as in public statements (interviews, articles published in the newspapers etc.).

The advantage of excluding only unprocessed food consists in a broader coverage of the overall consumer basket by the core inflation measure, which enhances its credibility. Besides, it may be argued that food price changes may provide an early signal of changes in inflationary pressure because food is one of the items bought most frequently by consumers (Motley (1997)). Therefore, when processed food price changes are taken into account by the measure of core inflation, this informational content of the food prices is not missed. On the other hand, it may be argued that since unprocessed food is an important input to the production of processed food, the prices of the latter may be considerably influenced by the changes of the former.<sup>30</sup> Therefore, the effects of the supply shocks on unprocessed food prices are likely to be at least partially transmitted onto processed food prices.

The challenges related to having processed food prices included in the core inflation measure may be illustrated by the changes of the HICP inflation excluding energy and unprocessed food<sup>31</sup> in Poland in the period of global food and energy price shocks. This core inflation measure grew by 1.7 percentage points between June 2007 and June 2008, ie much faster than in the euro area (Chart 3). At the same time, unprocessed food inflation in Poland decreased by 3.6 percentage points and in the euro area it increased by 1.0 percentage points. Those developments induced some commentators, including the Polish Minister of Finance, to claim that the growth in HICP core inflation in Poland could not be attributed to the global shocks and was rather indicative of too loose a monetary policy being pursued by the MPC. However, such statements were not justified in view of a more detailed analysis of the HICP core inflation growth. The unprocessed food HICP category encompasses mainly meat, fish, fruit and vegetables, whose prices remained relatively stable at global markets during the food price shock (Chart 4) and were shaped mainly by local factors. At the same time, food items with prices that grew most on the global markets (eg grain including oilseed crops, and milk) were mainly the inputs to processed food, which is not excluded from the HICP core inflation basket. Because of the higher share of processed food in the HICP core inflation basket (26.8% and 14.4%, respectively), the impact of the global food price shock on HICP core inflation development was even greater in Poland than in the euro area.

As can be seen, in this case the inclusion of the processed food prices in the HICP core inflation measure hampered interpretation of the inflationary developments in Poland. The NBP had to communicate the sources behind the HICP core inflation growth to the public and explain why the critique of the MPC's monetary policy was not justified on the grounds of the HICP core inflation developments. This communication effort was required in order to prevent the central bank's credibility being undermined by the above-mentioned accusations.

#### *Exclusion-based core inflation measures and persistent price shocks*

The most important objection to deriving core inflation by permanent exclusion of certain items from the consumer basket<sup>32</sup> is that such a procedure eliminates not only the "noise"

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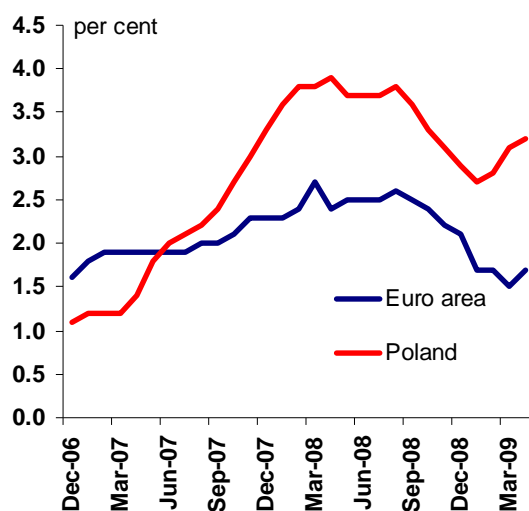
<sup>30</sup> The changes of unprocessed food prices in Poland provide useful information about the future processed food price changes. The correlation analysis have shown that the lagged values of the processed food inflation are highly correlated with the lagged values of the unprocessed food inflation, whereas the opposite does not hold. The highest value of the correlation coefficient (0.66) was observed for the fifth lag of the unprocessed food inflation series. The hypothesis that processed food price changes do not Granger-cause unprocessed food prices could not be rejected at lags 3 to 11; the hypothesis that unprocessed food price changes do not Granger-cause processed food prices was rejected for those lags at a significance level not greater than 0.05.

<sup>31</sup> Harmonised Indices of Consumer Prices and their sub-indices (eg HICP excluding energy and unprocessed food) are compiled on the basis of a legislated methodology, binding for all member states, and published by Eurostat.

<sup>32</sup> Another criticised feature of the core inflation measures of this type is that they do not allow for the adjustments for shocks that affect the prices of components not already excluded, which may themselves

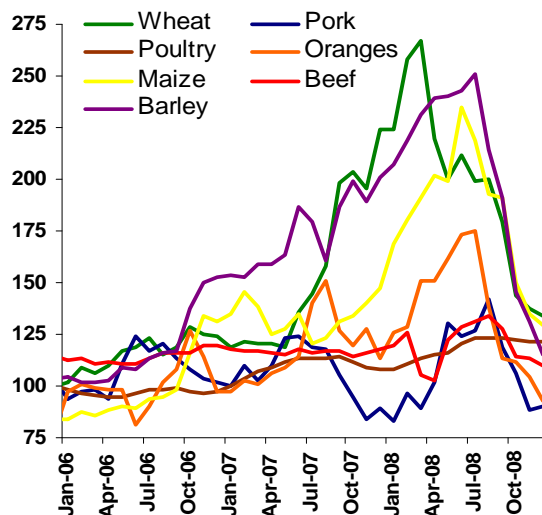
associated with these items but also their contribution to the inflation trend. If the excluded components follow a persistent trend that is divergent from the trend of the remaining headline inflation components, such a procedure can be particularly troublesome.

Chart 3. HICP inflation excluding energy and unprocessed food



Source: Eurostat data.

Chart 4. Global food price shock (2006Q1 = 100)



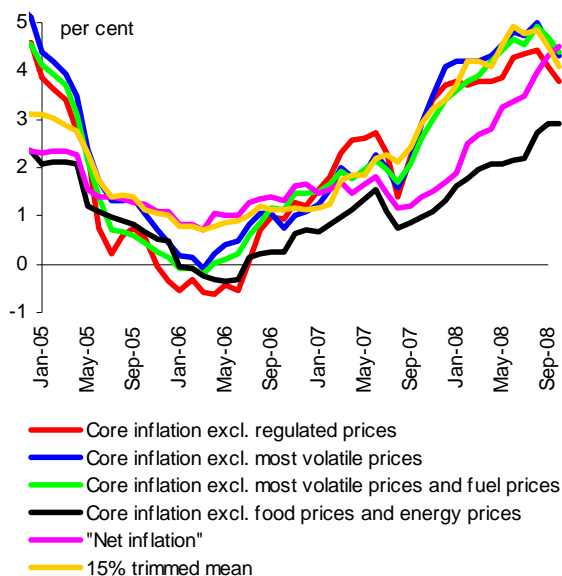
Source: IMF data.

This shortcoming of the exclusion-based core inflation measures was highlighted by the considerable rise of commodity prices (food and oil prices) in the world markets, which led to the rise in headline inflation in the world in 2007Q4. At the same time, core inflation measures net of food and fuels/energy prices remained relatively subdued in some countries, including Poland. The continuing divergence between headline and core inflation rates raised questions about the usefulness of such measures for predicting future inflationary trends. It had been argued that the rise in commodity prices in the world markets differs with respect to its sources from past shocks. Whereas much of the historical volatility in food and energy prices had been caused by temporary supply shocks, this time food and oil price inflation was attributed to the strong growth in demand on the back of the rise in the standards of living and the rapid industrialisation in emerging economies. Although this view was not held unanimously, these phenomena were expected to persist and, hence, a long-term upward trend in oil and food prices was anticipated. Under such circumstances, core inflation measures net of food and energy prices were criticised for not taking account of the information important for future inflation developments. The important role of food and fuel prices for the forming of inflation expectations was especially emphasised. The non-symmetrical treatment of the effects of globalisation by the “ex food and energy” measures was also highlighted. If food and oil prices were excluded – the argument went – because they had increased due to factors not directly controllable by domestic monetary authorities, then other goods whose prices are primarily affected by global developments should be excluded as well. That is, if core inflation measures are to capture domestic demand

show remarkable volatility. In such cases, assessment of more persistent inflationary developments using the core inflation measure may be hampered. The impact of energy prices on the development of the NBP’s core inflation net of food and fuel prices may be regarded as an illustration of this point (see Section 3.3.3).

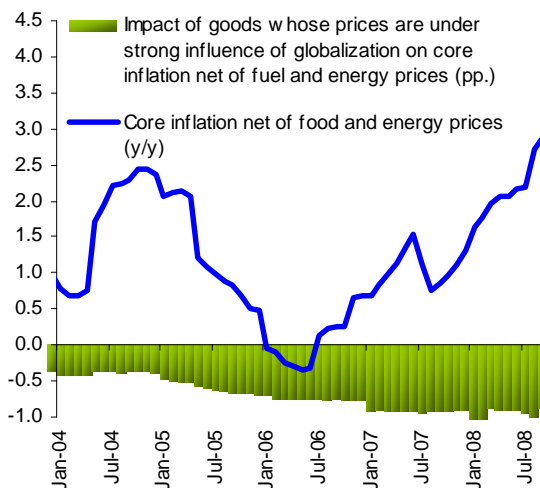
pressures properly, they should also account for the disinflationary effects of globalisation, which are also largely independent of domestic monetary policy.<sup>33</sup>

Chart 5. Core inflation in Poland



Source: Polish CSO data, NBP calculations.

Chart 6. NBP's core inflation net of food and energy and the disinflationary impact of globalisation



Source: Polish CSO data, NBP calculations.

In the context of the food and oil price shocks, central banks in the world had to deal with uncertainty regarding the persistence of these shocks, and their impact on the reliability of core inflation measures. Such a challenge was faced by the NBP, among others. Starting from August 2007, widening discrepancies were observed between net inflation – the core inflation measure that used to be the measure most often referred to in economic discussions in Poland – and the remaining NBP core inflation indices (Chart 5). Such divergence called for caution in using net inflation either as a guide for monetary policy decisions or as a communication tool. It also required making the public aware of the shortcomings of this measure. A special Box devoted to the core inflation concept was presented in the *Inflation Report* in February 2008, in which properties of net inflation were briefly discussed.<sup>34</sup> First, the public was informed that net inflation can omit some information on long-term headline inflation trend due to (expected) persistent shocks to food and fuel prices. Second, it was stressed that net inflation should not be interpreted as adequately representing the inflation resulting from domestic demand pressures because it only eliminates the inflationary impact of globalisation<sup>35</sup> on net inflation rate was quantified to illustrate the

<sup>33</sup> This objection to core inflation measures derived using the “exclusion approach” has been stressed, eg by Charles Bean, Deputy Governor of the Bank of England, who pointed to the common rooting of the food and energy price shock and the fall in the price of many manufactured goods in the structural changes in China and other emerging market economies (Bean (2006)).

<sup>34</sup> An article by one of the MPC members published in a daily newspaper also tackled this issue. In addition to discussing the shortcomings of the core inflation measures derived by the “exclusion approach”, this article also highlighted the risks associated with basing monetary policy decisions on such measures .

<sup>35</sup> This category of goods includes: clothing, footwear, audio and television equipment, photographic equipment, IT equipment, musical instruments, games and toys, hobbies, sports and camping equipment for outdoor recreation, electrical appliances for personal hygiene.

disinflationary effects of global developments that are not accounted for by this measure. As Chart 6 shows, the favourable developments of these goods' prices also have a substantial downward impact on the core inflation excluding food and energy prices.<sup>36</sup> In this context, the use of the 15% trimmed mean, which accounts for the bi-directional effects of globalisation, was recommended. The general message conveyed to the public by the NBP was that under the current circumstances it was difficult to indicate which of the core inflation measures best reflected the medium-term trend of price growth.<sup>37</sup>

The deterioration in the global economic outlook due to the intensification of financial turmoil in recent months has led to a considerable decline in prices of energy and food commodities on global markets, which – for the time being – have made this criticism less relevant and reinforced the trustworthiness of the “ex-food and energy/fuels” measures. However, the limitations of such measures remain in force and we are likely to see another spark of criticism against using them should the conditions in which these measures do poorly in approximating the non-observable inflation trend recur.

### 3.3.3 Price deregulation in CEE economies and core inflation measurement

Although many markets and prices in the CEE economies were deregulated and liberalised in the early years of transition, some sectors remain regulated or were liberalised only recently. Hence, the process of market liberalisation and price deregulation still significantly influences inflation developments in these countries.

Regulated prices comprise an important part of the consumer price indices in both developed and developing economies (Égert 2008). A characteristic feature of the CEE countries is, however, that their regulated price inflation has been running almost persistently above the average inflation in recent years (see Table 2).

Table 2

#### CPI and regulated price inflation in CEE economies (yearly averages)

	Czech Republic				Hungary				Poland			
	2004	2005	2006	2007	2004	2005	2006	2007	2004	2005	2006	2007
<b>Regulated price inflation</b>	3.6	5.7	9.3	4.8	9.3	6.1	3.7	14.6	3.2	3.7	3.3	2.5
<b>CPI inflation</b>	2.8	1.9	2.5	2.8	6.8	3.6	3.9	8.0	3.5	2.1	1.0	2.5

Source: National CSOs and central banks.

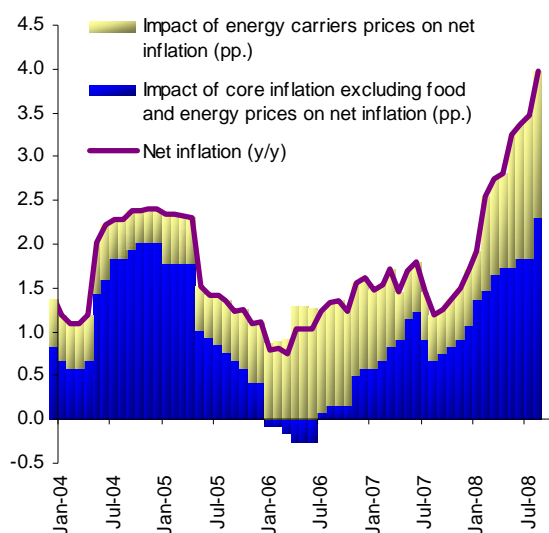
The changes of regulated prices are infrequent, are usually large in size, and are implemented at some specified period, usually at the beginning of the year. Therefore, they may obscure the movements of the general price level, which supports the exclusion of regulated prices from the core inflation indices. Yet, such exclusion may cause the same

<sup>36</sup> The prices of goods under strong disinflationary influence of globalisation lowered the year-on-year rate of core inflation excluding food and energy prices by 0.9 percentage points on average over the past 24 months, and net inflation by 0.8 percentage points respectively.

<sup>37</sup> Similar communication efforts aimed at explaining the shortcomings of core inflation in case of persistent shocks affecting the prices of excluded items was also taken by the MNB. In its *Quarterly Report on Inflation* from May 2008, the MNB explained that if the trend rise in prices of a number of commodities and food is determined by persistent changes in relative prices or a generally overheated world economy rather than by temporary shocks, then the indices excluding them are no longer better predictors of future inflation than headline inflation.

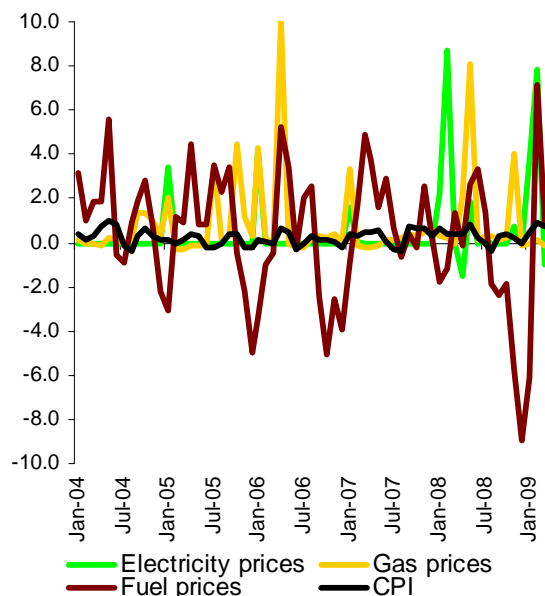
problems as the permanent exclusion of food and energy prices, because regulated prices strongly affect the costs of production and comprise a considerable part of the cost of living (see Section 3.3.2). On the other hand, if regulated prices are not fully excluded from core inflation indices, their changes and/or their deregulation – as will be shown below – may hamper the use of these measures as guides for monetary policy decisions or as communication tools.

Chart 7. Net inflation and energy price developments in Poland



Source: Polish CSO data, NBP calculations.

Chart 8. Energy price developments in Poland



Source: Polish CSO data, NBP calculations.

In an attempt to prevent excessively rapid price increases, deregulation of the electricity sector in Poland has proceeded gradually and its respective stages have often been postponed. The power distributors are still required to submit the electricity price tariffs charged to households to the Energy Regulatory Authority (URE) for approval.<sup>38</sup> The announced plans to lift this requirement on 1 January 2009, as well as the possible future deregulation of prices of other energy carriers (eg gas prices), would lead to significant energy price increases in Poland. These price hikes would also influence the net inflation developments since this did not exclude energy carriers' prices from the consumer price index. In fact, energy carriers' price increases have been an important factor determining the net inflation developments since 2006 (Chart 7), hampering its interpretation as an indicator of demand-driven inflationary pressures. Moreover, it could be expected that even after the adjustment process related to price deregulation has been completed, changes of these prices would still make the interpretation of net inflation developments problematic. The market-determined prices of energy carriers, similarly to fuel prices, are frequently affected by the supply-side shocks and hence are excessively volatile. Taking these considerations into account, the future reliability of net inflation as an analytical and communication tool has become a cause of increased concern for the NBP. As a result, the NBP has decided additionally to exclude energy carriers' prices from the core inflation price index.

The NBP started publishing the new core inflation index – core inflation net of food and energy prices – and using it in its macroeconomic projections in June 2008. Because of the

<sup>38</sup> On 1 January 2007, this obligation was lifted for the prices charged to businesses and institutional clients.

fact that net inflation used to be the core inflation measure with which the public was the most familiar, and because the NBP itself calculates and publishes core inflation indices on the basis of the data provided by the Polish CSO, the introduction of the new core inflation measure raised some credibility issues. The replacement of net inflation with the measure that was expected to run significantly below net inflation for some period might have been viewed by some of the public as the central bank manipulating the statistics. Especially so, in view of the significant share of the energy carriers in the consumer basket (15.3% of the CPI basket in 2009) and because of the fact that the introduction of the new index followed substantial electricity price increases in February 2008 (Chart 8). In order to secure the credibility of the new index, the press release that announced its introduction explained that the exclusion of energy prices from the core inflation index is in line with the practice of major central banks. In addition, one of the MPC members published an article in a daily newspaper, in which he explained to the public the reasons for introducing the new measure.

### **3.4 Can the CNB, MNB and NBP trust the core inflation measures they use?**

The analysis conducted in the previous sections has highlighted some shortcomings of the core inflation measures used by the CNB, MNB and NBP. The majority of these measures fail to fulfil many of the statistical criteria proposed for the evaluation of core inflation measures. Under certain circumstances (eg persistent food and energy price shocks, price deregulation) these measures can also provide misleading signals about future headline developments. Nevertheless they are intensively used by the central banks analysed, both as guides for interest rate decisions and as communication tools. How can such seeming contradiction be explained?

First, there is no single ideal measure of core inflation. Each core inflation measure has its limitations. To the extent that the central bankers do not want to base their interest rate decisions on erratic price movements, they can do no better than to use those imperfect measures.

Second, different measures do well along different dimensions. For example, the NBP's 15% trimmed mean performs quite well in terms of various statistical criteria analysed in Section 3.3.1. However, when we look at the ease with which changes in core inflation can be communicated to the public, it is clearly outperformed by the "exclusion-based" measures. The measures analysed in this paper are used primarily as communication tools. We should therefore primarily assess them relative to this purpose. Although they do poorly in tracking inflation trend, due to their simplicity, ease of computation and timeliness they still are useful in explaining the outlook for inflation and interest rate decisions to the public.

Third, central bankers are well aware of the shortcomings of the measures they use. Therefore, they rarely rely on a single core inflation measure. Rather, they use a set of such measures, which together provide a more or less coherent picture of the inflation dynamics.<sup>39</sup> They also utilise information gained by the decomposition of changes of different measures. Such knowledge helps them to decide when a certain use or interpretation of a given core inflation measure is justified, or when some measure falls short of its purpose and cannot be used.

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<sup>39</sup> The discrepancies between distinct measures may themselves provide valuable information on inflation developments.

## 4. Conclusions

The paper reviews some problems related to the concept and measurement of core inflation, with a focus on measures used by the Czech National Bank, the Magyar Nemzeti Bank, and the National Bank of Poland. Core inflation measures play an important role in the conduct of monetary policy at the analysed central banks. They are used as guides for monetary policy decisions and as communication tools. Yet the majority of the evaluated core inflation measures fail to fulfil all of the evaluation criteria proposed in the literature. Moreover, the measures used most intensively by these banks in monetary policy communication, ie the “exclusion-based” measures, are prone to many weaknesses, which have been highlighted by the recent global food and energy price shocks, inter alia. Sometimes these shortcomings will occur relatively rarely and will not affect the overall usefulness of a given core inflation measure. In other cases, they may require changes to the measures used by the central bank.

Despite the limitations of core inflation measures, central bankers can use them as guides for monetary policy decisions and communication tools. In order to reduce the risk that each core inflation measure will at times be misleading about underlying inflation developments, a set of different measures may be used. Moreover, the knowledge gained through experience with using different core inflation measures helps the central bankers to decide when they can justifiably trust a given core inflation measure. However, since this knowledge is not directly transferable to other countries, each central bank has to assess the usefulness and reliability of its core inflation measures relative to the purposes of using such measures in its own monetary policy conduct.



## Appendix 1: Descriptive statistics<sup>40</sup>

Tests were conducted on the equality of means of core inflation measures and CPI inflation. The \* and \*\* signify that the mean of core inflation measure is significantly different (using Welch F-statistics) from the mean of headline inflation at the level of 1% and 5%, respectively.

	Czech Republic			
	CPI inflation	Monetary policy relevant inflation	Adjusted inflation excluding fuels	Net inflation
	<b>January 1998–March 2009</b>			
<b>Mean</b>	3.6	3.2	2.0*	1.7*
<b>Median</b>	2.8	2.5	1.6	1.5
<b>Standard deviation</b>	2.93	2.70	1.94	1.92
<b>Coefficient of variation</b>	0.81	0.84	0.97	1.13
<b>First difference standard deviation</b>	0.66	0.54	0.28	0.47
	<b>January 2002–March 2009</b>			
<b>Mean</b>	2.6	2.1**	1.2*	1.1*
<b>Median</b>	2.4	1.8	0.9	0.8
<b>Standard deviation</b>	1.94	1.40	0.78	1.21
<b>Coefficient of variation</b>	0.75	0.67	0.65	1.10
<b>First difference standard deviation</b>	0.56	0.47	0.22	0.45

Source: CNB and Czech CSO data, own calculations.

<sup>40</sup> To facilitate inter-country comparability, an analysis was conducted for the core inflation sample period January 1998–March 2009 (except for the two NBP core inflation measures, for which the data have been available only since January 2001); the results of the analysis are presented in Appendix 1 and 2. In addition, in the case of the Czech Republic the errors were also calculated for the period starting in January 2002, which corresponds to the introduction of headline inflation targeting; in the case of Hungary for the period starting in January 2001, which corresponds to the introduction of inflation targeting; and in the case of Poland for the period starting in January 2004, which corresponds to the introduction of an inflation target of 2.5%.

	Hungary	
	CPI inflation	Core inflation (CSO)
<b>January 1998–March 2009</b>		
Mean	7.3	6.5**
Median	6.7	5.8
Standard deviation	3.32	3.30
Coefficient of variation	0.45	0.51
First difference standard deviation	0.55	0.41
<b>January 2001–March 2009</b>		
Mean	5.8	5.1**
Median	5.9	5.2
Standard deviation	2.14	2.27
Coefficient of variation	0.37	0.45
First difference standard deviation	0.54	0.39

Source: MNB and Hungarian CSO data, own calculations

	Poland				
	CPI inflation	Core inflation net of food and energy prices	Core inflation net of most volatile prices	Core inflation net of administered prices	15% trimmed mean
<b>January 1998–March 2009</b>					
Mean	4.6	4.4	x	x	4.3
Median	3.6	2.3	x	x	3.2
Standard deviation	3.64	4.44	x	x	3.36
Coefficient of variation	0.79	1.01	x	x	0.78
First difference standard deviation	0.50	0.34	x	x	0.35
<b>January 2004–March 2009</b>					
Mean	2.7	1.3**	2.4	2.4	2.5
Median	2.5	1.1	2.0	2.3	2.3
Standard deviation	1.36	0.92	1.15	1.65	1.24
Coefficient of variation	0.50	0.71	0.48	0.69	0.50
First difference standard deviation	0.41	0.26	0.28	0.51	0.25

Source: NBP data, own calculations.

## Appendix 2: Trend-tracking properties of alternative core inflation measures

Alternative core inflation measures were evaluated in terms of their deviations from a reference long-term measure of CPI inflation. As a robustness check, five different estimates of trend inflation were applied: 24-month, 36-month and 48-month centred moving average inflation rate (24 MA, 36 MA and 48 MA, respectively), Hodrick-Prescott filtered series with  $\lambda = 2$  (HP 2) and  $\lambda = 4$  (HP 4). Two metrics were used to assess the deviations of core inflation from the reference series: the root mean squared error (RMSE) and the mean absolute error (MAE). The lowest values of RMSE and ME are marked blue, the highest red. \* and \*\* denote that the errors for given core inflation measure are significantly different (at the 1% and 5% level, respectively) than the errors for the benchmark series, which is the core inflation measure associated with lowest RMSE or MAE. The significance of the differences was tested with the Diebold-Mariano (1995) test statistics, which were constructed using the Newey-West (1987) covariance matrix estimator.

### a) Czech Republic

	24 MA		36 MA		48 MA		HP 2		HP 4	
	ME	RMSE	ME	RMSE	ME	RMSE	ME	RMSE	ME	RMSE
<b>January 1998–March 2009</b>										
Monetary policy relevant inflation	1.03	1.39	1.25	1.62	1.45	1.91	1.32	1.78	1.42	1.91
Adjusted inflation excluding fuels	1.34	1.66	1.48	1.77	1.66	1.98	1.60	1.94	1.69	1.97
Net inflation	1.69*	2.14**	1.90*	2.47**	2.06**	2.71**	1.92**	2.5**	1.95	2.55
<b>January 2002–March 2009</b>										
Monetary policy relevant inflation	0.79	0.97	1.00	1.24	1.01	1.30	0.96	1.29	1.01	1.32
Adjusted inflation excluding fuels	1.30*	1.62*	1.34	1.67**	1.35	1.59	1.64*	2.01*	1.67*	1.95*
Net inflation	1.37*	1.57*	1.60*	1.83*	1.67*	1.94*	1.74*	2.13*	1.75*	2.12*

Source: CNB data, own calculations.

### b) Hungary

	24 MA		36 MA		48 MA		HP 2		HP 4	
	ME	RMSE	ME	RMSE	ME	RMSE	ME	RMSE	ME	RMSE
<b>January 1998–March 2009</b>										
Core inflation	1.15	1.50	1.37	1.80	1.68	2.04	1.28	1.63	1.45	1.80
<b>January 2001–March 2009</b>										
Core inflation	1.18	1.47	1.35	1.72	1.71	2.14	1.30	1.71	1.34	1.77

Source: MNB and Hungarian CSO data, own calculations.

c) Poland

	24 MA		36 MA		48 MA		HP 2		HP 4	
	ME	RMSE	ME	RMSE	ME	RMSE	ME	RMSE	ME	RMSE
<b>January 1998 - March 2009</b>										
Core inflation net of food and energy prices	1.08*	1.43**	1.14	1.41	<b>1.20</b>	<b>1.47</b>	1.17	1.37	1.19	1.36
Core inflation net of most volatile prices	x	x	x	x	x	x	x	x	x	x
Core inflation net of administered prices	x	x	x	x	x	x	x	x	x	x
15% trimmed mean	<b>0.63</b>	<b>0.84</b>	<b>0.99</b>	<b>1.22</b>	1.37	1.56	<b>0.93</b>	<b>1.11</b>	1.17	1.40
<b>January 2004 - March 2009</b>										
Core inflation net of food and energy prices	<b>1.28*</b>	<b>1.32*</b>	1.23**	1.36*	1.35	1.60	1.21	1.34*	1.15	1.30
Core inflation net of most volatile prices	0.53	0.65	0.80	0.88	<b>1.04</b>	<b>1.14</b>	<b>0.71</b>	0.83	<b>0.81</b>	<b>0.93</b>
Core inflation net of administered prices	1.02*	1.24*	<b>1.41*</b>	<b>1.67*</b>	<b>1.80*</b>	<b>2.04*</b>	<b>1.26*</b>	<b>1.55*</b>	<b>1.32*</b>	<b>1.60*</b>
15% trimmed mean	<b>0.49</b>	<b>0.54</b>	<b>0.79</b>	<b>0.85</b>	1.09	1.16	0.75	<b>0.83</b>	0.91	0.99

Source: NBP data, own calculations.

### Appendix 3: Marques criteria and alternative core inflation measures

- According to Marques, Neves and Sarmento (2002, p 768) core inflation measures should satisfy the following set of formal criteria:

1)  $\pi_t^*$  (core inflation) is I(1) and  $\pi_t^*$  and  $\pi_t$  (headline inflation) are cointegrated with unitary coefficient, ie  $(\pi_t - \pi_t^*)$  is a stationary variable with zero mean ( $\alpha = 0$ );

2) There is an error correction mechanism given by  $z_{t-1} = (\pi_{t-1} - \pi_{t-1}^*)$  for  $\Delta\pi_t$ , ie

$$\Delta\pi_t \text{ may be written as: } \Delta\pi_t = \sum_{j=1}^m \alpha_j \Delta\pi_{t-j} + \sum_{j=1}^n \beta_j \Delta\pi_{t-j}^* - \gamma (\pi_{t-1} - \pi_{t-1}^*) + \varepsilon_t \quad (*)$$

3)  $\pi_t^*$  is strongly exogenous for the parameters of the above equation (\*).

- The first condition (unbiasedness) was tested by performing the ADF test (with constant) to establish the stationarity of the  $(\pi_t - \pi_t^*)$ . Given that the  $(\pi_t - \pi_t^*)$  is stationary, the test of the condition  $\alpha = 0$  was carried by checking whether the constant term in the ADF regression is significantly different from zero (t-test). The number of lags was determined using Schwartz information criterion.

The second condition (property of being “attractor” for headline inflation) was tested by estimating the equation (\*), with and without the constant term, and checking whether the parameter  $\gamma$  is significantly different from 0.

The third condition (exogeneity) was tested by estimating the following equation:

$$\Delta\pi_t^* = \sum_{j=1}^r \delta_j \Delta\pi_{t-j}^* + \sum_{j=1}^s \theta_j \Delta\pi_{t-j} - \lambda (\pi_{t-1}^* - \pi_{t-1}) + \varepsilon_t \quad (**)$$

and testing with simple t-test whether we cannot reject the hypothesis that  $\lambda = 0$  (weak exogeneity) and, if so, whether  $\theta_1 = \theta_2 = \dots = \theta_s = 0$  (strong exogeneity).

- As a robustness check, an analysis using the Johansen approach was conducted for the full sample period. The conclusions coincided with the ones drawn from the Engle-Granger approach.
- The results reported in the tables below are reported for the full sample period. In the case of Czech Republic the results for the subsample January 1999–December 2007, which corresponds to the low inflation period in the Czech Republic, are additionally reported. To check the robustness of the results in addition to full sample period (January 1998–December 2008<sup>41</sup>), the tests were also applied to shorter sample periods. In particular, the ADF test (with and without constant; with various different lag lengths) was conducted for all sample periods starting in January 1998 and lasting at least until January 2003. Due to the relatively low power of the ADF test, an additional robustness check of the obtained results was performed. Regardless of the ADF test results, the significance of error correction terms in (\*) and (\*\*\*) was tested under different specifications of these equations

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<sup>41</sup> In case of NBP's core inflation net of most volatile prices and core inflation net of administered prices, the full sample period refers to the period January 2001–December 2009.

(constant/no constant, various number of lagged values of headline and core inflation). The information on the robustness check results is presented below. All tests were conducted applying 0.05 significance level.

- The results are summarised in the tables presented below. YES/NO means that the given condition is/is not satisfied by the core inflation measure. In the row “Unbiasedness” the “p-values” of the ADF unit root test on the series  $(\pi_t - \pi_t^*)$  are given in brackets. In cases where this series appeared to be stationary, the p-values of the t-test for the  $\alpha = 0$  are additionally reported. In the row “Exogeneity” the p-values of the test statistics for the  $\lambda = 0$  are presented in brackets. In the cases, where this hypothesis cannot be rejected, the p-values of the Wald test for the  $\theta_1 = \theta_2 = \dots = \theta_s = 0$  are additionally reported.

**a) Czech Republic**

		Net inflation	Adjusted inflation excluding fuels	Monetary policy relevant inflation
Unbiasedness	1998–2008	NO [p = 0.14]	NO [p = 0.43]	NO [p = 0.94]
	1999–2007	NO [p = 0.00; 0.00]	NO [p = 0.75]	NO [0.36]
Attracting headline inflation	1998–2008	x	x	x
	1999–2007	YES [p = 0.04]	x	x
Exogeneity	1998–2008	x	x	x
	1999–2007	YES [p = 0.71; 0.86]	x	x

- The results of the ADF test for net inflation were not robust to sample and lag length selection. The constant in the ADF regression differed statistically from zero in the longest samples only. However, the error correction term in (\*) was significantly different from zero in the majority of samples analysed. Net inflation was found to be strongly exogenous for the parameters of (\*\*) for the majority of examined samples and for various specifications of (\*\*).
- The results of the ADF tests for adjusted inflation excluding fuels were largely sample-dependant. The constant in the ADF regression was significantly different from zero in the largest samples examined. The error correction term in (\*) differed significantly from zero for the majority of the examined samples (excluding the longest ones). The results of the tests for significance of error correction term in (\*\*) varied with alternative specifications of (\*\*). In some cases this core inflation measure was found to be strongly exogenous for the parameters of (\*\*); in other cases weak exogeneity was rejected.
- The results of the ADF test for the monetary policy relevant inflation were robust to alternative sample selection and ADF regression specification. Robustness of the results were confirmed by tests of the significance of the error correction terms for the majority of sample periods under examination.

**b) Hungary**

	Core inflation (CSO)
Unbiasedness	NO [p = 0.56]
Attracting headline inflation	x
Exogeneity	x

The results are robust to alternative sample selection and ADF regression specification. Robustness of the results was confirmed by tests of the significance of the error correction terms for the majority of sample periods under examination.

**c) Poland**

	Core inflation excl. food and energy prices	Core inflation excl. most volatile prices	Core inflation excl. administered prices	15% trimmed mean
Unbiasedness	NO [p = 0.11]	YES [p = 0.03; p = 0.78]	NO [p = 0.16]	YES [p = 0.04; p = 0.3]
Attracting headline inflation	X	YES [p = 0.05]	x	YES [p = 0.04]
Exogeneity	X	NO [p = 0.03]	x	YES [p = 0.24; 0.87]

- 1) The results of the ADF test for core inflation excluding food and energy prices varied with the sample period and ADF regression specification. Unit root was rejected for regressions that included no constant term and had a lag length exceeding 5. For selected specifications of (\*\*), the error correction term was significantly different from zero. Therefore, if there is some long-run convergence between this core inflation measure and headline inflation, then it is the headline inflation that acts as an attractor for them and not the other way round.
- 2) The results of the ADF tests for core inflation excluding the most volatile prices were largely sample-dependant. Unit root could be rejected for only the largest subsamples and the results of the Engle-Granger approach were highly dependent on the number of lagged values of headline and core inflation included in the estimated equation.
- 3) The results of the ADF test for core inflation excluding administered prices were robust to changes in sample periods and lag length.
- 4) The ADF test results for 15% trimmed mean showed that the unit root can be rejected only for selected lag lengths and only for larger samples when a constant is included in the ADF regressions. The error correction term in (\*) was significantly different from zero in the majority of analysed samples only when no constant was included in (\*). The 15% trimmed mean was found to be strongly exogenous for the parameters of (\*\*) for the majority of examined samples and for various specifications of (\*\*).

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# Monetary policy and the measurement of inflation: prices, wages and expectations

Abdulrahman Al-Hamidy<sup>1</sup>

Realistic measurement of inflation is of crucial importance for the conduct of monetary policy, which, almost universally, seeks to achieve price stability and keep inflation within reasonable bounds along with promoting financial stability. This is because an unrealistic measure of inflation to go by in monetary formulation could be unproductive or even counterproductive.

The importance of having a realistic measure of inflation has acquired added significance and prominence in the recent period, with an increasing number of countries, especially in the industrialized world, adopting a monetary policy framework of “inflation targeting”, which involves a formal commitment to a specific rate of inflation; and in order not to put their credibility at risk, their monetary authorities take extra care to ensure that this specific rate is based on a realistic measurement of the current rate of inflation and the prospective economic and financial conditions that are likely to affect it in the year ahead.

Conceptually there are several measures of inflation, each having its own merits and shortcomings, but the one that is most appropriate and commonly used for monitoring inflation is the Consumer Price Index (CPI). It covers prices of those items that enter into the representative consumption basket of the household sector and is typically available on a monthly basis with short time lags. Once published, it is rarely revised. It is also widely known and used in revising contracts for inflation. Thus, on grounds of transparency and timeliness, the CPI is the preferred index for monitoring inflationary trends.

However, to make the CPI credible, it is important that it should be computed by an independent national statistical agency, separate from the central bank, that should have an elaborate organizational set-up to collect detailed, reliable and up to date data on prices on a frequent basis and to undertake family budget surveys periodically to incorporate in the representative consumption basket the changes that take place in consumers’ needs and preferences over reasonable time periods. It should also make suitable adjustments in the CPI should there be a substantial quality change in any item that is included in the consumption basket.

The staff of the statistical agency should also be competent enough to distinguish between “once off” or transitory factors and more permanent factors affecting inflation and remove volatile items to construct the “core” CPI as distinct from the “headline” (total) CPI. This is important because in several cases, the core index provides an appropriate measure of the underlying inflationary trend for the central bank to determine appropriate policy responses.

While a realistic and credible measure of inflation plays a crucial role in the conduct of monetary policy, it is equally important that central banks be autonomous in formulating their policies without interference from other quarters. At the same time, they should have adequate powers and instruments at their disposal to implement their policies effectively. Further the financial system should be developed and well integrated so that the effects of monetary measures taken in one of its parts are transmitted and felt by other parts promptly.

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In the case of oil exporting countries, there are some other special factors which profoundly affect the conduct of their monetary policy. Their dependence on the export of a single commodity, viz oil, makes the role of fiscal policy paramount and constitutes the major source of liquidity in these economies. Then, their non-oil production base is relatively limited. As a result, they depend on imports of goods and services for meeting their domestic requirements. This makes the domestic price situation of imported items highly reflective of the price trends abroad and, at the same time, disturbs their balance of payments equilibrium. Also, oil producing countries have generally pegged their currencies, which has resulted in their interest rates closely tracking the developments in international financial markets. This serves to relatively restrict the maneuverability in their monetary policy actions. In addition, their financial systems are not as developed and integrated as in advanced countries and so provide a less efficient transmission mechanism for monetary policy measures.

## **Saudi Arabia's case**

As in most countries, the primary objective of monetary policy in Saudi Arabia is to maintain domestic price and exchange rate stability and promote financial stability.

For achieving the objective of domestic price stability, the Saudi Arabian Monetary Agency (SAMA), the central bank of the country, does not follow the policy of "inflation targeting". Instead, it takes measures to ensure that inflation remains within reasonable bounds and does not adversely affect the growth process and the welfare of the community. For this purpose, it constantly assesses the developing price situation and acts accordingly, taking other economic indicators also into account.

The most handy and useful indicator for the price situation available to SAMA is the Cost of Living Index (CLI), which is prepared and published by the Central Department of Statistics and Information of the Ministry of Economy and Planning on a monthly basis with less than a month's time lag. This index is a fairly good and reliable inflation indicator based on retail prices of items that enter into the consumption basket of a cross section of the population. Its geographical and item-wise coverage has been enlarged, its weighting system revised and the base year changed from time to time on the basis of periodical consumer expenditure surveys, the latest one having been done in 1999. The number of cities from which price data are collected now covers all the administrative regions of the Kingdom. The number of items for which prices are collected also has been considerably enlarged. The base year of the index, 1999, is in line with the base year used in the system of national accounts. This permits a meaningful comparison between the trends in the CLI and the GDP deflator. Moreover, the CLI has nine sub-indices for various groups of items of expenditure, which have proved to be analytically very useful in determining the areas experiencing inflationary pressures most.

It may be mentioned that in Saudi Arabia no distinction is made between headline and core inflation by excluding food and energy prices from the CLI. This is because food constitutes the largest expenditure item in the CLI, and its exclusion would render the core CLI unrepresentative of the cost of living of the general public. Energy prices are not excluded as energy does not constitute a substantial component in consumer spending and as such it is less important as an inflation factor in Saudi Arabia than in non-oil economies.

In addition to the general price index, wage trends and inflation expectations are generally helpful in monetary management. However, in Saudi Arabia wages are more stable due to a liberal labour policy, while inflation expectations have been governed by the prolonged stability in prices.

The policy measures that SAMA takes to promote domestic price stability seek to ensure that the growth in domestic liquidity is broadly in line with the growth of supply of goods and

services in the economy. In this connection, it faces certain limitations that arise from the structural makeup of the Saudi economy.

Saudi Arabia, being an oil based economy, has two distinct features that profoundly affect the conduct of monetary policy. First, the oil income accruing to the government makes fiscal operations the major source of domestic liquidity. This is indicated by the fact that the net domestic expenditure of the government accounted for as much as 77% of the total domestic liquidity (gross) generated during 2003–07 (Table 2). Secondly, the non-oil production base of the country is relatively limited, necessitating a large import of goods and services. This results in a substantial private sector balance of payments deficit through which the bulk of the gross liquidity generated in the economy leaves the country (73% in 2003–07). These two influences on domestic liquidity are quite powerful but are not directly amenable to SAMA's control. The factor affecting domestic liquidity that lends itself to SAMA's control is bank credit to the private sector, but because of the relatively limited size of the private sector, its influence on domestic liquidity is much smaller than that of government domestic expenditure and the private sector's deficit in its external transactions. Additionally, with the current expansion of both money and capital markets, the efficacy of monetary policy in Saudi Arabia is being strengthened.

In spite of the above limitations, SAMA has succeeded in achieving its monetary policy objectives by conducting its policies in coordination with the fiscal and trade and payments policies of the government. By reinforcing each other, these policies have proved quite effective in achieving monetary and financial stability in both the domestic and external spheres. This is demonstrated by the remarkable stability in the domestic price level and the exchange rate of the Saudi riyal at the same time over a long period.

For about the quarter century up to 2005, inflation in Saudi Arabia, as measured by the CLI, remained on average well below 1 percent per annum. It is only since 2006 that inflation has been on the rise in the country. It may be mentioned in this connection that, since 2002, the increase in government spending has led to intensification in economic activity, especially in the private sector, and the economy has started to get close to its capacity. The increase in government spending has also caused accelerated growth in the money supply, which averaged 13% per annum during 2002–05 and spurted to over 19% in 2006 and 2007. These developments indicate that it is the substantial rise in government expenditure based on increased income accruing from oil exports, rather than any monetary policy impulse, that has contributed to the recent emergence of inflationary pressures in the country. The sharp increase in international food prices and an inordinately large pickup in domestic rents, two items that together carry a substantial weight (44%) in the household's expenditure budget, have also been important contributory factors.

The inflation rate picked up to 2.2% in 2006 and to 4.1% in 2007. It rose further in 2008 to reach the highest level in 30 years, at 11.2% (year over year) in the month of July.

The upsurge in inflation prompted responses from both the government and SAMA. To provide relief to the people, the government has granted a subsidy on basic food stuffs, reduced import tariffs and service charges, provided an inflation allowance for three years and raised social insurance benefits. Also, mortgage and other relevant laws are in the process of being approved, and the Public Authority for Housing has been established. SAMA, for its part, increased the reserve requirement for banks against their demand deposits from 7% to 9% in November 2007, to 10% in January 2008, to 12% in April 2008 and to 13% in May 2008. It also raised the reserve requirement for time and savings deposits from 2% to 4% in May 2008. SAMA also took prudential measures to restrain the growth in consumer credits. Moreover, it kept the benchmark repo rate unchanged at 5.5% from February 2007 until 11 October 2008 to signify its anti-inflationary resolve.

These monetary measures by SAMA proved quite effective in restraining credit extension by banks. Meanwhile, rent and food prices also steadied. In consequence, the inflation rate declined from its peak level of 11.2% in July 2008 to 10.9% in August and further to 10.4% in

September. In view of these developments and to ensure that economic activity does not suffer due to tight credit conditions, especially in the context of bearish influences of the prevailing global financial crisis, SAMA relaxed its policies by bringing down the reserve requirement for banks on their current account deposits from 13% to 10% on 12 October 2008, and further to 7% on 23 November. It also reduced the repo rate from 5.5% to 5.0% on 12 October, to 4% on 30 October and to 3% with effect from 22 November 2008. These measures are expected to boost the liquidity position of banks which would enable them to expand credit and thereby provide the much needed stimulus to domestic demand for sustaining economic activity, especially in the context of the prevalent worldwide recessionary trends.

It can thus be seen that SAMA has used its policy instruments flexibly to suit the changing circumstances, with its policy stance always remaining geared to promoting and achieving the objectives of domestic price and financial stability and the exchange rate stability of the Saudi riyal.

The exchange rate of the Saudi riyal (SAR) has been maintained at SAR 3.75 per US dollar since 1986. It may be mentioned here that the Saudi riyal has been formally pegged to the US dollar since the beginning of 2003 at SAR 3.75 per dollar. Prior to that it was pegged to the SDR, but since 1981, when the margins of 7.25% around SDR/SAR parity were suspended, a de facto link was maintained with the US dollar, which is the intervention currency. Since mid-1986, the link has been maintained at SAR 3.75 per U.S. dollar, on a de facto basis up to the end of 2002 and formally since then.

The exchange rate of the Saudi riyal vis-à-vis other international currencies have also remained within tolerable limits. SAMA keeps a careful watch on the Saudi riyal market to ensure its smooth functioning and takes corrective measures should there be any disruptive activities. Only on a few occasions, some pressures on the Saudi riyal's exchange rate have developed, but these have been promptly relieved by SAMA's intervention in the market.

The moral that emerges from the above episode of SAMA's monetary management is that in an oil-based economy, there is a greater need for a coordinated approach between monetary, fiscal and other economic policies than in other economies.

**Table 1 – Saudi Arabia: Cost of Living Index  
(1999 = 100)**

<b>Year</b>	<b>General index</b>	<b>% change</b>
2001	97.8	-1.1
2002	98.0	+0.2
2003	98.6	+0.6
2004	98.9	+0.3
2005	99.6	+0.7
2006	101.8	+2.2
2007	106.0	+4.1
<u>2008</u>		
July	117.3	+11.2 (yoy)
August	117.9	+10.9 (yoy)
September	118.3	+10.4 (yoy)

**Table 2 – Saudi Arabia: Factors Affecting Domestic Liquidity (M3)**

	<b>2003–07 (billions of Saudi riyals)</b>	<b>% share in gross generation of domestic liquidity</b>
Government net domestic expenditure	1,154.7	77.3
Change in bank credit to the private sector	397.6	26.6
Miscellaneous factors	-58.2	-3.9
<b>Gross generation of domestic liquidity</b>	<b>1,494.1</b>	<b>100.0</b>
Leakage through private sector bop deficit	-1,090.6	-73.0
<b>Net generation of domestic liquidity</b>	<b>403.5</b>	

**Table 3 – Saudi Arabia: Changes in Non-oil GDP, Domestic Liquidity and Cost of Living Index (In percent)**

<b>Period</b>	<b>Non-oil GDP in constant prices</b>	<b>Domestic liquidity (M3)</b>	<b>Cost of living index</b>
1981-1990 Average	1.8	7.4	-0.2
1991-1995	2.1	5.2	2.1
1996-2000	3.7	5.7	-0.4
2001-2005	4.1	11.7	0.1
2006	5.1	19.3	2.2
2007	4.8	19.6	4.1
<u>2008</u>			
July		20.8 (yoy)	11.2 (yoy)
August		21.8 (yoy)	10.9 (yoy)
September		19.4 (yoy)	10.4 (yoy)



# Monetary policy and the measurement of inflation: prices, wages and expectations – a South African perspective

South African Reserve Bank

## 1. Introduction

The successful conduct of monetary policy in any country is subject to the availability of appropriate and sound measures of inflation, be it in producer prices, the prices of consumer goods and services, labour costs, or asset prices. In recent years, South Africa has made significant progress in the improvement of measurement practices related to the compilation of these inflation indicators. Over and above the aforementioned advances made in the measurement of inflation, expectation surveys concerning various aspects of the domestic economy have also become part and parcel of the suite of economic indicators available to policymakers.

Not only has the South African economy progressed from having political and economic sanctions imposed on it during much of the 1980s and early 1990s due to its undesirable political dispensation at the time, but the country has also adopted far-reaching changes in the way it conducts monetary policy, among other things. In February 2000, the so-called eclectic approach to monetary policy formulation made way for the adoption of an inflation targeting monetary policy framework. The adoption of this framework necessitated the development of a suite of inflation forecasting models by the South African Reserve Bank (the Bank), supplemented by information obtained from an Inflation Expectations Survey commissioned by the Bank.

In terms of methodological improvements that were made in the measurement of price change in the economy in recent years, the abandoning of the postal survey method for the compilation of the consumer price index in favour of a direct price collection approach, as propagated in the ILO Prices Manual, has brought price collection procedures in South Africa in line with international best practice. The application of the direct price collection method was rolled out to all metropolitan areas during 2005. Furthermore, the classification system for the Consumer Price Index (CPI) sub-indices was changed from the International Trade Classification (ITC) approach to the Classification of Individual Consumption by Purpose (COICOP) in January 2009, which is the preferred classification internationally.

Labour market statistics collection has also improved considerably during the past couple of years. The coverage of an enterprise-based employment statistics publication, the *Quarterly Employment Statistics* survey, has been expanded meaningfully during recent years. The household-based *Labour Force Survey* has been re-engineered, and changed from a semiannual survey to a quarterly survey from August 2008.

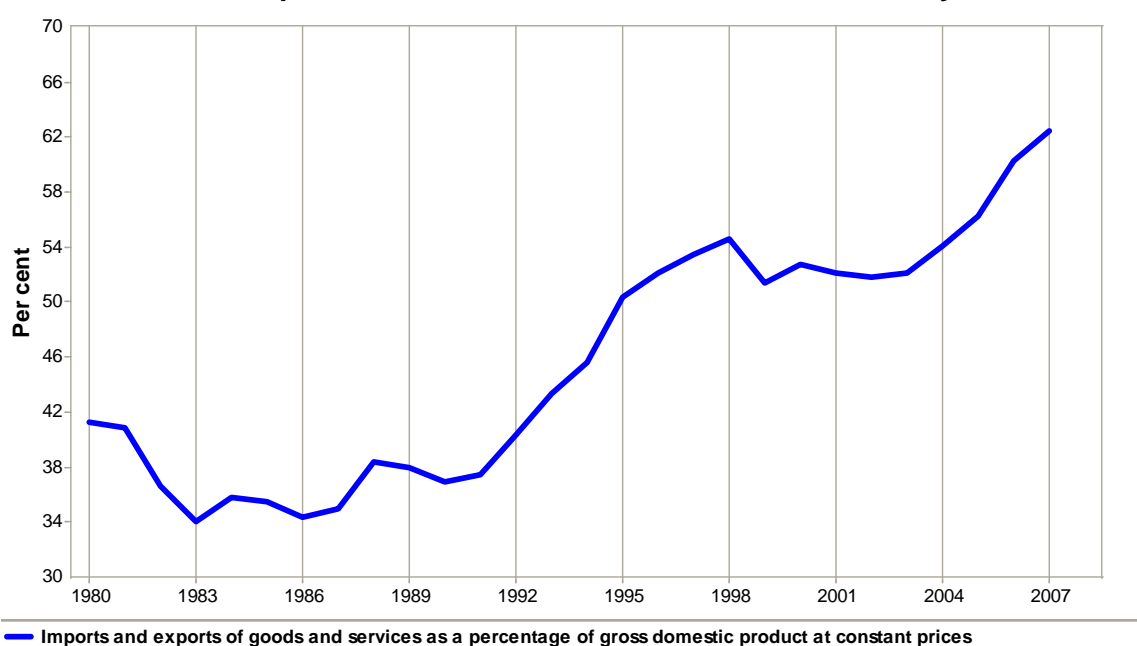
This paper provides information on structural changes in the economy and their impact on inflation measurement and outcomes. It also addresses measurement of wage changes in the economy, with supplementary comments regarding real wage growth and unit labour cost developments in the economy. Monetary policy challenges imposed by factors such as productivity changes and terms-of-trade shocks are discussed. The CPI is analysed as an expenditure-based price indicator, with specific reference to the distinction between core and headline measures of price change, the assessment of inflation persistence, administered prices, the compilation and coverage of the new 2009 CPI, and possible effects on the measured level of consumer price change. The interaction between price developments, inflation expectations and wage settlement rates is discussed, supplemented by a description of practices the Bank is pursuing to improve its communication channels to various constituencies in the economy in an effort to enhance transparency and influence inflation expectations. The paper concludes with an explanation of measurement biases in the CPI and steps taken by Statistics South Africa (Stats SA) in dealing with these biases.

## 2. Structural changes in the South African economy

The transition of the South African economy from being relatively closed to relatively open (the openness indicator being the sum of imports and exports of goods and services expressed as a percentage of gross domestic product, as shown in graph 1) resulted primarily from the implementation of a process of trade liberalisation that took place during the 1990s and into the new millennium. The degree of openness hovered around 37% on average during the 1980s, picking up to 54.6% in 1998. After remaining roughly at this level for the next couple of years, the degree of openness of the South African economy increased meaningfully during the period 2005–2007 alongside rapid advances in world growth. At 63.0% in 2007, the degree of openness of the South African economy was almost double that in the 1980s.

Graph 1

### Openness indicator of the South African economy



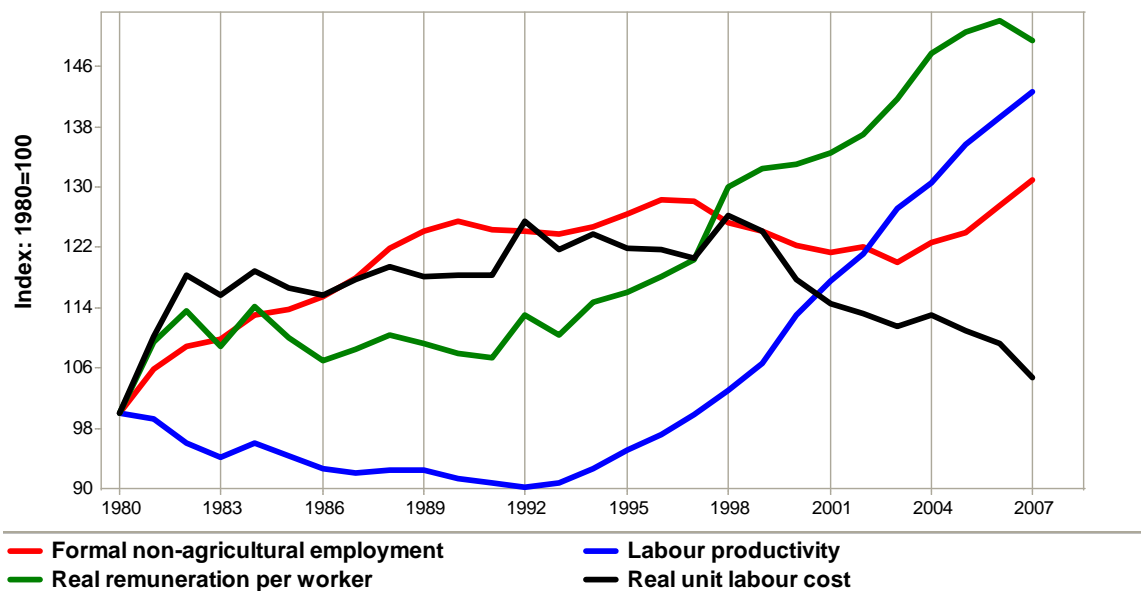
As a consequence of the higher degree of openness of the economy in recent years, the economy has also become more vulnerable to the international business cycle, with associated terms-of-trade shocks occurring from time to time. Accurate measurement of inflation statistics under such circumstances poses a real challenge to statistical agencies, as the exercise to change the weights and composition of price index baskets should preferably be synchronised with structural changes taking place in the real economy.

This process of trade liberalisation, as already mentioned, initially produced in substantial employment losses in various sectors in the economy. Consequently, the measured level of productivity growth, ie production increases per worker, advanced at a rapid pace from the latter half of the 1990s up to around 2003 at rates generally in excess of 5%, as jobs were shed. However, official labour market statistics overaccentuated the decline in employment during that period, as employment migration generally took place from the formal and well-surveyed sectors of the economy to the informal and less accurately surveyed sectors. As a consequence, labour productivity growth rates, ie increases in production per worker, incorporated some upward bias since employment losses may have been overstated to some extent. Despite these biases, rapid labour productivity growth suppressed nominal unit labour cost increases, affording a steady rise in real remuneration increases for people who were gainfully employed. This structural rise in the level of real remuneration had a direct bearing on inflation dynamics in the economy, pushing real disposable income levels higher.

As graph 2 shows, a structural downward drift in real unit labour cost started from 1999 alongside further advances in labour productivity. Since 2004, labour productivity advances have no longer been made at the expense of job losses, but were made possible by production increases in excess of employment growth.

Graph 2

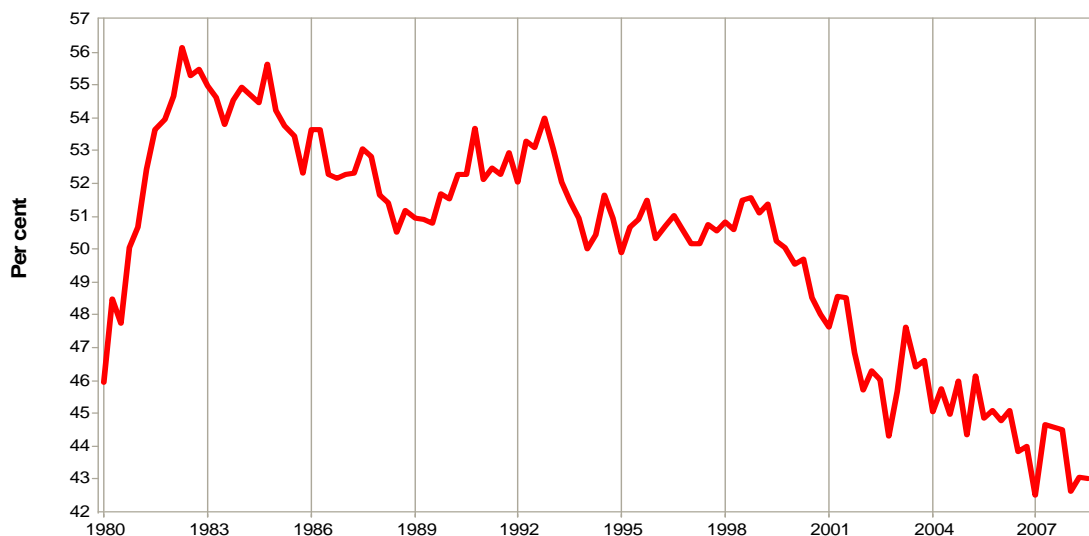
**Formal non-agricultural employment, labour productivity, real wage growth and real unit labour cost**



The structural downward drift in real unit labour cost since 2000 was assisted by the fact that the nominal compensation of employees as a share of gross national income dropped substantially from 1999, from a share of 51.6% in the fourth quarter of 1998 to 41.9% in the second quarter of 2008, as shown in graph 3.

Graph 3

**Nominal compensation of employees as a share of gross national income at market prices**



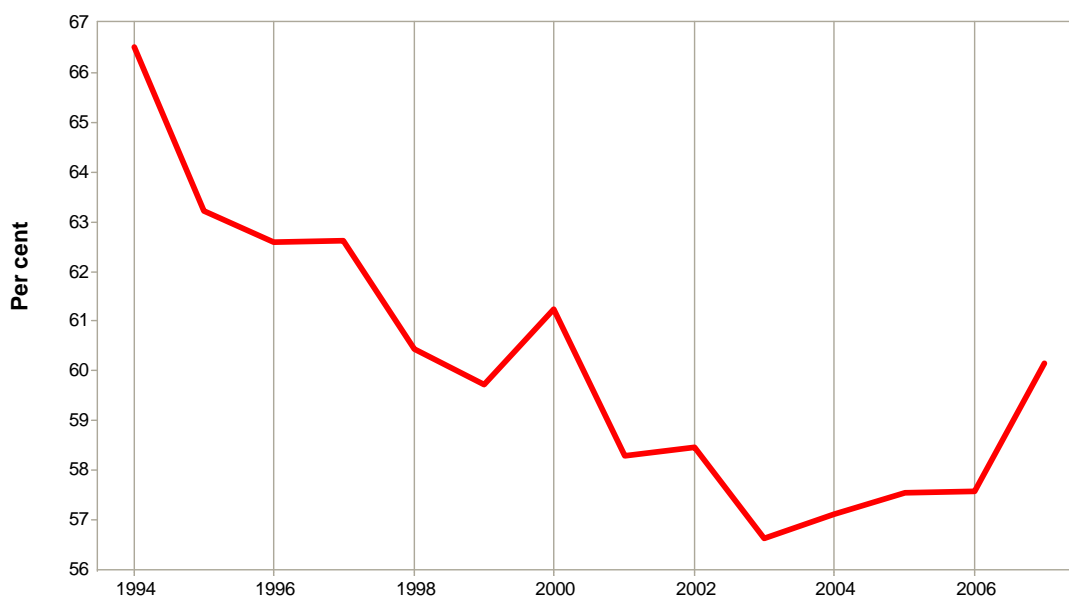
Statistical agencies should always be cognisant of the occurrence of structural changes in an economy and make provision for this accordingly in their survey and statistics compilation procedures, to capture these dynamics as they evolve. In times of change, there should be a more regular adjustment schedule of weights applied in the compilation of indicators, to reduce measurement biases, not only in prices statistics, but economic statistics in general as well.

### 3. The effects of terms-of-trade shocks on price indices

The share of total mining and agricultural product exports in total merchandise exports drifted steadily downward from around 66.5% in 1994 to 56.6% in 2003, but subsequently rose to 60.2% in 2007. This reversal in the downward trend occurred alongside the international commodity price boom during that period and the higher import propensity of the economy. The vulnerability of the South African economy to commodity price cycles and shocks, whether sharp price rises or declines, is obvious from the high share that commodities comprise in total goods exports.

Graph 4

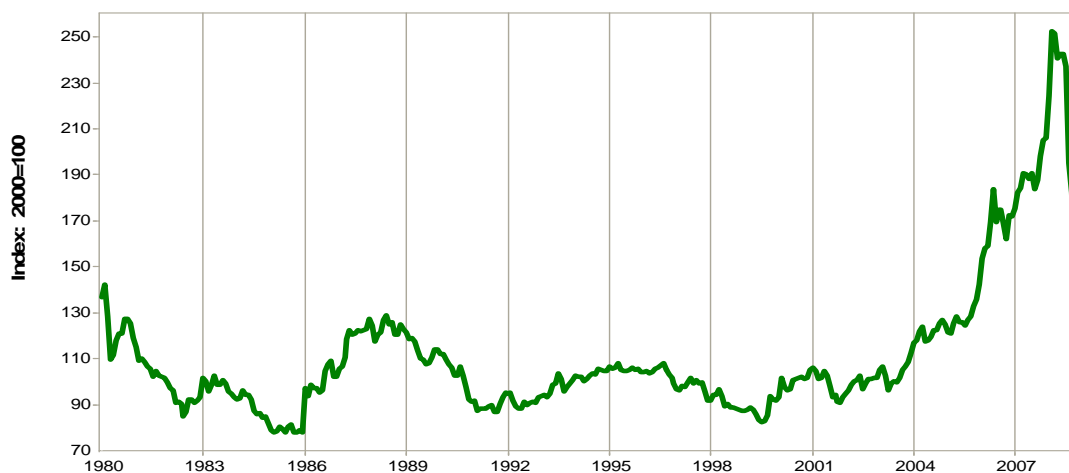
#### Total exports of mining and agricultural products as a percentage of total goods exports



The dramatic rise in commodity prices from 2003 to early 2008, as shown in graph 5, had a major impact on the South African economy, not only via export revenue gains, but also through its effect on the exchange rate of the rand. The abrupt fall in commodity prices since their peak in early 2008 certainly contributed to the marked depreciation in the exchange rate of the rand in the fourth quarter of 2008, within an environment of risk aversion brought on by international financial market turmoil.

Graph 5

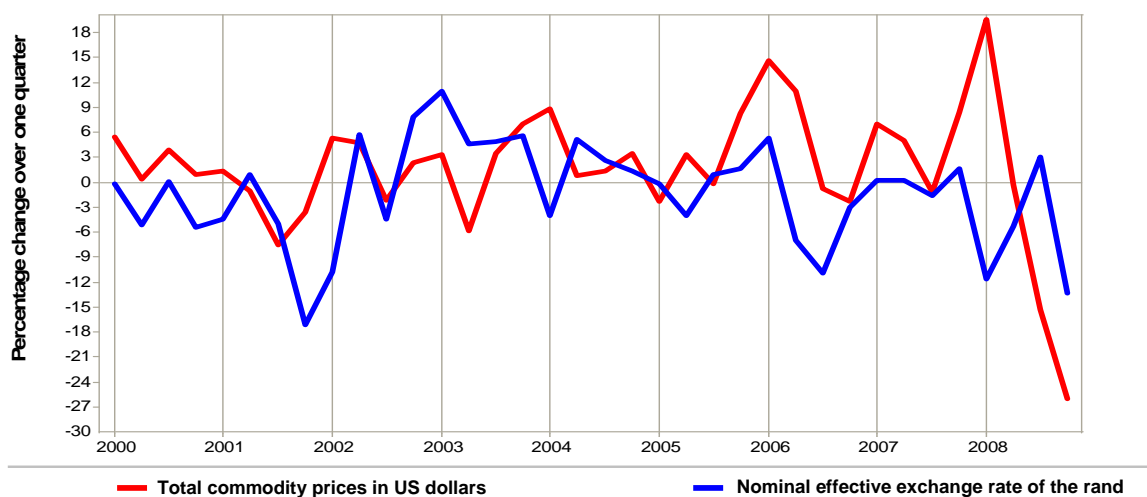
**Prices of South Africa's 12 main exported mining and agricultural commodities**



When quarter-to-quarter changes in commodity prices are plotted alongside those in the nominal effective exchange rate of the rand, a certain degree of co-movement is noticeable. Lags play an important role in import and export transaction flows, and both leads and lags can be important in financial flow as recorded in the financial account of the balance of payments. It is therefore incorrect to assume a one-on-one causal relationship between commodity price changes and exchange rate movements of the rand. Nevertheless, judging from the following graph, a certain degree of relationship does exist, indicating that commodity price changes do play a role in the exchange rate of the rand.

Graph 6

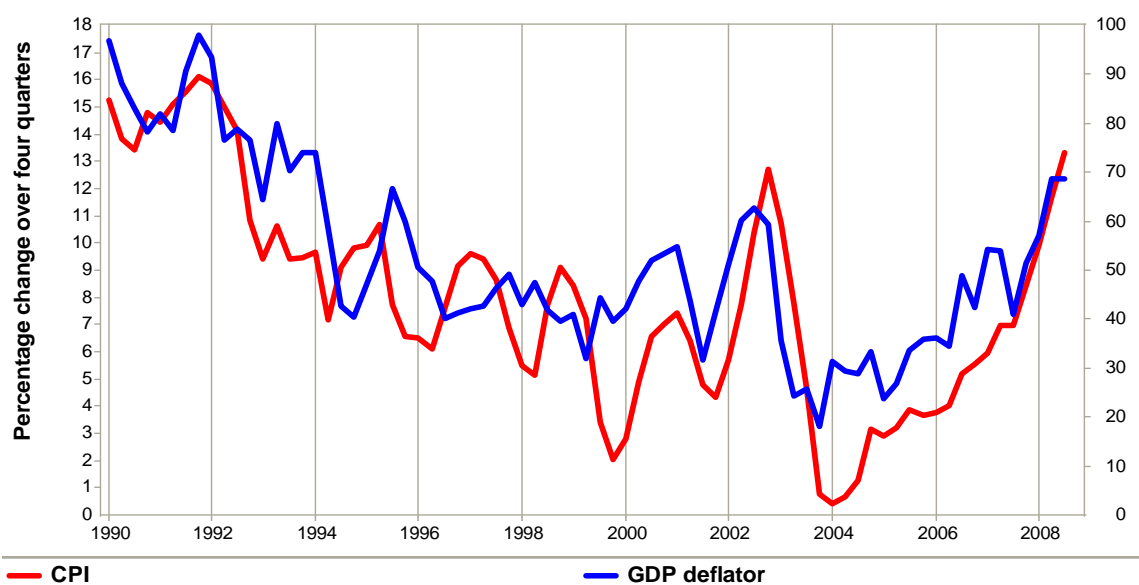
**Commodity prices and the exchange rate of the rand**



In ascertaining the price effects of such exchange rate changes, two sets of price indicators may be applied: expenditure-based price indices such as the consumer price index, and output-based measures such as the gross domestic product deflator. Due to the different measurement points and compilation procedures being applied in calculating these different sets of price indices, they respond differently to excessive price swings imposed by abrupt exchange rate changes. This leads to some divergence and therefore warrants closer analysis. Policymakers should be cognisant of the reasons why such gaps develop between various sets of price indicators, and be able to interpret such divergences correctly.

Graph 7

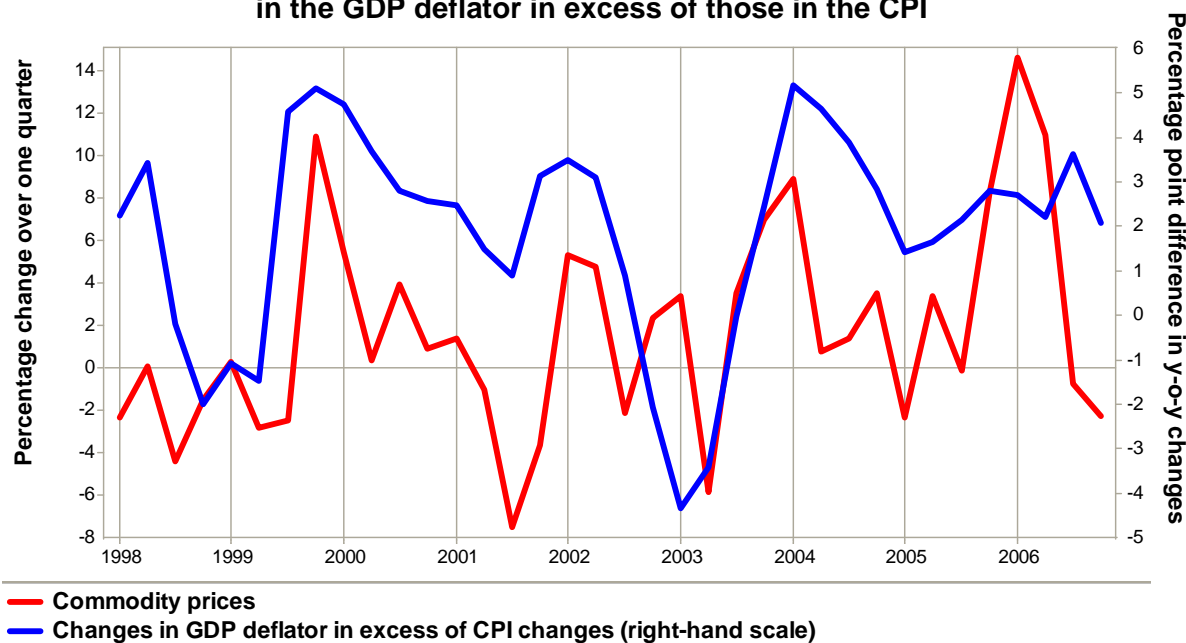
**Consumer price index and gross domestic product deflator**



Graph 7 attempts to explain the different responses of an expenditure-based price index and a consumption-based price index to commodity price changes. When the quarter-to-quarter changes in commodity prices are plotted alongside annual changes in the GDP deflator in excess of CPI changes, some consistency in their co-movement is observable. An interpretation of this phenomenon requires technical knowledge about the compilation of these different price indices. The GDP deflator indicates changes in the level of nominal GDP in excess of real GDP. In determining real GDP, a combination of volume indicators, producer and consumer price indices is applied to deflate the level of nominal GDP. The structure of an economy will determine which price indicator – the PPI or the CPI – will be more prominent in the calculation of real GDP. In an economy where the services sector comprises a larger share of total activity, the CPI will be applied to a greater extent compared to the PPI, for deflation purposes. In commodity-producing countries such as South Africa, the PPI will have a greater bearing on the outcome of real GDP, which partly serves as an explanation of why the GDP deflator is more sensitive to commodity price changes than the CPI. Changes in the PPI normally lead changes in the CPI as price pressures work their way through price formation processes in an economy.

Graph 8

**Changes in commodity prices and increases in the GDP deflator in excess of those in the CPI**

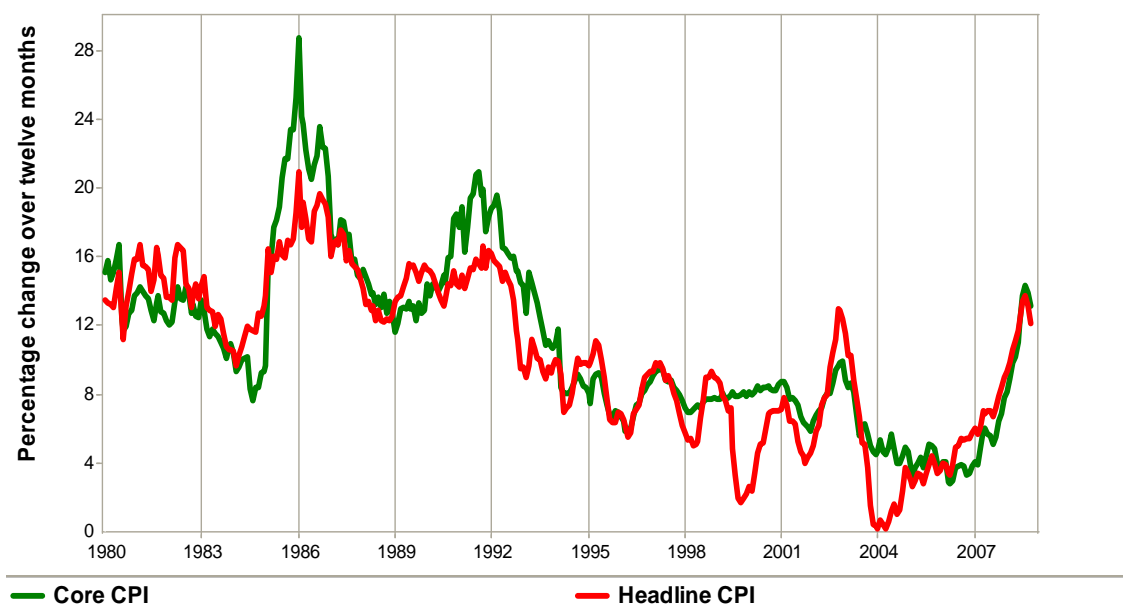


#### 4. The consumer price index as an expenditure-based price indicator

##### 4.1 The distinction between core and headline measures of price change

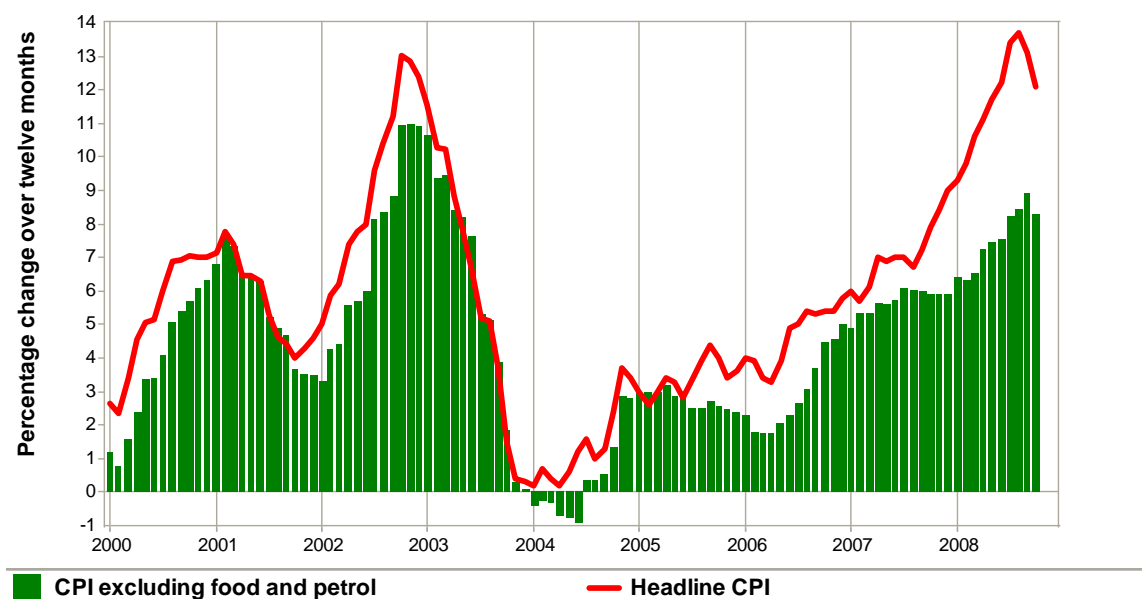
It is of paramount importance to policymakers to have a clear indication not only of changes in the headline consumer price index, and even more, of the evolution of underlying or more broad-based price pressures in an economy. To this end, the South African monetary authority also monitors price changes in the economy by means of a core measure of price change as published by Stats SA, the national statistics agency. This core measure of price change excludes certain volatile food items, assessment rates and value added tax, but does not omit petrol prices. As a consequence, the use of an indicator that excludes both food and petrol prices from the CPI has gained popularity in recent years.

Graph 9  
Core CPI and headline CPI



Graph 10 shows that price pressures in the economy started to mount in the middle of 2004, indicated by both the headline measure of price change and the underlying measure of price change, ie the CPI excluding food and petrol prices (the main driver of consumer price inflation during that period). In September 2008, the year-on-year rate of increase in the headline CPI was as much as 32% higher than that in the underlying measure. This divergence in the indication of price pressures in the economy is indicative of the necessity to consider core or underlying inflation measures as well, when deciding on policy intervention in the price formation process. The Bank also considers an inflation measure that excludes food, petrol and *electricity* due to the exceptional price increases foreseen for electricity due to the expansion programme by Eskom (the state's power utility). A trimmed mean inflation rate is furthermore calculated to assist monetary policy formulation.

Graph 10  
CPI excluding food and petrol and headline CPI





## 4.2 Assessment of inflation persistence

When considering the persistence of inflationary pressures in an economy, the framework under which price inflation is being assessed will have to be brought into the discussion. As already mentioned in the introduction to this paper, South Africa adopted an inflation targeting monetary policy framework in 2000, and therefore inflation persistence in the domestic economy will have to be assessed in terms of the inflation target range of 3–6%.

After remaining within the inflation target range for a period of three and a half years, CPIX inflation accelerated beyond the upper limit of the range in April 2007. Year-on-year CPIX inflation consistently remained outside the target range for the remainder of 2007 and the whole of 2008, and is only projected to return to the target range in the second quarter of 2010, and to an average of 5.5% in the final quarter of that year.

Inflation persistence will be determined by the effectiveness of the monetary and fiscal policy response to mounting inflationary pressures in an economy. Policy measures should therefore promptly address second-round price effects before they take hold. The structure of the economy in terms of the relative consumption of goods and services will also help determine the persistence of inflation, as services price inflation normally lag goods price inflation; but it is also less likely to be moderated after inflationary pressures have gained momentum.

Inflation persistence in a more technical sense refers to the degree of inflation inertia present in the inflation process, where previous inflation pressures feed into subsequent inflation outcomes. Similar to other emerging market economies, the inflation process in South Africa is largely subject to inflation inertia or persistence, which aggravates the containment of inflation.

## 4.3 Administered prices

An administered price can be defined as the price of a product or service that is set consciously by an individual producer or group of producers, and/or any price that can be determined or influenced by government, either directly, or through one or other government agency without reference to market forces.

Price indices for administered prices were first officially published by Stats SA in June 2005 for the May 2005 data point. Prior to this date, administered price indices were constructed by the Bank by applying appropriate sub-indices from Stats SA's database. Goods and services with prices that are administered comprise 17.89% of the headline CPI basket.

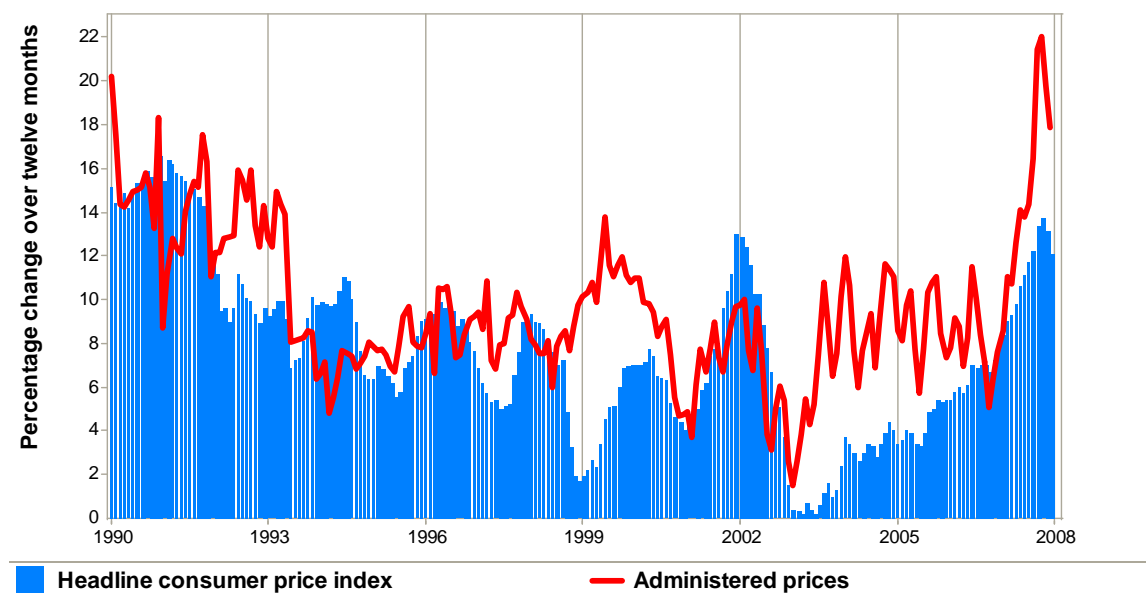
The following administered prices are included in the CPI basket:

- Housing (sanitary fees, refuse removal, assessment rates, water and university boarding fees)
- Fuel and power (electricity and paraffin)
- Medical care (public hospitals)
- Communication (telephone calls, telephone rental and installation, postage, cell phone connection fees and calls)
- Education (school fees and university, technicon and college fees)
- Transport (petrol, public transport – municipal buses and trains, motor licences and registration)
- Recreation and entertainment (television licence)

The effectiveness of monetary policy is partly subject to the extent to which price changes are being administered in an economy. In South Africa, with a prevalence rate of close to

18%, or almost one fifth of the headline CPI basket being administered, policymakers should pay close attention to the evolution of administered price inflation. As graph 11 shows, administered price increases generally remained in excess of headline CPI inflation during the period being covered.

Graph 11  
**Headline CPI and administered prices**



In addressing administered price increases, monetary authorities may endeavour to achieve a “buy-in” from other entities in the economy to try and avert unwarranted administered price increases. Not only does the Bank voice its opinion on administered price increases in its official Monetary Policy Statements, but joint meetings between officials of the Bank and other role players take place on a regular basis to assess the validity of certain administered price increases. The only “instrument” immediately at the disposal of the monetary policy authority in dealing with administered price adjustments is moral persuasion. The effectiveness of such intervention is subject to the political will of all concerned. In most instances, however, economic realities will dictate the outcome of administered price adjustments. An example of such an outcome is the most recent round of electricity price increases in South Africa, which were deemed necessary to sustain and increase electricity generation in the country.

#### 4.4 **Compilation and coverage of the new CPI and possible effects on the measured level of consumer price inflation**

In 2005, Stats SA embarked on a process to revamp the CPI through an extensive review of weights, composition and method of calculation. The previous rebasing of the CPI occurred in January 2002, but no significant changes were made to the composition of the CPI basket at that time. A thorough review of the CPI was thus deemed necessary to ensure that the figures provide a more accurate picture of inflationary pressures in the economy. The new methodology will apply to the January 2009 CPI inflation figures, being released in February 2009.

The new CPI series will differ from the old series in the following ways:

- The old CPI series was based on the International Trade Classification (ITC) system, while the new series is based on the Classification of Individual

Consumption by Purpose (COICOP). COICOP is the preferred classification internationally

- Interest rates will no longer be used as a measure of housing costs in the headline CPI measure and will be replaced with a measure of owner's equivalent rent
- The CPI will undergo reweighting with the introduction of new expenditure weights based largely on the Household Income and Expenditure (IES) Survey of 2005/06
- The CPI will be rebased so that the average index for 2008 will equal 100

The new index will be calculated from January 2008, which will make it possible to calculate consistent year-on-year and month-on-month inflation rates from January 2009, based on the newly defined index. Stats SA started to collect price data based on the new basket of goods (COICOP) in January 2008 while continuing to collect price data for the old basket of goods (ITC).

There will be no revisions to historical inflation data. However, the break in the series between December 2008 and January 2009 will pose some challenges for time series analysis and Stats SA will therefore publish COICOP-consistent historical price series where the data allow.

One of the major methodological changes in the calculation of the CPI is that mortgage interest rates will no longer be used as a measure of housing costs in the new headline CPI; a measure of owner's equivalent rent will be used instead. This is in line with international best practice and should be seen as an improvement in the CPI methodology. Mortgage interest costs were previously excluded from the target measure of inflation (CPIX) because of the perverse relationship between headline CPI and monetary policy. However, this problem will not occur with the new headline CPI measure.

The weights of the CPI represent the proportions of consumption expenditure by households in a specific period, obtained primarily from the IES 2005/06, but also from other sources. In the following table, the existing CPIX weights are compared with the new CPI weights for total country and for primary and secondary urban areas (previously referred to as metropolitan and other urban areas). The major difference in the new CPI weights between total country and primary and secondary urban areas is a result of the fact that food carries a higher weight and housing a lower weight in the total country CPI than in the primary and secondary urban areas' CPI. This should be expected since the total country includes rural areas. In the discussion below, the existing CPIX weights are compared with the CPI weights for total country only.

The weight of food and non-alcoholic beverages falls by nearly 7.0 percentage points from 26.9% to 20.2% in the new CPI when including restaurants. The drop in the food weight is in line with the increase in per capita GDP. As income per capita increases, the proportion of income spent on food declines relative to expenditure on services like transport and housing. Importantly, however, a comparison of the food groups between 2000 and 2006 shows that there has not been a major change in the *distribution* of food expenditure.

The weight of food is significantly higher than was suggested by the IES (15.6%). Stats SA has indicated that certain categories, like food, were underreported in the IES. Stats SA consulted and used a range of additional data sources (national accounts data, industry sources) in finalising these weights. Due to systematic underreporting, changes to the weights for personal care and alcoholic beverages and tobacco were also made. It is widely known that respondents in the household expenditure surveys underreport their actual purchases of alcohol and tobacco. In order to get a more realistic level of expenditure for these items, Stats SA utilised data on excise taxes and volume sales data from producer organisations.

Table 1  
Comparison of the old CPIX weights and the new CPI weights<sup>1</sup>

COICOP category	2000 weights CPI metro areas (headline CPI)	2000 weights CPIX metro and other urban areas	2006 weights (CPI primary and secondary urban areas) <sup>2</sup>	2006 weights CPI total country
Food and non- alcoholic beverages	22.09	26.92	15.68 (17.53 incl. restaurants)	18.28 (20.19 incl. restaurants)
Alcoholic beverages and tobacco	2.54	3.05	5.58	5.56
Clothing and footwear	3.25	4.06	4.11	4.42
Housing	22.14	15.85	25.5	23.66
<i>Actual rental for     housing</i>	4.56	4.76	3.49	3.2
<i>Mortgage interest     costs</i>	11.43	n/a	n/a	n/a
<i>Owners' equivalent     rent</i>	n/a	n/a	12.21	11.25
<i>Maintenance and     repair</i>	1.42	1.43	1.68	1.55
<i>Water and other     services     (incl. insurance)</i>	4.73	5.38	6.25	5.48
<i>Electricity and other     fuels</i>	3.49	4.28	1.87	2.18
Household contents, equipment and maintenance	8.13	9.24	5.86	6.14
<i>Furniture</i>	2.53	3.15	3.22	3.57
Health (incl. medical aid)	7.15	7.70	5.15	4.85
Transport (incl. insurance)	14.84	15.30	19.34	18.26
<i>Vehicles</i>	5.95	5.69	11.25	10.23
<i>Running costs     (excl. petrol,     incl. insurance)</i>	2.13	2.24	1.43	1.35
<i>Public transport</i>	1.84	2.29	2.73	3.07
<i>Petrol</i>	4.92	5.08	3.93	3.61
Communication	2.98	3.19	3.22	3.13
Recreation and entertainment	3.31	3.39	4.19	3.93
Education	3.48	3.77	2.19	2.15
Restaurants and hotels	n/a	n/a	2.78 (0.93 excl. restaurants)	2.78 (0.87 excl. restaurants)
Personal care	3.67	4.37	1.99	1.97
Miscellaneous (excl. insurance)	3.32	3.63	5.34	5.74

<sup>1</sup> Due to rounding, the contribution of some sub-components may not add up to the weight of the component.

<sup>2</sup> The previous term, *metropolitan and other urban areas*, has been replaced by the term *primary and secondary urban areas*.

Sources: Stats SA, NT own calculations

The transport component increased its share significantly from 15.3% to 18.3% as high income per capita led to increases in purchases of vehicles over the IES period. Interestingly, the share of petrol declined from 5.08% to 3.6%. Stats SA compared the IES petrol weights with petrol sales, showing that the latter have increased by only 7.0% since 2000, consistent with a decrease in the importance of petrol as a consumption item (and with the improved fuel efficiency of vehicles).

The housing component share rose to 24.0% from 15.9% previously and is now the single largest component. The newly introduced subcomponent, owners' equivalent rent, accounts for 11.3%, just less than half of the total housing share. Fuel and power, which comprised a separate category under the ITC classification, and which includes electricity, gas, petroleum products etc., will now fall under the housing component. Its weight has almost halved to 2.2%, which will lower the impact of the future electricity price increases on the outcome of the measured level of consumer price inflation.

The downward bias in the new inflation figures – at least initially – results from the following:

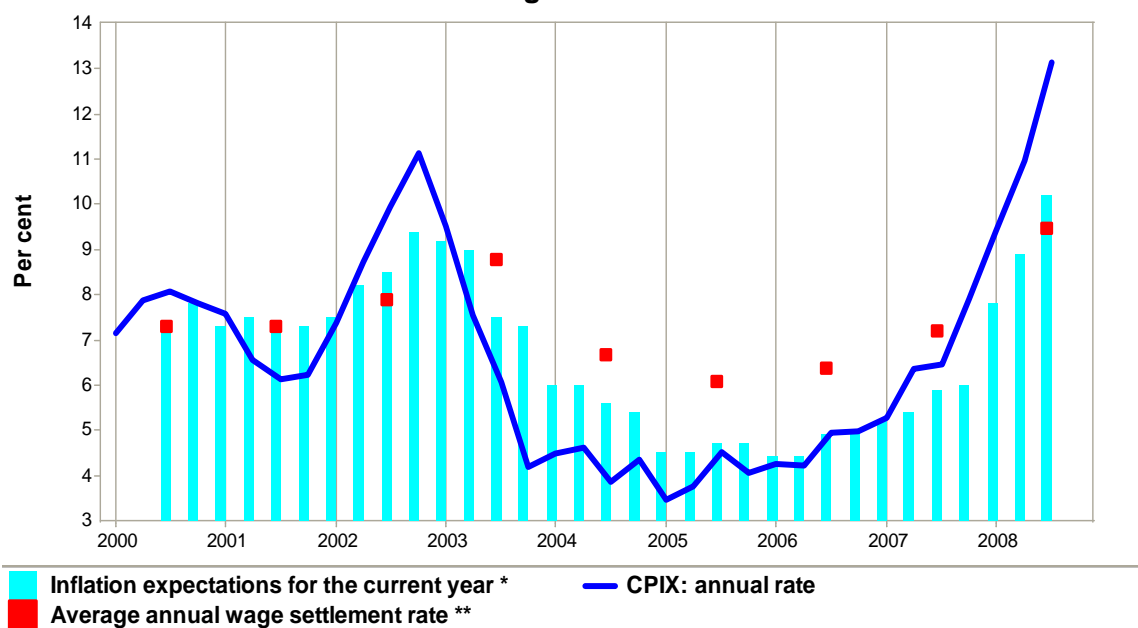
- Lower weights for current (2008) high-inflation items like food, petrol and electricity;
- The impact of rebasing. Over time a substitution bias creeps into a fixed-weight methodology, where high inflation items have higher *effective* weights over time.

At the same time when Stats SA introduces the new methodology for the CPI, it will rebase the series to 2008 = 100. If an index is not regularly rebased when a fixed-weight methodology is used, a substitution bias will emerge where high inflation items have a higher *effective* weight over time, which places an upward bias on inflation. This means that simply rebasing the CPI series (without changing the weights or basket of goods) should have a downward impact on overall inflation. Based on May 2008 inflation numbers, it is estimated that the **rebasing** of the index alone can reduce total inflation by about 1.2 percentage points. Estimates show that the **reweighting** exercise has reduced overall inflation further by about 2.0 percentage points at current levels of food and petrol price inflation, at the time of analysis in May 2008. However, even if we assume a lower rate of inflation for these components by the end of 2008, it is still likely that the new weights will reduce inflation by about 1.0 percentage point between December 2008 and January 2009.

## 5. Interaction between price developments, inflation expectations and wage settlement rates

Inflation expectations provide a key link between wage and price developments in an economy. As depicted in graph 12, average annual wage settlement rates fell short of consumer price inflation in 2002 and 2008 (periods of accelerating inflation), while consistently exceeding it during t2003–07 (a period of moderating or contained rates of inflation). From this observation, it is clear that wage settlement rates generally tend to undercompensate for inflationary effects during periods of high and rising inflation, while the inverse applies during periods of moderating and relatively contained rates of consumer price inflation. Furthermore, actual inflation outcomes seem to lead inflation expectations, followed by movements in the average wage settlement rate.

Graph 12  
**Consumer price inflation, inflation expectations  
and wage settlement rates**



Sources: \* Bureau for Economic Research, Stellenbosch \*\* Andrew Levy Employment Publications

The graph shows that inflation expectations are of paramount importance to the outcome of wage settlement rates, with wage growth in turn contributing to secondary inflationary pressures being encapsulated in future inflation outcomes, if not compensated for by productivity gains. Policymakers should therefore be cognisant of the crucial role that inflation expectations play in the evolution of price change in an economy. The accurate measurement of all three indicators should not be compromised, as a full understanding of their interrelationships is crucial to sound policymaking.

Central bank communication to the public has a crucial role to play in the formation of inflation expectations and should therefore be managed in such a way that it is in full support of actual monetary policy steps being taken to contain inflationary pressures in an economy. To this end, the Bank has set up semiannual Monetary Policy Forum meetings across the country, where members of the Monetary Policy Committee, assisted by other Bank staff, explain policy actions, and also solicit inputs from various constituencies. To coordinate information flow, all external communication from the Bank is being channelled through the office of the Governor of the Bank. While the minutes of the MPC meetings are not being published, a full Monetary Policy statement, explaining the Committee's policy actions, is published after each MPC meeting. To supplement information flow from the Bank further, over and above information disseminated in various official publications of the Bank, senior Bank officials regularly address audiences across the country on various pertinent issues concerning the state of the economy. The structured approach to information flow from the Bank to help shape inflation expectations, as well as to raise economic literacy levels, is commendable and contributes to the effectiveness of monetary policy.

## 6. Inflation measurement biases

The elimination of biases in the calculation of the CPI should remain the priority of any statistical agency in its effort to produce accurate data on the evolution of price change in an economy. Due to the intricate nature of various biases associated with prices statistics, statistical agencies find it extremely difficult to address and measure many of these biases;

this is also the case in South Africa. Many of the same obstacles that prevent the elimination of biases in the calculation of the CPI also stand in the way of estimating biases. These include the lack of complete data on product-level consumer preferences and spending behaviour, and the inability to observe and value all differences in quality between items in the marketplace. Without such information it is impossible to calculate a true cost of living index, and similarly impossible to measure the divergence between its rate of growth and the growth rate of the consumer price index.

In order to ensure public confidence in a consumer price index, a detailed and up-to-date description of the methods and data sources should be published. The document should include, among other things, the objective and scope of the index, details of the weights, and last but not least, a discussion of the accuracy of the index, with specific reference to the existence of biases in its calculation. A description of the sources and magnitude of the sampling and non-sampling errors (coverage, non-response rates etc.) in the CPI, provides users with valuable information on the limitations that might apply to their uses of the index. To this end, at the time of writing of this paper in late 2008, Stats SA was in the process of completing such a manual, which will give a clearer indication of the compilation of the CPI and certain limitations originating from the existence of biases present in the CPI numbers.

To address substitution bias in the calculation of the CPI, Stats SA would start to price a fairly similar product when an outlet no longer carries the specific product. No account is taken of buying power moving from, for instance, red meat to fish, over and above the five-yearly weight changes being implemented to the whole CPI basket, based primarily on the outcome of the Household Income and Expenditure Survey. When outlets refuse to partake in the CPI price collection process, another willing outlet in the same area will be used for price collection purposes. No account is being taken in the CPI of buying power moving from one outlet to another. Stats SA does not cater for new products and services on an ad hoc basis, but incorporates them only during the five-yearly composition and weight change exercise. Stats SA takes little account of changes in the quality of goods and services, but such an intervention is being contemplated for later implementation.

## 7. Conclusion

The effectiveness of monetary policy intervention in an economy is directly related to the quality of statistics being made available to policymakers. Their ability to interpret such data is of equal importance and requires a sound knowledge of the informational strengths and limitations of available data. Data outcomes should always be interpreted in context, with due consideration being given to structural changes taking place in an economy and their effect on the appropriateness and quality of available data. The existence of interrelationships between various economic processes has a direct bearing on economic indicator outcomes and should be taken note of in the policy decision-making process. The elimination of biases in data being made available to policymakers should always receive the highest priority, to facilitate optimal policy formulation.

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# Monetary policy and underlying inflation pressures: the essence of monetary policy design

Atchana Waiquamdee,<sup>1</sup> Pranee Sutthasri and Surach Tanboon<sup>2</sup>

## 1. Introduction

The recent rise in oil and other commodity prices has called into question the decision made by the Bank of Thailand in 2000 to choose a measure based on the CPI excluding fresh food and energy (“core inflation”) as the inflation target. Between the first quarter of 2004 and the third quarter of 2008, CPI inflation (“headline inflation”) averaged 4.0%, whereas the average core inflation registered 1.5%. During that period core inflation had been consistently lower than headline inflation in every quarter. Among the several questions raised by policymakers, the most crucial one is: given such a divergence, is core inflation still pertinent to the conduct of monetary policy as the target measure? Other relevant questions have included: why did the central bank choose core inflation in the first place? and what does theory say?

This paper offers a justification for and assurance of the efficiency of a monetary policy design that is based on using core inflation as the policy target. Illustrated in a framework where the microeconomic foundation with rigidities of various types is the central feature, the first part of the paper starts with an important reminder of the reason why central banks need to focus on inflation as their primary objective. Instability of the general price level leads to undesired variation in the relative prices of goods, and, given the presence of price rigidity, allows only some subset of prices to adjust freely. These relative price distortions lead to inefficient resource allocation.

Once the mandate of price stability is established, the next questions are: which measure(s) of inflation, according to theory, is/are most relevant to the conduct of monetary policy? Should the monetary authority stabilise the general price level or a narrower price index? In addition to prices of goods and services that are consumed by households, should other prices such as wages or asset prices be taken into consideration?

While the literature broadly suggests that stabilising a target index that places more weight on the stickier prices is a better policy, it has mostly come to a conclusion that the monetary authority should be mindful of developments in a broad variety of prices. For example, if, in addition to prices, wages are not free to adjust, then price stabilisation may not be a good approximation of the optimal policy, and in this case monetary policy may need to stabilise wage inflation as well as price inflation. Another example occurs in the open economy context in which the monetary authority must decide between stabilising headline inflation or a narrower measure that is restricted to domestic inflation. Domestic prices are intrinsically stickier than the overall price level, as exchange rate fluctuations naturally cause import prices and hence the general price level to be more volatile. Here, the key factor in deciding whether domestic price stabilisation is optimal depends on the assumption of exchange rate pass-through. If the pass-through is full and immediate, then optimal policy requires that domestic inflation be fully stabilised. However, if the pass-through is imperfect, then strictly stabilising domestic inflation is suboptimal. In this case the general price level cannot be adjusted flexibly, rendering price-setters to look into the future movements in the overall price

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level and not just the domestic price level when making their decision. In essence, while theory has established that optimal monetary policy from a welfare-theoretic analysis is one that targets the rate of changes in sticky prices, that conclusion also depends on other features of the economy such as the degree of wage rigidity and exchange rate pass-through. As a result, while the choice of the policy target in the case of Thailand comes down to core inflation, the central bank needs to take into consideration developments in various aspects of the economy, especially when core inflation and headline inflation deviate from each other for an extended period.

In its implementation of the inflation targeting framework, the Bank of Thailand also looks at several indicators that help to gauge underlying price pressures as accurately as possible. The first type of indicators is designed to separate noise from underlying inflation signals based on different methodologies. Indicators based on smoothing and/or reweighting the general price level time series have proved especially useful, not only during the previous episodes of rising oil prices, but also at the present time given unintended price distortions caused by a heightened extent of government price controls. Moreover, with the government reducing the prices of certain public utilities temporarily (or setting them to zero in certain instances) to help low-income households, the central bank needs to be alert in adapting the existing inflation indicators and in looking for new ones so as to accurately measure underlying price pressures. The second type of inflation indicators are those from the labour market such as movements in wages and unit labour costs as well as wage setting behaviour. Third, as inflation expectations are central to inflation dynamics and given that anchoring inflation expectations is one of the most important objectives of monetary policy, indicators of inflation expectations – for example, those obtained from surveys and financial markets – play an important role in the formulation of monetary policy. All three types of indicators are closely monitored by the Bank of Thailand.

The rest of the paper is organised as follows. Section 2 briefly sets the stage by emphasising the importance of price stability using the recent ideas that are grounded in the New Keynesian framework or the so-called “new consensus in macroeconomics.” Once price stability is firmly established as the central bank mandate, section 3 subsequently focuses on the appropriate measure of inflation that needs to be stabilised in theory. Section 4 then looks at various indicators of underlying inflation and measures of inflation expectations that are used in practice. Section 5 explores an outstanding issue in the analysis of inflation in Thailand, namely, price controls and their implications for the conduct of monetary policy. Section 6 concludes. The appendix gives details on the construction of the consumer price index in Thailand.

## **2. The importance of price stability**

Price stability, generally considered to be the primary objective of monetary authorities, is broadly characterised as an environment in which inflation is “so low and stable over time that it does not materially enter into the decisions of households and firms” (Greenspan (2002)). Indeed, as noted by Woodford (2003), a notable feature of recent developments in monetary theory and policy is the increased emphasis given to maintaining a low and stable rate of inflation. The motivation of recent theoretical work comes from the inability of some input suppliers (especially households that supply labour) as well as producers of goods and services to adjust wages and prices for a period of time in response to various shocks that prevent the economy from producing efficiently *in the short run*.

From a public policy point of view, there are at least two approaches to solving this inefficiency. One is to remove structural inflexibility in wages and prices through, for example, an elimination of protracted wage-price contracts. This approach is perhaps not always possible in the real world. The other is to create an environment for firms in which they are

content with existing prices, even though they cannot change their prices due to the structural constraints. This is what monetary policy aims to achieve. This approach, now more or less a consensus, posits that inflation has a deadweight loss – that is, it causes inefficient allocation and utilisation of resources through relative price distortion. The loss arises when individual prices, which signal supply and demand by the household and business sectors, cannot adjust freely and instantaneously while the general price level changes. Consequently, the profitability of producing goods and services no longer reflects the relative social costs of producing them, which in turn yields a suboptimal allocation of resources<sup>i</sup> (see endnotes for technical details). Under this view, the central bank should use monetary policy to simulate a flexible-price environment by generating and committing to price stabilisation.<sup>ii</sup>

### 3. Which measure of inflation to stabilise in theory?

#### 3.1. Stabilising movements in sticky prices

Given the constraint on price adjustments and the consequent relative price distortions caused by inflation, recent research shows, in a simplified setting abstracting from such frictions as the downward nominal wage rigidity or the zero lower bound on nominal interest rates, that monetary policy should aim to engineer zero inflation. In reality, with imperfect inflation measurement and other rigidities and constraints, monetary policy should aim to obtain a low and stable (ie near zero) inflation trend. In particular, it should aim to stabilise sticky prices – rather than a broader price index that puts much weight on prices that already can adjust frequently.

An analytical framework can be constructed such that prices in one sector are more rigid than those in another; within this framework, it can be shown that society benefits more if monetary authorities place more emphasis on stabilising inflation in the sticky-price sector. To be precise, *the welfare loss function puts a higher weight on variations in the sticky-price sector relative to those in the flexible price counterpart.*<sup>iii</sup> In a simplified setting of Aoki (2001), imperfection in price adjustments that is the root cause of relative price distortions is located in the sticky-price sector only and not in the flexible price sector. In such an environment, complete stabilisation of an aggregate price index is not optimal; instead, stabilisation of inflation in the sticky-price sector is a better policy.<sup>3</sup> In a related setting, Benigno (2004) considers a case of a monetary union consisting of two countries, which can be interpreted as a two-sector closed economy with completely segmented labour markets, to show that a policy that is nearly optimal is characterised by targeting an inflation index that puts a higher weight on inflation in the region with a higher degree of nominal rigidity.

In this simplified framework, theory suggests that optimal monetary policy should focus on stabilising a measure of sticky prices, which is interpreted as core inflation. Central banks should not lose sight of other developments in the economy, however, especially those that have the potential to affect the public's formation of expectations. For instance, if the rate of change in the price of a weighty item excluded from the CPI measure deviates from its trend over an extended period of time, perhaps on account of a large persistent shock, then overall inflation can tend away from the central bank's core measure and core inflation would appear

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<sup>3</sup> In reality, prices regulated by the authorities are present in some economies and are no doubt very sticky. However, such prices respond differently to economic fundamentals compared with freely determined prices. Given that regulated prices are artificially sticky, and not rationally set by profit-maximising firms, the notion of stabilising sticky prices obtained from the basic New Keynesian model cannot be construed to include regulated prices.

an inadequate measure of underlying inflation. According to Mishkin (2008a), “[A] prolonged divergence between core and headline measures of inflation could complicate central bank communications with the public, because core inflation would require some adjustment before it would provide a clear gauge of underlying inflation.” During those episodes, in the interest of expectation management, which is crucial to a central bank’s inflation trend anchoring, central banks have to work hard to ensure effective communication with the public about the underlying price pressures in the economy to avoid the so-called second-round effects that are prone to occur during such episodes.

Similar questions regarding the choice of stabilising a narrow or broad price index also arise in the open economy context. In an open economy, movements in foreign import prices and exchange rates result in a difference between domestic inflation and overall price inflation. Gali and Monacelli (2005) use the Phillips curve to show that the dynamics of domestic inflation in their open-economy model can still be described by an equation analogous to that associated with a closed economy. However, the determinants of the real marginal cost, in addition to domestic output and technology, are also foreign output and the terms of trade, as changes in foreign demand affects domestic resource utilisation while changes in the terms of trade affect the relative price of foreign goods with respect to domestic goods. As the welfare loss function in this setting depends on variations in domestic inflation and not overall inflation – imperfection in price adjustments is exclusively located in the domestic sector and not in the foreign counterpart – *optimal policy requires that domestic inflation be fully stabilised, while allowing headline inflation, and implicitly the nominal exchange rate, to adjust as needed in order to reproduce the response of the terms of trade that would be obtained under flexible prices.*<sup>iv</sup> In short, this finding in the open-economy context has a fundamental idea that is consistent with targeting the inflation rate of the sector that has more nominal inertia, and also resonates with the economic interdependency and increased globalisation of late. Fluctuations in oil prices – as reflected in the erstwhile upswing caused by surging demand from a large and rapidly growing Asian economy, or in the recent collapse in oil prices caused by an ongoing slowdown in activity in many foreign economies, especially the world’s largest one – result in the overall price level of any small open economy possibly not accurately reflecting underlying price pressures. In such circumstances the monetary authority should look through headline inflation and focus instead on domestic inflation.

Nevertheless, it is important to note that Gali and Monacelli abstract from several channels that potentially render a strict domestic inflation targeting policy suboptimal. For example, in the case where foreign commodity prices have a distinct trend or the exchange rate pass-through is not immediate and full, both the domestic price *and* the general price level are rigid – the latter now inherits inertia from the external economy in addition to the domestic price that is intrinsically inflexible. In this case, responding to movements in the general price level may be appropriate. In all, no matter what assumptions are made regarding the degree or speed of foreign inflation pass-through, monetary policy should focus on a measure of inflation that reflects nominal rigidities that give rise to inefficiency in resource allocation.

### 3.2. Stabilising movements in other prices?

**Wages.** In the presence of sticky prices *and* sticky wages, various theoretical works such as Erceg, Henderson and Levin (2000), Giannoni and Woodford (2003), and Woodford (2003) have shown policies that focus exclusively on stabilising price inflation to be suboptimal. Intuitively, in addition to variations in the output gap and price inflation, fluctuations in wage inflation, subject to the sluggish response of nominal wage, bring about relative wage distortions that result in an inefficient allocation of labour and a consequent welfare loss. As a result, given wage rigidities, strict targeting of price inflation is no longer optimal, and theory suggests that central banks should target a weighted average of price and wage inflation, with the weights proportional to the degree of rigidity.<sup>v</sup> Nevertheless, problems in the measurement of labour costs may partly explain a small role of wages, relative to prices, in

many central banks' price stability objective. Bernanke (2008) observes that in the United States, compensation per hour in the nonfarm business sector, a commonly used measure of labour cost, "displays substantial volatility from quarter to quarter and year to year, is often revised significantly, and includes compensation that is largely unrelated to marginal costs." Several problems can also be found in the Thai wage data. For example, wages in the public sector turn out to be higher than those in the private sector. Hence, *although theory suggests wage inflation should be explicitly included in their target, data availability and data quality – let alone confidence in various functional forms and accuracy of calibrated/estimated structural parameters – possibly prevent central banks from having done so in practice.* Although this leaves out wage inflation as a primary target of central banks, we regularly monitor various measures of labour market pressures so as to gauge as accurately as possible the overall price pressures in the economy.

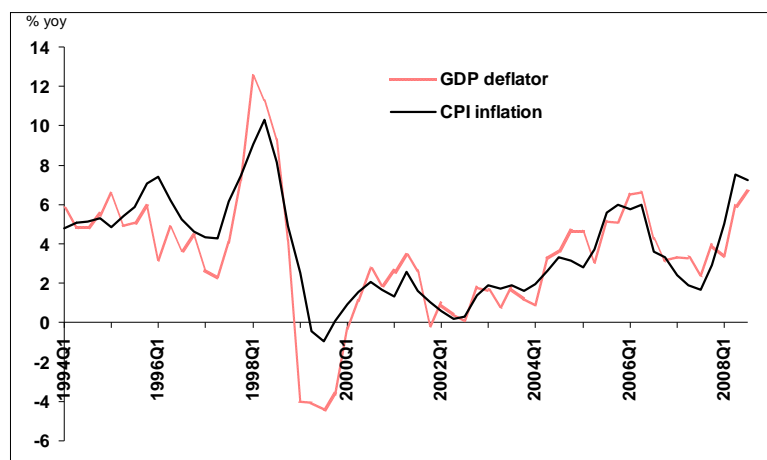
**Asset prices.** Although a bursting asset price bubble potentially has deleterious effects on the economy, several arguments have been put forward against an explicit inclusion of asset price inflation in monetary policy rules. First, a central bank needs to identify the existence of a "bubble" – whether asset prices have moved away from their equilibrium level to such an extent that asset price fluctuations affect output and inflation. Identification is not an easy task. Furthermore, as Mishkin (2008b) notes, attempts to influence asset prices when the central bank is uncertain about the presence or extent of a bubble can interfere with the role of asset prices in allocating resources. Second, once a bubble is large enough to be identified reliably, argues Bean (2007), it is perhaps especially difficult for the central bank to predict the timing and strength of monetary policy transmission from interest rate changes to asset price inflation compared to the effects of the interest rate on CPI inflation. As bubbles are departures from normal behaviour, impacts of the usual tool of monetary policy – that is, the setting of overnight interest rates – are not exactly clear and to a certain extent can be "blunt." Instead of including asset price inflation as a monetary policy target, Goodhart (2007) suggests using another instrument in response to asset price fluctuations, namely, countercyclical prudential regulations that are restrictive during an episode of asset price bubbles and stimulatory during an episode of asset price downturns.

## **4. Indicators of underlying inflation and measures of inflation expectations**

### **4.1. CPI as a proxy for the general price level**

Given that households and firms in Thailand appear to use CPI inflation, which is transparent and well understood by the public, to index wages, salaries, pensions and long-term contracts, and that data on CPI inflation are timely, published regularly, and not subject to revision, the Bank of Thailand considers CPI inflation as a reliable measure of the change in the general price level, and uses it to form a basis for calculation of underlying inflation, which ideally approximates movements of changes in sticky prices in the economy. The other available proxy for the general price level is the GDP deflator (in Thailand the price deflator for personal consumption expenditure is not available). However, the GDP deflator is released only on a quarterly basis, with the difference between inflation based on the CPI and the GDP deflator being relatively minor, except during the period in which the economy experiences large terms-of-trade shocks such as the 1997 currency crisis, as shown in figure 1.

Figure 1  
CPI inflation and GDP deflator

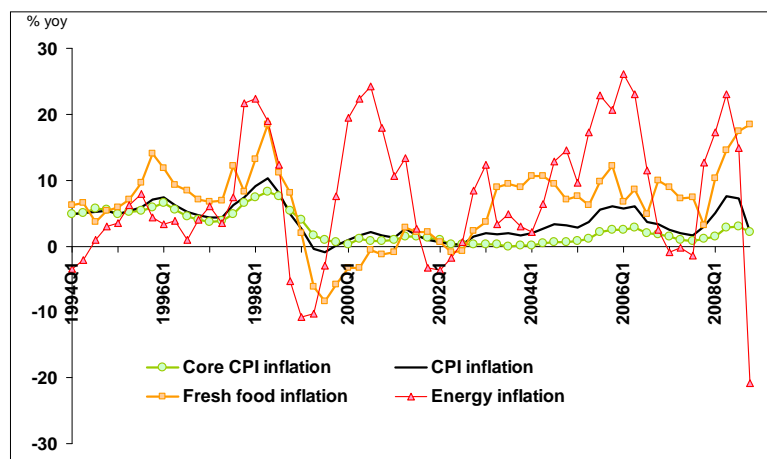


Sources: Ministry of Commerce and the National Economic and Social Development Board.

#### 4.2. Official target: core inflation based on fixed-item exclusion

In calculating underlying inflation, the Bank of Thailand has used the fixed-item exclusion approach – that is, excluding the prices of fresh food and energy from the CPI. The rationale behind the exclusion is that these prices are the most volatile relative to other prices in the CPI, as illustrated in figure 2.

Figure 2  
CPI, core CPI, fresh food and energy inflation



Source: Ministry of Commerce.

Core CPI inflation has been a monetary policy target in Thailand since the adoption of the inflation targeting framework in May 2000. There have been criticisms of whether core inflation is an appropriate target, particularly in the past few years during which headline inflation and core inflation drifted apart given continuous rises in food and energy prices; see Khemangkorn et al (2008) for details. Consequently, the Bank of Thailand has not placed its sole emphasis on developments in core inflation but instead on a variety of underlying inflation indicators.

### 4.3. Measures of underlying inflation other than core inflation

#### 4.3.1. Measures based on price inflation

According to Roberts (2005), there are two broad approaches to constructing measures of underlying inflation. The first is to estimate underlying inflation by using a theoretical model with economic restrictions (eg Quah and Vahey (1995)). The second is based on statistical methods such as reweighting or smoothing as described below.

	No reweighting across items	Reweighting across items
No smoothing across time	– CPI	– Fixed-item exclusion (core CPI) – Trimmed mean
Smoothing across time	– Simple averaging; moving averaging – Exponential smoothing	– Unobserved component model

Table 1, adapted from Brischetto and Richards (2007), shows underlying inflation indicators currently monitored by the Bank of Thailand. As mentioned above, the CPI forms the basis for the calculation of underlying inflation. Smoothing the changes in the CPI across time while leaving the weights given to the price of each CPI component unchanged gives, for instance, simple averaging, moving averaging, and exponential smoothing. Reweighting the CPI components permanently or period by period gives core CPI inflation or trimmed mean inflation. One can also both reweight each CPI component and smooth the resulting trend across time to obtain a measure of underlying inflation using an unobserved component model. Details of the construction, advantages and disadvantages of these methodologies are given in Khemangkorn and Tanboon (2007) and Sutthasri (2008), and are summarised as follows.

**Fixed-item exclusion measure.** This approach gives zero weights to items in the CPI basket whose prices are considered most volatile – usually unprocessed foods and energy. Sometimes the excluded items are in the fresh food category only. Occasionally, not only food and energy but also mortgage interest payments are left out. A caution is in order. This approach relies on an assumption that prices of the excluded items are the most volatile in every period. If this assumption does not hold at any time, such an indicator may fail accurately to capture underlying inflation, especially when price movements of the excluded items exhibit a distinct trend following persistent demand shocks, thereby leading to bias over the long run.

**Trimmed mean inflation.** To ensure that prices of the excluded CPI components are indeed the most volatile in each period, this approach constructs a weighted average based on the ranked distribution of price changes of all CPI components. This is in contrast to the fixed-item exclusion above because the present methodology does not permanently exclude the same items in every period. Trimming can be symmetric or asymmetric depending on the distribution of price movements. However, one problem with the trimmed mean inflation measure involves communication with the public because the excluded items vary over time. In addition, it is subject to revision, especially when the index is constructed on the month-on-month basis, as new data may alter the seasonal factors and consequently the rate of change in the price of each CPI component.

**Kalman-smoothed inflation measure.** Given that underlying inflation is unobserved, one way to estimate it is to use the unobserved component model with the Kalman filter. This methodology is based on Bryan, Cecchetti and Sullivan (2002), whereby movements in the price of each CPI component depend on changes in the common trend and an idiosyncratic shock specific to that CPI component. An advantage of this methodology is that it accords policymakers the judgment to alter the signal parameters when the economic environment changes. However, the problem of this leeway is the difficulty in communicating with the public and the possibility of revision following changes in the signal parameters.

### **Results for Thailand**

Figure 3, which shows indicators of underlying inflation constructed by Sutthasri (2008) based on the concepts outlined above, illustrates the necessity of having inflation measures other than a single core inflation indicator. One policy challenge drawn from the Thai experience is that core inflation possibly reflects pressures in economic activities only partially during certain episodes.

In particular, during 2003–05, just after the Thai economy came out of the crisis, there were greater inflationary risks as a result of higher economic growth, credit expansion, a tightening labour market – not to mention a continued rise in oil prices. Meanwhile, the trend in core inflation at the time did not reflect any inflationary pressures. This was due to a decline in rent, which constitutes 21% of the core CPI basket and 16% of the CPI basket. Consequently, a larger negative contribution of rent weighed down on core inflation to a level close to zero, which is the lower bound of the target range. In this case, the potential failure of core inflation accurately to gauge pressures in the economy necessitates the Monetary Policy Committee to look for alternative indicators of underlying price pressures with more flexibility to capture the changing dynamics of the economy. By either fully or partially excluding rent from overall inflation, measures of underlying inflation such as a trimmed mean are more appropriate for inflation analysis.

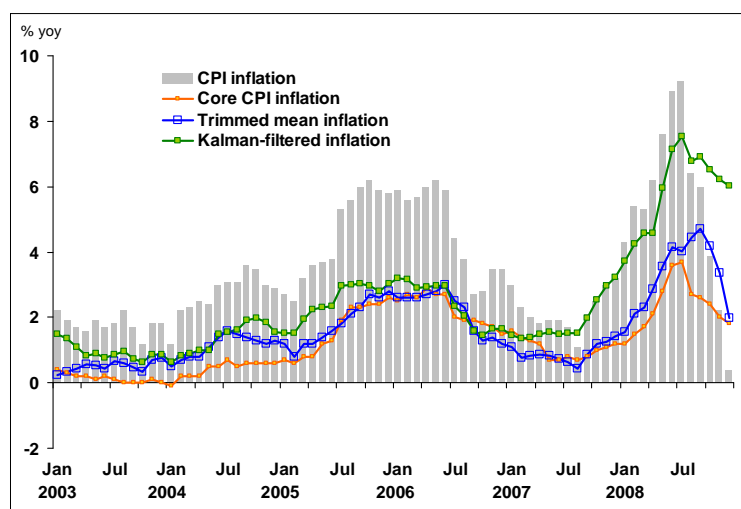
Another instance in which measures of underlying inflation other than core inflation serve as a more accurate inflation gauge is when prices of permanently excluded items in the core CPI basket exhibit a distinct trend. For instance, between January 2004 and July 2008, the gap between CPI inflation and core inflation was persistently large. Conversely, the counterparts for the indicators based on trimming or filtering were smaller, as these indicators did not miss an upward inflation trend in the excluded items – arguably resulting from demand pressures rather than supply shocks – that is left out in the calculation of core inflation. Consequently, by looking at core inflation alone, we may fail accurately to detect inflationary pressures.

The problem with exclusively focusing on core inflation has also become more apparent, especially recently, when there are extreme price distortions caused by the ongoing government measures that involve price controls and extensive subsidies in response to rapid increases in the general costs of living and, most recently, to a subsequent slowdown in economic activity (more on the implication of price controls for the conduct of monetary policy below).



Figure 3

## Underlying inflation indicators



Source: Bank of Thailand.

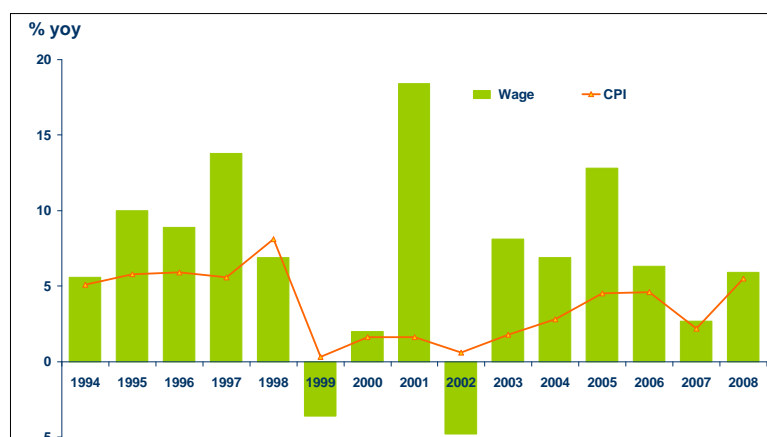
#### 4.3.2. Measures based on wage inflation

Wages have the potential to play a crucial role in inflation dynamics. Given that the key variable that drives inflation dynamics in the New Keynesian Phillips curve is real marginal cost, which in turn is primarily driven by real wage, labour markets provide vital information about the future path of inflation. Data in Thailand are less than perfect, unfortunately, given that the large informal sector within the country and the continuous inflow of (legal and illegal) migrant workers from neighbouring countries render the measurement of labour market pressures especially difficult. Nevertheless, the Bank of Thailand attempts to extract signals from labour market data and regularly monitors the following measures.

**Wage and hourly compensation.** Hourly compensation is defined as all payments made directly to workers that include wages, salaries, overtime premiums, bonuses and employee benefits. (For ease of exposition, in what follows we use the term “wage” more broadly to mean hourly compensation). As shown in figure 4, on average wage inflation is higher than CPI inflation in almost every year, except during 1998–99 owing to the financial crisis and devaluation of the baht. CPI inflation and wage inflation in Thailand appear to converge in the past 15 years, with the correlation coefficient over 1994–2008 being equal to 0.44. It should be noted that the National Statistical Office modified survey questions in 2001, which means that data before and after 2001 are not on the same compilation basis. Consequently we calculate correlation between CPI inflation and wage inflation over 2002–08 and find the coefficient to be 0.64. A positive correlation means that in a period of rising inflation, wage inflation increases as well. In order to gauge pressures in the labour market and their subsequent effects on prices meaningfully, we need to examine whether the higher growth in *real wage net of changes in productivity* is increasing. Under that circumstance firms are bearing an increase in costs that is not due to an increase in productivity, and that makes firms likely to pass on the higher costs to consumers. Here, the notion of unit labour costs is useful as an indicator of price pressures.

Figure 4

### CPI inflation and wage inflation



Remark: The term “wage” is used more broadly to refer to hourly compensation.

Sources: Ministry of Commerce; National Statistical Office; authors’ calculation.

**Unit labour costs.** Computed as wage divided by output per hour, the (nominal) unit labour cost is a widely known indicator of labour market pressures. Intuitively, given that costs associated with labour represent a majority of input costs, rising wages will eventually affect prices.<sup>4</sup> A related notion, the real unit labour cost, which is computed as real wage divided by output per hour, is a potentially useful measure of inflation because it provides a direct comparison between real wage and labour productivity: if real wage rises faster than labour productivity, firms are worse off and need to raise prices if they can. Empirical results in Woodford (2001) and Sbordone (2002) suggest that real unit labour cost, which proxies real marginal cost, is the driving variable in the New Keynesian Phillips curve (and is a better explanatory variable for inflation relative to the output gap). This structural relationship forms a basis for our analysis of inflation. The top panel of figure 5 shows the components of the real unit labour cost, namely, real wage and labour productivity. The bottom panel attempts to portray the relationship between inflation and the real unit labour cost (the latter is shown in terms of percentage deviation from trend). A quick calculation shows correlation between the two variables to be 0.08. We also find that the real unit labour cost leads inflation in two quarters, with a correlation coefficient of around 0.35.

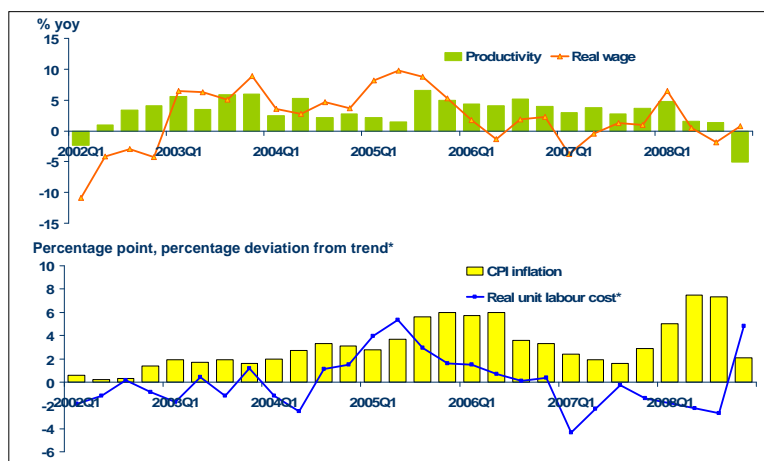
What we have learned from looking at pressures in the labour market is that there appears to be a very small degree of pass-through of labour market pressures to prices. That the degree of pass-through is not full and immediate is perhaps not surprising given that there are several factors that can affect firms’ pricing powers, such as economic conditions, the degree of competitiveness in both domestic and foreign markets, and, especially in the case of Thailand, the extent of price controls by the authorities (more on this on section 5). For instance, over 2004–05 when the real unit labour cost was rising as real wage grew faster than labour productivity, with the economy expanding, firms could pass on the higher costs to

<sup>4</sup> However, Banerji (2005) finds a weak relationship between inflation and the nominal unit labour cost, using the Bry-Boschan peak-trough procedure on the six-month smoothed annualised rate of growth in the CPI and the unit labour cost (as well as the employment cost and the average hourly earnings indices). Banerji concludes that labour cost inflation cannot be relied upon as an accurate predictor of cyclical movements in general consumer price inflation.

prices, and here we witnessed rising inflation over this period. In contrast, during 2008 when the real unit labour cost was rising again as productivity grew at a negative rate in the fourth quarter following a significant slowdown in the world economy, firms were unlikely to raise their prices even though the real unit labour cost was on the rise, but instead cut employment in order to reduce labour costs. Here we see that there are other factors at play that can affect the pass-through of labour market pressures onto prices, and simply looking at wages will not be enough.

Figure 5

### Wage, productivity, unit labour cost and inflation



Sources: National Economic and Social Development Board; National Statistics Office; authors' calculation.

**Minimum wage.** Another important indicator of labour market pressures is minimum wage. Although only 7% of the labour force actually earn the minimum wage, the rest earn wages that move in line with movements of the minimum wage to some extent. The Central Wage Committee is a tripartite minimum-wage setting panel consisting of employers, employees and state authorities (including a representative from the central bank). The collective bargaining process reveals an important feature of the wage-setting process in Thailand that is rather backward looking: the minimum wage is generally adjusted only once a year and is indexed to the previous year's inflation rate. Even in the periods of high inflation such as during 1994–96 and 2008, wage setting is still conducted in a backward-looking manner (although resetting can occur during the year). In terms of the pricing power of labour, wage setters in Thailand do not have much bargaining power, in part because of the presence of (illegal) foreign labour and weak labour unions. Regulation by the authority features prominently in Thailand to the extent that only part of requested increase in wages is granted by the tripartite committee.

#### 4.4. Measuring and assessing inflation expectations

Inflation expectations of households and firms are a key factor in determining the actual behaviour of inflation. As inflation results from the aggregate consequences of purposeful price-setting decisions by forward-looking firms, today's inflation depends critically on current marginal cost and particularly on expected future inflation. Given that the traditional Phillips

curve explains only a modest part of inflation fluctuations, policymakers have focused on measuring and assessing inflation expectations.<sup>5</sup>

In Thailand, we primarily rely on two sources in assessing inflation expectations, namely, surveys of businesses, and information gathered from financial markets. With regard to survey-based measures of expectations, there are two important points are. First, respondents appear to give estimates based on recent and past inflation instead of future inflation; such behaviour in effect gives rise to expectations that are formed in a rather backward-looking manner. Second, the survey previously asked respondents about the range in which year-ahead inflation was expected to lie so as to facilitate responses. Given an important drawback that the only information we gain from the survey is how the proportions of firms with different inflation projections change (see figure 6), we have recently modified survey questions to elicit specific point estimates and hope to obtain a more accurate measure of inflation expectations.

With regard to measures of inflation expectations based on information from the financial markets, we look at movements of implied forward interest rates as indicators of changes in financial market expectations of future inflation. We estimate the term structure of interest rates using government bond yields; the estimated term structure allows us to extract the implied forward rates at various points in the future. By assuming in the following equation

$$\Delta i_t = \Delta r_t + \Delta \pi_t^e + \Delta \eta_t$$

that real interest rates are stable ( $\Delta r_t = 0$ ) and that changes in the risk premium are relatively small ( $\Delta \eta_t = 0$ ) in the long end, changes in the implied forward curve in the long end can be taken to approximate changes in inflation expectations ( $\Delta i_t = \Delta \pi_t^e$ ).

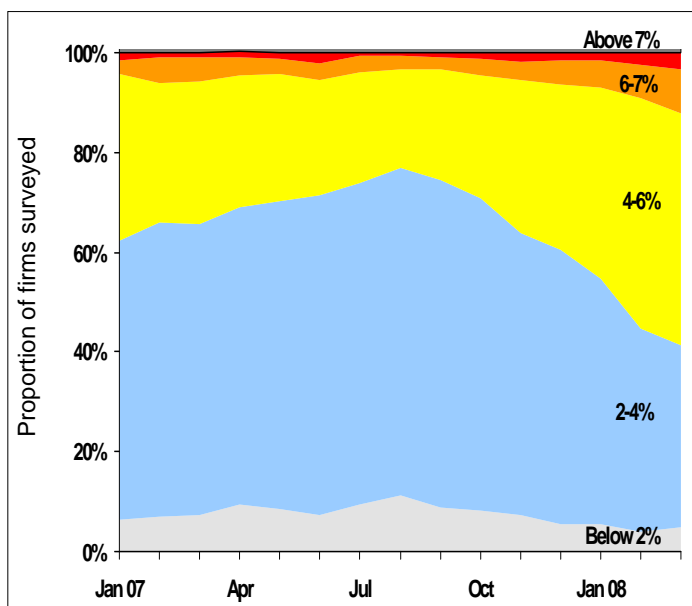
How the above inflation expectations indicators are used in the conduct of monetary policy can be illustrated as follows. During the first half of 2008 when commodity prices were on the rise, figures 6 and 7 show that, although the survey-based one-year-ahead inflation expectations are found to be increased in line with inflation at that time, the long-term inflation expectations from the implied forward curve remain mostly unchanged.

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<sup>5</sup> Inflation expectations also have the potential to affect inflation persistence. Once instance is during 1971–76, when the increase in inflation in Thailand was due to temporary supply shocks. However, inflation continued to be elevated for several subsequent years over 1977–80. Khemangorn et al (2008) find that such a persistent effect was in part explained by a monetary policy that was too accommodating at the time, owing to the pegged exchange rate regime that obliged domestic monetary policy to follow the loose monetary policy stance of the United States. Their finding, based on a Taylor-type rule, shows that inflation persistence tends to increase in an environment of too loose a monetary policy.

Figure 6

**Survey-based one-year-ahead inflation expectations**

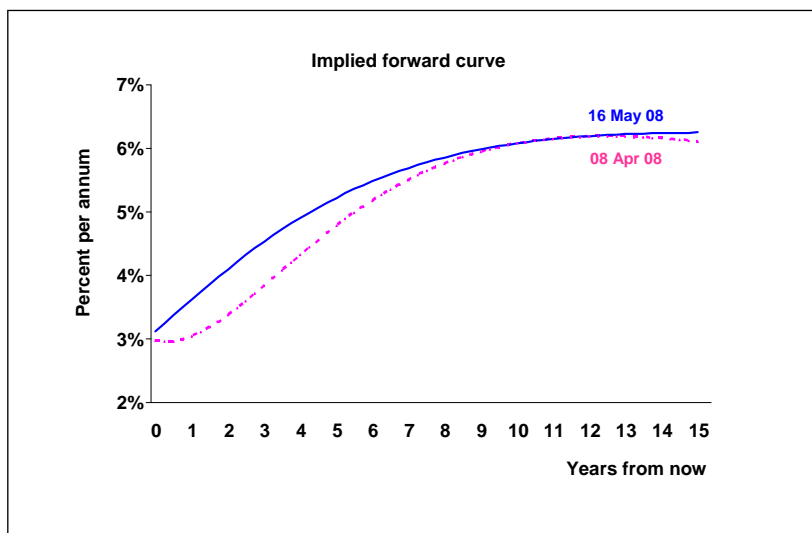


Remark: Different shades denote different ranges of inflation expectations.

Source: Bank of Thailand.

Figure 7

**Market-implied inflation expectations**



Source: Calculation by Bank of Thailand staff.

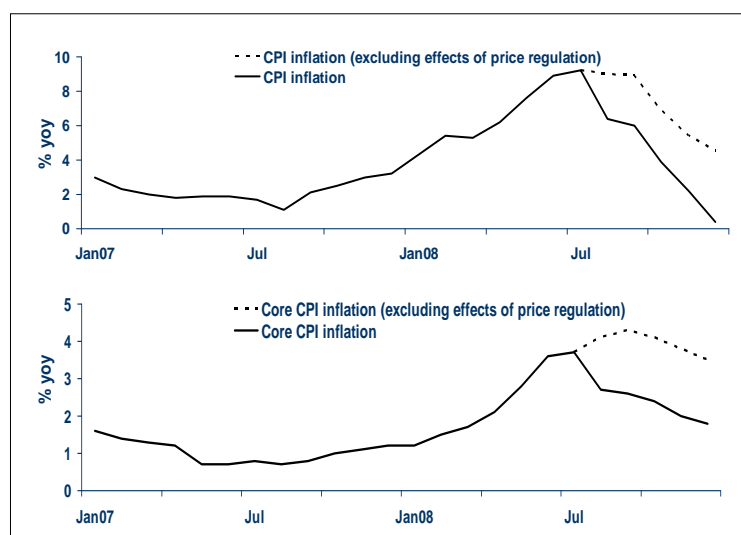
**5. An outstanding issue in Thailand: price regulation**

In addition to closely monitoring the prices of over 200 items in both the consumer and producer baskets since 2005, with the weights of the regulated items in CPI and core CPI baskets at around one third, the Thai government subsequently introduced a new package of six measures designed to benefit low-income households, effective from August 2008. These

measures essentially entail free or reduced prices in household use of tap water, electricity and public transport if consumed within certain limits, with the government taking up the shortfall in revenues. While the weights of these utilities in the CPI and the core CPI baskets – approximately 9% and 2%, respectively – may look like a small portion in the baskets, but when those prices are reduced by 36–100%, the impacts of these government measures can be significant, with the CPI and the core CPI falling immediately by 3.4 and 1.7 percentage points in August 2008 on a year-on-year basis.

An important implication for the conduct of monetary policy of these government measures is that the monetary authority needs to look for appropriate measures of underlying inflationary pressures. The above government intervention inevitably obscures measures of broad inflationary pressures and confounds seasonal patterns in various prices – the latter in effect distorts the construction of underlying inflation indicators. The Bank of Thailand consequently excludes the effects of these regulated prices and finds that, in the absence of government measures, CPI and core CPI inflation are significantly higher as shown in figure 8. At the same time, the trimmed mean and Kalman-filtered inflation measures appear to provide a more accurate picture of underlying inflationary pressures, which is not distorted by artificial reduction in prices controlled by the authority.

Figure 8  
Price regulation and inflation



Sources: Ministry of Commerce; Bank of Thailand; authors' calculation.

## 6. Conclusions

In the New Keynesian framework, monetary policy has a unique role in rectifying resource misallocation caused by price rigidity. Given that firms cannot adjust their prices as often as they wish, the average markup will vary over time in response to shocks and can thus be different from the optimal markup firms would want to charge if prices were flexible. Consequently, given the predetermined prices, the goal of monetary policy is to stabilise the current value and the future path of marginal cost at a level consistent with firms' optimal markup. If that policy is credible, no firm will have an incentive to change their prices regardless of whether they have the opportunity to do so, because they are effectively charging their optimal markup now, thanks to monetary policy, and will continue to do so

indefinitely. As a result, the aggregate price level is fully stabilised. Price stability is thus closely associated with optimality at the micro level and the attainment of the efficient allocation.

In theory, with regard to the appropriate inflation stabilisation policy – stabilising core inflation versus headline inflation, domestic inflation versus overall inflation, price inflation versus wage inflation – theory broadly suggests that optimal monetary policy should stabilise inflation in the sticky-price sector, because this is where the restriction of price adjustments that is the source of allocatory inefficiency lies. Consequently, much of the literature points to stabilising core inflation in the closed economy, stabilising domestic inflation in the open economy, and stabilising a combination of price and wage inflation if there are nominal rigidities in both goods and labour markets. Nevertheless, it is important to keep in mind that these theoretical results depend on the model setups and the associated assumptions. For instance, in the open-economy context, if full and immediate exchange rate pass-through is assumed, stabilising domestic inflation is a better policy. When this assumption is relaxed so that import prices become sticky, there are now inefficiencies in the markets for imported goods as well as domestic goods. In this environment monetary policy should stabilise prices in both markets by targeting overall inflation. In the end, regardless of the setup and model assumptions, the gist of optimal policy is that the monetary authority should stabilise the inflation measure corresponding to where price rigidity is located.

In practice, once the monetary authority chooses a preferred gauge on inflation, which reflects as far as possible the persistent component of inflation, as policy target to anchor expectations, it also considers a variety of inflation measures as supplementary indicators of price pressures. As is well known, there is no single indicator that corresponds perfectly to what the central bank considers to be inflation in the sticky-price sector(s) according to theory. The Bank of Thailand recognises the limitations of core inflation. Furthermore, even though we have been monitoring a number of underlying inflation indicators, there are several factors that have the potential to influence inflation dynamics, and they are consequently under our careful observation. We also keep a close watch on changes in equity and bond prices as well as real estate prices – because such asset prices potentially provide useful information about the inflation outlook – and also on the expansion in credits as this in turn facilitates increases in asset prices. In summary, while our evaluation of inflation pressures primarily focuses on developments of a measure that we consider to best reflect underlying price pressures on average, we are aware of and keep ourselves alert to a variety of prices and costs that directly or indirectly indicate pressures in the economy, to ensure that our commitment to maintaining price stability is fulfilled to the best of our ability.

## Appendix: Consumer price index in Thailand

**Methodology.** The consumer price index (CPI) and the core consumer price index (core CPI) are published by the Bureau of Trade and Economic Indices of the Ministry of Commerce on a monthly basis, and are usually released on the first working day of the following month. The core CPI is defined as the CPI excluding unprocessed food and energy prices.

The Bureau constructs the CPI as a fixed-weight average of prices of individual goods and services using a Laspeyres formula. In general, the CPI measures the change in the price of goods and services purchased by representative households in some base period. The base period is generally updated every four years. Inflation figures released since January 2004 are based on consumption patterns in 2002, with the weights used in the construction of the CPI obtained from the National Statistical Office based on a household expenditure survey. The new CPI series based on consumption patterns in 2006 will soon be released in the first half of 2009.

**Coverage.** The CPI and the core CPI cover 374 and 266 items, respectively. CPI and core CPI components are shown in Table A below.

Table A  
Disaggregated components in the CPI and the core CPI

Components	Weight	
	CPI	Core CPI
1. Food and beverages	36.06	
2. Apparel and footwear	3.40	
3. Housing and furnishing	23.86	
4. Medical and personal care	6.04	
5. Transport and communications	21.98	
6. Recreation and education	5.82	
7. Tobacco and alcoholic beverages	2.83	
<b>Total</b>	<b>100.0</b>	<b>75.95</b>

The overall CPI basket can also be classified into three categories: unprocessed food, energy items, and core CPI with the weights of 15.00%, 9.05%, and 75.95% respectively. Unprocessed food consists of four subcategories: (1) rice, flour and cereal products; (2) meat, poultry and fish; (3) eggs and dairy products; and (4) fruit and vegetables. Energy consists of three subcategories: (1) fuel; (2) cooking gas; and (3) electricity.

**Caveats.** As is well known, the CPI is arguably biased. One instance is substitution bias coming from the Laspeyres formula. The formula assumes that households must purchase the same basket of products as surveyed in the base period – which is not necessarily true when households substitute away from the higher-priced products. Another instance of bias in the CPI arises when new products enter the market, as they will not be incorporated into the CPI calculation until the CPI basket has been updated. This type of bias is known as new product bias. Other types of bias are outlet substitution bias and quality bias; see a classic



study by Boskin et al (1996) for further details. The size of bias partly depends on how frequently the basket has been updated: the longer the time between the revisions of the basket, the more severe the bias. The consensus in international findings is that the size of bias is quite small, but most central banks, including the Bank of Thailand, are still interested in finding the size of bias precisely in order to measure inflation as accurately as possible.

## Technical notes

i One may wonder how exactly inflation affects a household's welfare, given that the arguments of household utility functions generally are assumed to be the *quantities* of various goods and services, but not their *prices*. A second-order Taylor expansion of the household's utility around a steady state with constant prices yields the household's welfare loss, which is a function of variations in a measure of real activity (ie the output gap) and the cross-sectional variance of relative prices – the latter can be shown to increase with inflation. The welfare loss function can be written algebraically as

$$\begin{aligned} \mathcal{W} &= \frac{1}{2} E_0 \sum_{t=0}^{\infty} \beta^t \left[ \left( \sigma + \frac{\varphi + \alpha}{1 - \alpha} \right) x_t^2 + \frac{\varepsilon}{\Theta} \text{var}(p_{i,t}) \right] \\ &= \frac{1}{2} E_0 \sum_{t=0}^{\infty} \beta^t \left[ \left( \sigma + \frac{\varphi + \alpha}{1 - \alpha} \right) x_t^2 + \frac{\varepsilon}{\lambda} \pi_t^2 \right] \end{aligned}$$

where the second equation uses the fact that price dispersion is directly related to inflation. Focusing on the inflation term, welfare loss is increasing in the elasticity substitution among different goods ( $\varepsilon$ ) and in the degree of price rigidity (which is inversely related to  $\lambda$ ). Intuitively, given price dispersions, the more easily goods can be substituted for each other, the stronger the degree of resource misallocation and the higher the welfare loss. Second, the more strongly prices change, the higher the degree of price dispersions, as prices fail to adjust in tandem, leading to a higher welfare loss. As a result, the desirability of minimising relative price distortions provides a key rationale for monetary policy to promote price stability by targeting inflation.

ii Consider a *structural* environment in which firms find it costly to change prices. These firms normally have to stick with “pre-fixed” prices until they have an opportunity to adjust them. Consequently, the *aggregate* price level today will depend on last period's aggregate price level and today's new prices set by those firms that are allowed to change their prices. In other words, there is persistence in the aggregate price level, and this persistence comes from structural inability to change prices freely in response to shocks at any date and state. To maximise a stream of expected future profits, the “rigid-price” firms, when they can, decide on new prices, taking as givens the prices of all other goods, aggregate demand, and the real disturbances.

Consider now the world in which there is zero inflation *on average*. In this case, when these rigid-price firms actually get a chance to change their prices, it turns out that they will voluntarily maintain their prices at the average of existing prices. They do this only when they can operate in the consistent belief that, on average, other firms behave similarly by keeping their prices unchanged. In aggregate, then, the average of existing prices never changes and so the new “sticky” prices chosen will be the same prevailing prices, thereby keeping the general price level unchanged. In the absence of price dispersion, the relative prices among various goods and services are not distorted, and resources can be efficiently allocated even when certain prices cannot instantaneously change in response to shocks.

iii Aoki (2001) and Woodford (2003) use a two-sector dynamic stochastic general equilibrium model in which prices are fully flexible in one sector but sticky in the other to show that the period loss function depends on variations in (1) the rate of inflation in each sector individually; (2) the deviation of the output gap from its efficient level; and (3) the deviation of the relative price between the two sectors from its natural (ie efficient or flexible-price) counterpart:

$$L_t = \sum_{j=1}^2 w_j \pi_{jt}^2 + \lambda_x (x_t - x^*)^2 + \lambda_R (p_{Rt} - p_{Rt}^n)^2$$

where

$$w_j = \frac{n_j}{\kappa_j} (n_1 \kappa_1^{-1} + n_2 \kappa_2^{-1})^{-1}$$

Here  $w_j$ , the weight given to the inflation variation in sector  $j$ , is increasing in  $n_j$  (the share of sector  $j$  in national income) but decreasing in  $\kappa_j$  (a smaller value of which indicates a higher degree of price rigidity). It can be shown that a policy that completely stabilises the price index for the sticky-price sector is optimal, because it achieves the same allocation of resources as would occur under price flexibility. However, *such a policy does not completely stabilise the broader price index. This is because for the relative price,  $p_{Rt}$ , to track the natural counterpart while the sticky-price index remains constant, there must be a variable inflation rate in the flexible-price sector insofar as the natural relative price is a function solely of exogenous disturbances.*

iv

A second-order approximation to the welfare of the representative household in Gali and Monacelli (2005) yields a period welfare loss that is a function of the variances in the domestic output gap and inflation in the home country:

$$L_t = \frac{1}{2} (1 - \alpha) \left[ (1 + \varphi) x_t^2 + \frac{\varepsilon}{\lambda} \pi_{H,t}^2 \right]$$

This welfare loss function is almost identical to the closed economy counterpart given in endnote 1, except that domestic inflation, not the overall inflation, being the relevant inflation variable. It should be noted that in the present model several parameters are assumed to take certain values (including the coefficient of relative risk aversion ( $\sigma$ ), which is set to 1) so that a second-order approximation to welfare can easily be derived analytically. Furthermore, Gali and Monacelli also abstract from several channels that may potentially render a strict domestic inflation targeting policy suboptimal (eg imperfect pass-through).

v

The mechanics underlying Erceg, Henderson and Levin (2000) can be described as follows. A second-order Taylor approximation to the household's lifetime utility yields a welfare loss:

$$\mathcal{W} = \frac{1}{2} E_0 \sum_{t=0}^{\infty} \beta^t \left[ \left( \sigma + \frac{\varphi + \alpha}{1 - \alpha} \right) x_t^2 + \frac{\varepsilon_p}{\lambda_p} (\pi_t^p)^2 + (1 - \alpha) \frac{\varepsilon_w}{\lambda_w} (\pi_t^w)^2 \right]$$

The presence of sticky wages implies an additional welfare loss that arises because of fluctuations in wage inflation. In the last term of the above expression the contribution of wage inflation volatility to welfare loss is increasing in the elasticity of output with respect to labour input ( $1 - \alpha$ ), the elasticity of substitution among labour types ( $\varepsilon_w$ ), and the wage stickiness (which is inversely related to  $\lambda_w$ ). Given the above welfare loss function, for a certain parameterisation so that an analytical solution exists, the optimal policy is to target a weighted average of price and wage inflation defined as

$$\pi_t \equiv (1 - \vartheta) \pi_t^p + \vartheta \pi_t^w$$

where

$$\vartheta = \frac{\lambda_p}{\lambda_p + \lambda_w}$$

is the weight on wage inflation, which is increasing in the degree of wage rigidity.

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# Difficulties in inflation measurement and monetary policy in emerging market economies

Mehmet Yörükoğlu<sup>1</sup>

## Introduction

Making sound monetary policy in an economy requires good understanding of the inflation-unemployment and inflation-growth rate relationships. Similarly, the output growth-interest rate trade-off should be well understood to establish an appropriate Taylor rule. The prerequisite to all of these is having a perspective on the stable growth potential for the economy. However, for emerging market economies (EMEs) potential growth is hard to determine, due to the Solow's convergence process in general, and to the computing and information technology (CIT) growth wave that the world economy has been experiencing for a while.

Another great challenge for monetary policy in emerging market economies is the measurement of the inflation itself. It is now well known that there are potential upward biases in measurement of inflation. We think that at least three of these biases are significant: quality measurement bias, outlet substitution bias, and new goods bias. There are now numerous empirical studies attempting to quantify these biases for advanced economies. The results give a range of 0.5–2.0% under measurement of inflation due to these biases in advanced economies. In this paper we argue that, although it has not been sufficiently studied empirically, these biases may potentially be more important for EMEs.

The historical process that EMEs are currently experiencing through technological catch-up, convergence and urbanisation etc has a potential to magnify these biases. For instance, during the catching-up process, the emerging economy grows rapidly in both the quantity and quality dimensions. If some of these improvements in the quality dimension go unmeasured (as a significant proportion of it probably will be), this will create an upward bias in the measurement of inflation. If we assume that growth in quality is proportional to growth in quantity, and the fraction of quality improvements unmeasured is constant, then this bias will be proportional to the measured growth rate of the economy. Therefore, we can expect the quality measurement bias to be more significant for EMEs than for the advanced economies.

An important change taking place in developing economies is a rapid evolution of the basic structure of commerce. Historically, small, labour-intensive traditional shops have dominated commerce in developing economies, but that is rapidly changing. More capital-intensive supermarkets, megamarkets and big shopping centres are spreading at a dramatic speed. In developing economies, more and more people are shopping in these centres, which offer not only a higher-quality shopping experience but also other services and conveniences such as the use of credit cards, and savings of time for the customer. However, at the same time, large fixed costs are incurred in establishing these centres. The extra service value and value of time saving offered are not internalised by the inflation and output statistics. Hence, the price difference between traditional small shops and big shopping centres are accounted as an increase in price level. Note that after diffusion matures, this creates a one-time increase in the price level; in other words, it does not create a permanent increase in

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inflation. This is probably more or less the case for advanced economies, where diffusion of shopping to these centres has come to halt and the composition of trade has matured and stabilised. However, for EMEs, the diffusion is increasing rapidly, and as long as it continues this will create an upward bias in inflation measurement.

A significant driver of growth is the introduction of new goods into the economy. Studies show that the importance of new goods for growth is increasing. Introduction of new goods creates bias in inflation measurement mainly through two channels. First, the introduction of a previously nonexistent good increases the welfare of consumers, which is not captured in inflation measured. Second, after introduction of a new good, its price declines rapidly due to learning-by-doing, technological progress, and increased competition created by the entries of new firms (brands) into the market. However, many of these new goods will never be significant enough to become part of the consumer basket used to measure inflation. For these goods, their price decline after introduction will not be captured by the measured inflation. Even for the new goods that will eventually become significant enough to enter the CPI basket, it will take time. Again, up to this point the decline in prices will not be captured despite the fact that a significant proportion of price declines occur during this phase of the goods' life cycle. There is an asymmetry here, between advanced and developing economies. New goods' diffusion speed and income level are positively related. In other words, new goods diffuse faster among high-income groups. If we extend this across countries, a successful new good, since it diffuses more rapidly in high-income country, becomes part of high-income countries' CPI basket sooner. Therefore a larger fraction of total price declines in the life cycle of this new good is accounted in the high-income country compared to the low income one. Thus, new good bias in inflation measurement is likely to be more important in developing countries.

Another difficulty related to monetary policy and inflation targeting in developing economies is a by-product of the global convergence process. The weight of food and agricultural products in CPI baskets of developing economies is still very significant. Furthermore, the income elasticity of food demand in these countries is still very large. Therefore, when these economies grow at an unprecedentedly rapid pace, global demand for food increases drastically, putting an upward pressure on world food prices. Unlike demand, the supply of food is not that elastic. This is again due to convergence dynamics. Labour productivity in agriculture in developing economies is much smaller than in industries in these economies. During convergence, urbanisation rapidly increases and, because of labour productivity, differential labour migrates from agriculture towards industries. Agricultural land use is also declining because of the urbanisation and industrialisation processes. In these countries, unlike advanced economies, agriculture is not capital intensive and historical total factor productivity (TFP) growth in agriculture is very poor. These together imply that in the mid-term, as industrialisation and urbanisation continues in these countries, supply of food will not be elastic to price increases unless significant TFP growth is not attained in agricultural output.

## **1. Uncertainty about the growth potential**

Solow's convergence process is well known. In this paper, I consider the CIT growth wave and show, as an example, how CIT growth wave might affect macroeconomic variables in Turkey as an EME, concluding with a discussion of the potential implications for monetary policy.

As is well known, assuming capital mobility, Solow's model implies that capital should flow to locations where it will have highest return. As a result, capital should flow from initially richer countries to poorer ones so that returns are equalised across countries. Hence, during this process poorer countries grow faster, and their output growth rates decline through time as



they converge to richer ones. Finally, today, we can say that Solow's convergence process has started to work, at least for EMEs. With the recent sound and liberal macro- and microeconomic policies coupled with positive global financial conditions, we are experiencing convergence process-like behaviour in EMEs.

But a challenge for monetary policy arises here, since these countries' growth potential becomes more uncertain as convergence works. Consider hypothetical Phillips curves for emerging market economies and advanced economies. During convergence with higher growth potential, EMEs enjoy more favourable Phillips curves with lower unemployment rates for a given level of inflation. However, where these Phillips curves are really located is more uncertain for EMEs than for advanced economies. In addition, as the convergence process operates, these curves will probably shift in a more or less uncertain manner for EMEs.

Similarly, now consider hypothetical Taylor rules, again for EMEs and advanced economies. *Ceteris paribus*, EMEs can afford to have higher real interest rates, and yet enjoy the same level of growth rate as the advanced economies. Again, however, where these Taylor rules are really located is more uncertain for EMEs than for advanced economies.

Now, on top of this convergence process, EMEs have started to feel the effects of the so-called CIT growth wave on their macroeconomic variables. The developed countries that are close to the world technological frontier experienced these effects much earlier, as they adopted these new technologies earlier. Studies show that the macroeconomic effects of CIT diffusion in these countries have been quite significant.

What is the CIT growth wave? Usually, new technologies are not significant enough individually to produce significant macroeconomic effects. However, once in a while, there is a breakthrough new technology (a general-purpose technology, or GPT) that will have significant macroeconomic effects. The steam engine during industrial revolution of the 1760s, the electrical dynamo at the turn of the 20th century, and CIT since 1970s are commonly accepted GPTs. A new wave of technology like CIT contributes significantly to economic growth during its diffusion. EMEs like Turkey are just at the rebound post of this new technology.

I would like to give more information on the observed macroeconomic effects of the CIT growth wave on the developed countries, and using a dynamic general equilibrium model calibrated to the Turkish economy I would like to elaborate on potential effects of this wave on Turkish economy in the future and discuss challenges and implications for monetary policy.

For developed countries, such as the United States, which are at the world technological frontier, the effects of the CIT growth wave started in the early 1970s. These countries experienced higher gross national product (GNP) and productivity growth rates, and faster-declining prices of goods intensive in CIT. For the developed economies, since this technological breakthrough took place unexpectedly, due to lack of human capital and know-how, the diffusion of this technology took longer. For EMEs, however, the diffusion has started later but is expected to be faster. Hence the effects on EMEs will most probably be magnified.

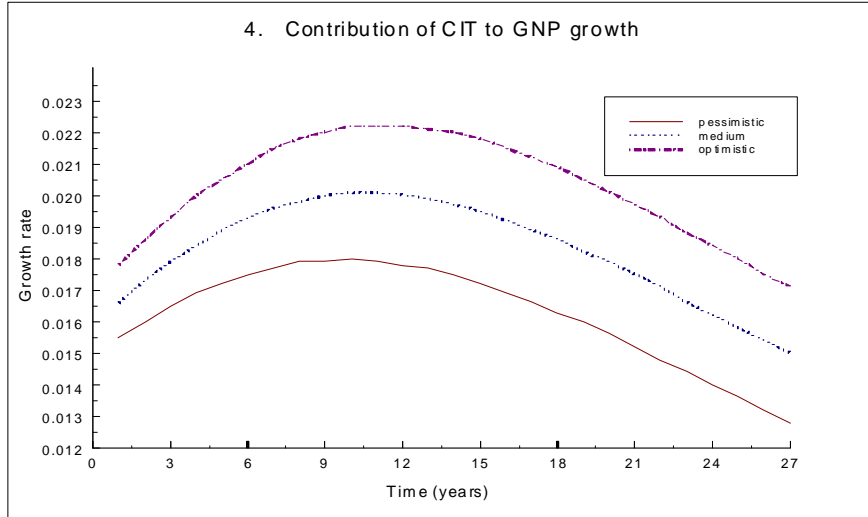
Yorukoglu (2005) uses a dynamic general equilibrium model calibrated to the Turkish economy as a laboratory to see the possible effects of CIT growth wave on the Turkish economy. In order to model and parameterise the hypothetical economy more realistically, cross-country CIT diffusion data are used. Yorukoglu shows that the most significant factors determining the CIT diffusion process are the average level of human capital, the relative price of capital goods, and the competitiveness index in a country.

Figure 1 plots the contribution of CIT to GNP growth in Turkey under optimistic, base, and pessimist scenarios. CIT's contribution to growth in the next 20 years will be very significant.

Figure 1



# Contribution of CIT to GNP growth



- Optimistic scenario:
  - growth rate of human capital is 4% a year,
  - relative price of capital goods declines at 3% a year,
- Medium scenario:
  - growth rate of human capital is 3% a year,
  - relative price of capital goods declines at 2% a year,
- Pessimist scenario:
  - growth rate of human capital is 4% a year,
  - relative price of capital goods declines at 2% a year.

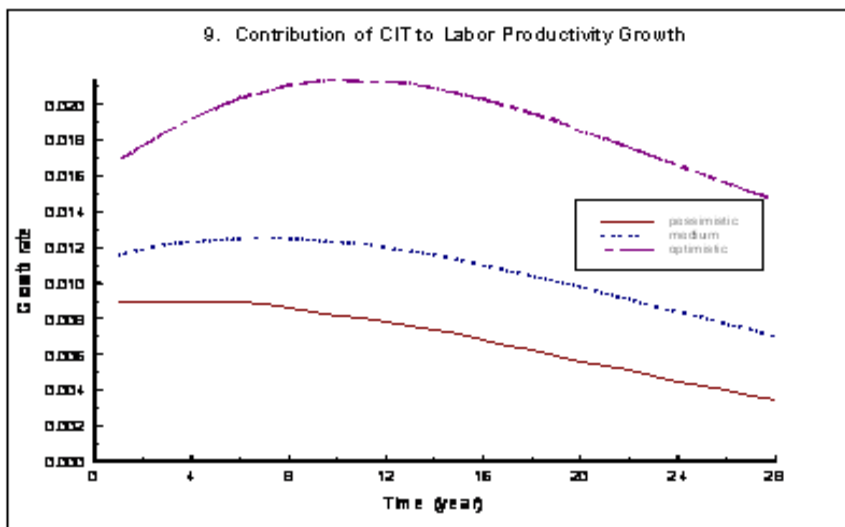
Figure 2 illustrates the contribution of CIT to labour productivity growth in the next 20 years. CIT will make a very important contribution to labour productivity in the future, but the level of this contribution will depend on the unravelling fundamentals in the scenarios.

Making monetary policy in an economy that is on the convergence path coinciding with the CIT growth wave is a challenge since the potential growth rate is quite uncertain under these circumstances.

Figure 2



# Contribution of CIT to Labor Productivity Growth



## 2. Measurement bias in inflation in emerging market economies

Monetary policy and other important private and decisions and programmes take inflation measurement as an important input. Therefore, inflation indices are extremely important tools for economic analysis. For these economic decisions and analysis to be accurate and efficient, inflation measures should be accurate and reliable. There are at least three sources of measurement bias of inflation, namely quality (change) bias, new goods bias, and outlet substitution bias. Recent studies on measurement biases of inflation in some advanced economies show that these biases can be quite significant. For instance, Hausman (2002a) shows that for the United States, all these three biases have first-order effects on CPI measurement. In another paper he finds that many new products and services have a significant effect on consumer welfare. Hausman (2002b) estimates that the gain in consumer welfare from the introduction of the cellular telephone in the United States exceeded \$50 billion per year in 1994 and \$111 billion per year in 1999.

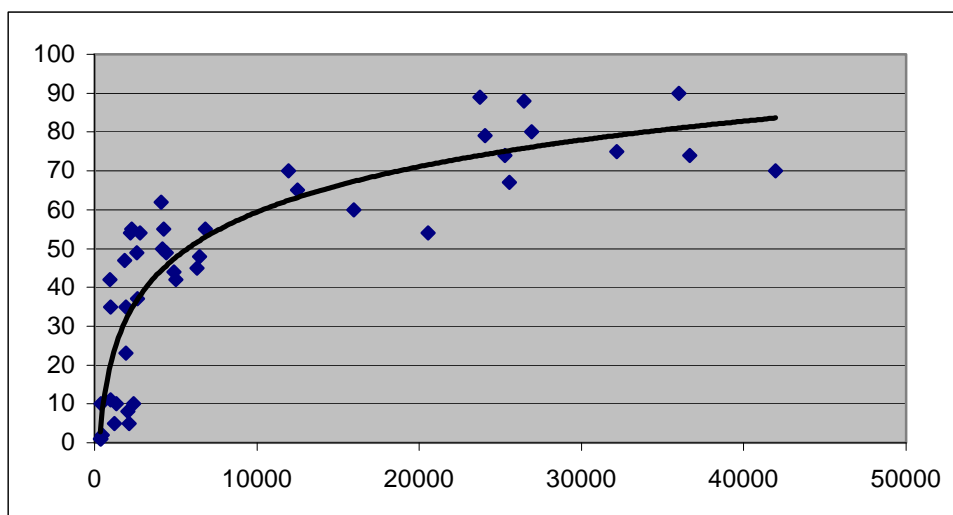
Costa (2001) and Hamilton (2001) estimate bias in the CPI by using expenditure survey data to estimate the increase in households' expenditures versus their real income over time. This procedure will capture outlet substitution bias but it will not measure either new goods bias or quality bias. Costa (2001) uses food and recreation expenditures. Using data from 1972–94 Costa finds that cumulative CPI bias during this period was 38.4% with an annual bias of 1.6% per year. Hamilton (2001) also estimates CPI bias to be 1.6% per year during this period, using a similar econometric approach on a different data set. The actual bias would be even greater if the effect of new goods bias and quality bias were included.

Similarly, Bills and Klenow (2001) find a significant estimate of quality bias over the period 1980–96. They estimate that the Bureau of Labor Statistics understated quality improvement and overstated inflation by 2.2% per year on products that constituted over 80% of US spending on consumer durables. These more aggregate studies along with microstudies on particular goods demonstrate that CPI bias is likely to be substantial.

The rapid spread of supermarkets and shopping centres in the developing world has a potential to magnify the outlet bias in inflation measurements studied earlier for advanced economies. Unlike the Wal-Mart phenomenon in the United States, these supermarkets and shopping centres provide customers with other services, which have not been available in traditional shopping, and therefore are on average more expensive. Historically, small, labour-intensive traditional shops have dominated trade in developing economies, but that is rapidly changing. More capital-intensive supermarkets, megamarkets and big shopping centres are spreading at a dramatic speed. Starting with rich individuals, in developing economies, more and more people are shopping in these centres, which offer not only a higher-quality shopping experience but also other services and conveniences, such as the use of credit cards, and savings of time for the customer. But, at the same time, since large fixed costs are incurred in establishing these centres, they sell at a mark-up. That is why the diffusion starts with the rich. The extra service value and the value of time-saving offered in these big shopping centres are not internalised by the inflation and output statistics. Hence the price difference between traditional small shops and these big shopping centres are accounted as an increase in price level. Note that after diffusion matures, this creates a one-time increase in the price level; in other words, it does not create a permanent increase in inflation. This is probably more or less the case for advanced economies, where diffusion of shopping at these centres came to halt and the composition of trade matured and stabilised. However for EMEs the diffusion is rapidly increasing, and as long as the diffusion continues, this will create an upward bias in inflation measurement. Many recent works in the literature have studied the rapid spread of supermarkets in developing and middle-income countries and forecast its continuation. Traill (2006) quantitatively models the level of supermarket penetration (share of the retail food market) on a cross section of 42 countries representing all stages of development. He finds that GDP per capita is very significant in explaining the cross-country variation in supermarket penetration; a 1% increase in per

capita GDP increases the penetration rate by around 0.37%. Income distribution, urbanisation, female labour force participation, and openness to inward foreign investment turn out to be very significant as well. The penetration rates are higher in countries where the labour force participation of females is higher. The greater the income inequality of a country, the higher the supermarket penetration rate is. Projections to 2015 suggest significant further penetration; increased openness and GDP growth are the most significant factors.

Figure 3  
Penetration rate of supermarkets



Note: x-axis per capita income, y-axis, percent of population.

Figure 3 plots the penetration rate of supermarkets vs per capita GDP in the country. Logarithm of the per capita GDP very successfully relates to the penetration rate.

Cunningham (1996) provides the following guesstimates of bias in the UK retail price index. Cunningham's guesstimate of total bias ranges 0.35–0.80. Table 1 is taken from Shiratsuka (1999), which provides guesstimates of bias in consumer indices for some advanced countries taken from different studies.

Table 1 Bias in the Consumer Price Index in Major Countries

Source of measurement error	United States	Japan	Germany	United Kingdom	Canada
Upper level substitution	0.15	0.00	0.10	0.05–0.10	0.10
Lower level substitution	0.25	0.10			
New products/quality change	0.60	0.70	< 0.60	0.20–0.45	0.30
New outlets	0.10	0.10	< 0.10	0.10–0.25	0.07
Total	1.10 (0.80–1.60)	0.90 (0.35–2.00)	0.75 (0.50–1.50)	n.a. (0.35–0.80)	0.50

Note: "<" indicates estimated bias is lower than the figure in the table.

Sources: Advisory Commission to Study the Consumer Price Index (1996), Shiratsuka (1999), Hoffmann (1998), Cunningham (1996), Crawford (1996).

Although the bias in inflation measurement among EMEs has been studied little, in this paper we argue that the bias for these countries is potentially more significant. The historical process that EMEs are currently experiencing, through technological catch-up, convergence and urbanisation etc, has a potential to magnify these biases. For instance, during the catching-up process, the emerging economy grows rapidly in both the quantity and quality

dimensions. If some of these improvements in the quality dimension go unmeasured (as most of it probably will be), this will create an upward bias in the measurement of inflation. If we assume that growth in quality is proportional to growth in quantity, and the fraction of quality improvements unmeasured is constant, then this bias will be proportional to the measured growth rate of the economy. Therefore, we can expect the quality measurement bias to be more significant for EMEs than for the advanced economies.

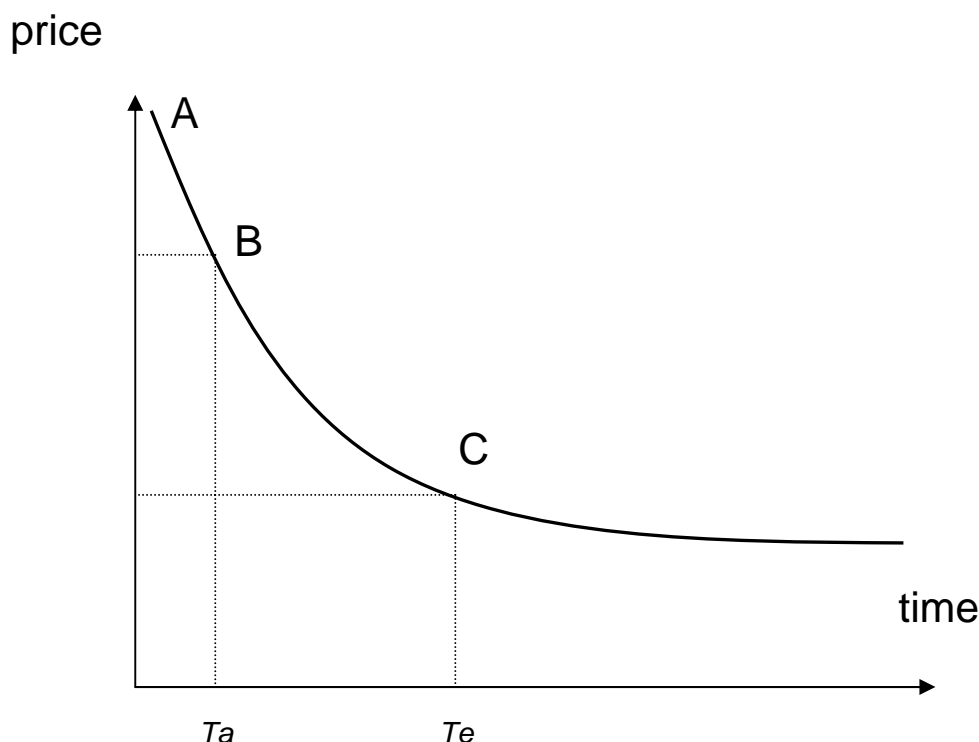
Consider the following growth model capturing an economic environment where individuals get utility from both quantity and quality of consumption. Let us assume that quality improvements and productivity of production in the quantity dimension are productive to a similar degree. In this environment, it is likely that a constant fraction of welfare growth will be due to quality improvements. It is also likely that quality growth will be proportional to overall output growth. Let us assume that a constant fraction of quality measurement goes unmeasured in the output and inflation statistics. Now, compare two economies, namely, low-growth and high-growth economies, and assume that growth rate ratio between these two countries is given by  $n$ . Then if the bias in inflation measurement due to unmeasured quality in the low-growth economy is  $x$ , the bias in high-growth economy will be  $nx$ . Now, as an example, let us take an average advanced economy growing at 2% a year, and an EME with a growth rate of 6%. Using the table above for advanced economies gives an average bias for advanced economies of 0.30. Our approach yields a bias of 0.9% for the EME.

Introduction of new goods creates a significant proportion of growth. Studies show that the importance of new goods for growth is increasing. Introduction of new goods creates bias in inflation measurement mainly through two channels. First, the introduction of a previously nonexistent good increases the welfare of consumers, which is not captured in inflation measured. Second, after introduction of a new good, its price declines rapidly due to learning-by-doing, technological progress, and increased competition created by the entries of new firms (brands) into the market. However, many of these new goods will never be significant enough to become part of the consumer basket used to measure inflation. For these goods, their price decline after introduction will not be captured by the measured inflation. Even for the new goods that will eventually become significant enough to enter the CPI basket, it will take time. Again, up to this point the declines in prices will not be captured despite of the fact that a significant proportion of price declines occur during this phase of the goods' life cycle. There is an asymmetry here, between advanced and developing economies. New goods' diffusion speed and income level are positively related. In other words new goods diffuse faster among high-income groups. If we extend this across countries, a successful new good, since it diffuses more rapidly in high-income country, becomes a part of high-income countries' CPI basket sooner. Therefore a larger fraction of total price declines in the life cycle of this new good is accounted in the high-income country compared to the low income one. Thus, new good bias in inflation measurement is likely to be more important in developing countries.

Figure 4 gives the new good's price decline curve after its introduction to the market. Here the new good is considered eventually to become significant enough in both advanced and EME economies so that it becomes a part of the CPI basket in both economies. The good is introduced to the market at point A. At point B, it becomes part of the advanced and economy's CPI basket. Similarly at C, it becomes part of the EME's CPI basket. In addition,  $T_a$  and  $T_e$  represent the time point at which this good becomes part of advanced and EMEs' CPI baskets, respectively.

Figure 4

**Price decline in new goods following introduction**



The decline in price between points A and B will not be taken into account in inflation measurements in the advanced country, whereas the price decline between points B and C will. However, for the EME, the price decline up to point C will be ignored by the inflation measurements. The time gap between  $T_a$  and  $T_e$  will crucially depend on the per capita income difference between these two countries. It will also depend on the average price decline rate between these two points. The greater the income difference, the larger the time gap will be. A higher average price decline rate between these two points will shorten the time gap.

### 3. Convergence and inflation dynamics

Another difficulty related to monetary policy and inflation targeting in developing economies, which has become quite significant recently, is a by-product of the global convergence process. The weight of food and agricultural products in CPI baskets of developing economies is still very significant. Furthermore, there is still great income elasticity of food demand in these countries. Therefore, when these economies grow at an unprecedentedly rapid pace, global demand for food increases drastically, putting an upward pressure on world food prices. Unlike demand, the supply of food is not so elastic. This is again due to convergence dynamics. Labour productivity in agriculture in developing economies is much smaller than in industries in these economies. During convergence, urbanisation rapidly increases and, because of labour productivity, differential labour migrates from agriculture towards industries. Agricultural land use also declines, because of the urbanisation and industrialisation processes. In these countries, unlike advanced economies, agriculture is not capital intensive and historical TFP growth in agriculture is very poor. These together imply that in the mid-term, as industrialisation and urbanisation continues in these countries, supply

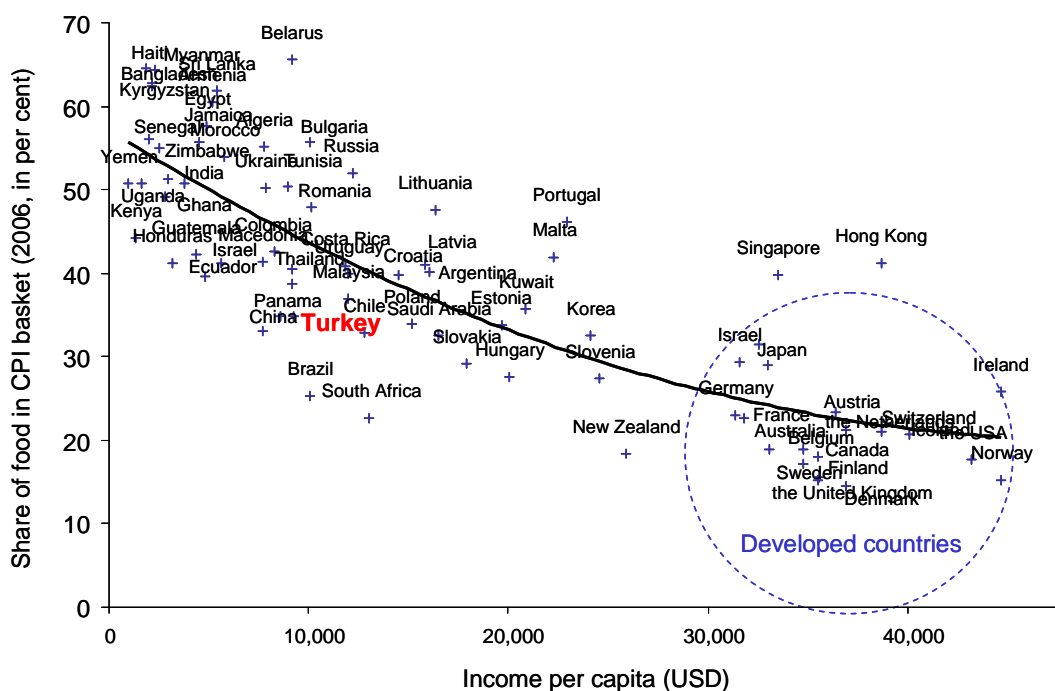
of food will not be elastic to price increases unless significant TFP growth is not attained in agricultural output.

Figure 5 plots share of food in CPI basket vs income per capita for the countries where these shares are available. It is clear that the share of food in CPI basket is significantly smaller in richer countries. We see, for instance, Bangladesh where the weight of food is more than 60%, and at the other extreme, the United States, where the weight is less than 15%.

Figure 5

**Share of food in CPI basket – income per capita**

Share of food in CPI basket (2006, in per cent)  
and income per capita (purchasing power parity, 2006, USD)



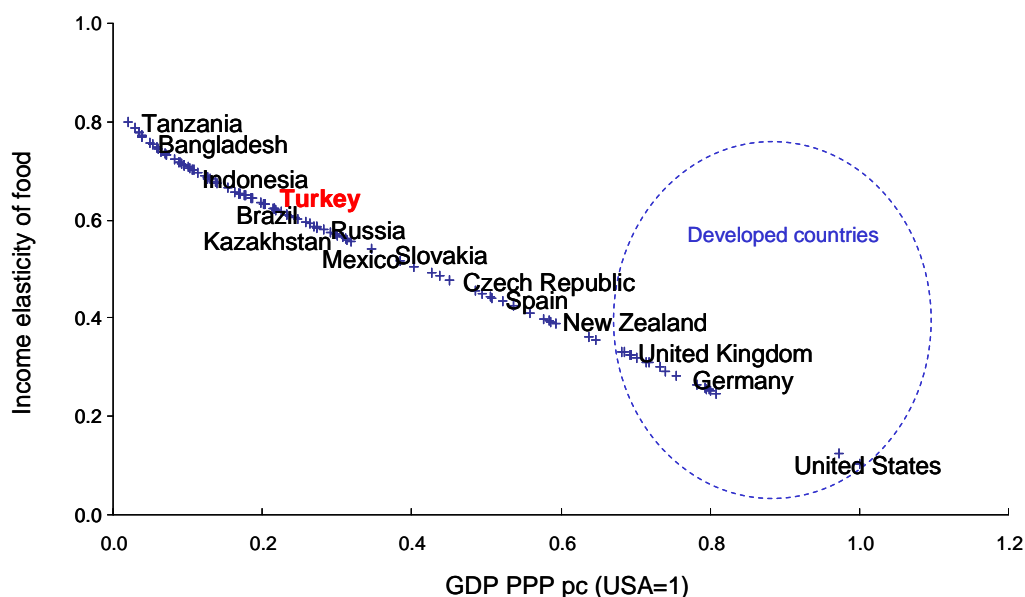
Source: ILO, CBT.

The income elasticity of food demand decreases significantly, as expected, as income per capita increases. Figure 6 shows that food demand in Bangladesh increases by more than 0.7% if income per capita increases by 1%.

Figure 6

### Income elasticity of food demand

Income elasticity of food and income per capita  
(purchasing power parity, 1996, USD)



Source: USDA, CBT.

At the other extreme is the United States, where demand for food increases by only around 0.1% when income increases by 1%. As expected, for all countries income elasticity of food demand is less than one. Hence food becomes less important in the CPI basket as a country becomes richer.

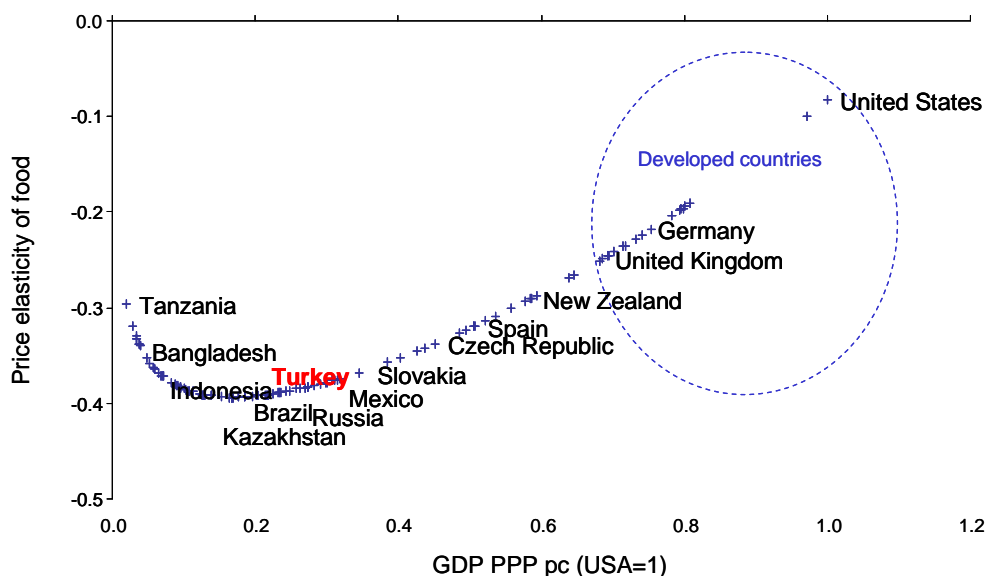
Figure 7 gives the price elasticity of food demand for different countries. These three graphs are consistent with the stylised facts about the economics of agriculture. First, income elasticity of food, although it varies significantly across sub categories, is less than one. For instance it is around 0.9 for meat and dairy products whereas it is only around 0.2–0.4 for cereals. These facts imply that to understand the change in the global demand for food, not the average growth in world income but the composition of world income is crucial. In other words whether the engine of growth in global economy is the advanced economies or the developing economies changes the global demand for food very significantly. Since absolute value of price elasticity of food demand is less than one, the equilibrium price of food will be very sensitive to supply-demand gaps. This is more significant for advanced economies like the United States.



Figure 7

**Price elasticity of food demand**

Price elasticity of food and income per capita  
(purchasing power parity, 1996, USD)



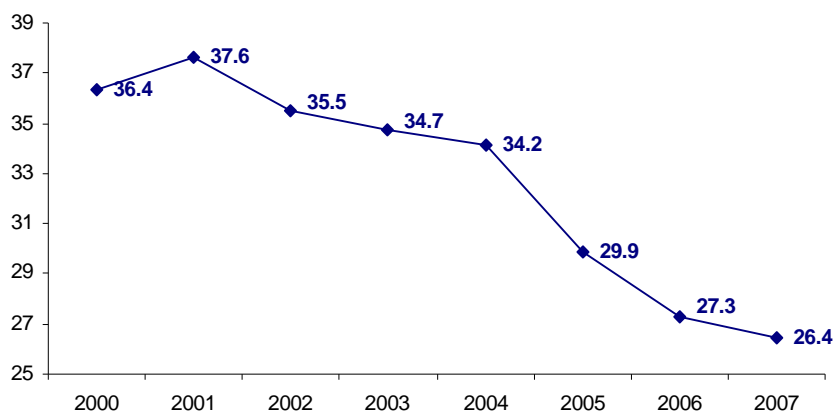
Source: USDA, CBT.

The stylised facts about the supply of food are also very asymmetric between advanced and emerging market economies. In advanced economies, agricultural production is capital intensive. Labour and land use in agriculture in advanced economies are also quite stable. TFP growth in agriculture in advanced economies is high and is generally above 1% a year. Unlike advanced economies, agriculture is labour intensive in developing economies. Land use and employment is rapidly shrinking due to industrialisation and urbanisation. TFP growth is slow; well below 1% a year. Another asymmetry between advanced and developing economies is that the labour productivity in agriculture compared to that in industries is significantly lower in developing economies. In advanced economies, labour productivity in these sectors are quite close to each other.

Figure 8

**Employment share of agriculture in Turkey**

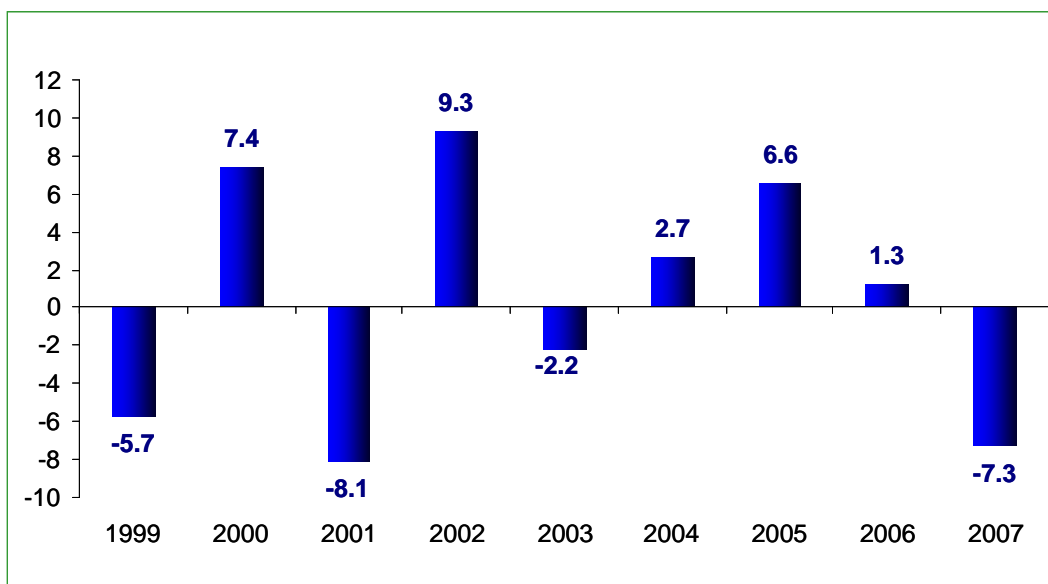
Agricultural employment/total employment (%)



Source: Turkstat.

The employment share of agriculture is shrinking rapidly in EMEs and labour is flowing from agriculture, where average labour productivity is lower than for manufacturing and services. Figure 8 presents the employment share of agriculture from 2000 to 2007. In just seven years, the employment share of agriculture declined from 37% to 27%. Although demand for food and agricultural products are growing significantly due to rapid income growth in EMEs, because of declining employment, land use and poor TFP growth in agriculture in these countries, the supply of food does not catch up. This, together with price-inelastic food demand, puts significant pressures on food prices locally and globally. As these fundamentals suggest, supply growth of food in Turkish economy has been poor in the last decade. Figure 9 plots the growth of agricultural output in Turkey from 1999 to 2007. Average growth rate in this period was 0.9% a year. There were large fluctuations in agricultural output in this period.

Figure 9  
**Growth of agricultural output in Turkey**  
 Agricultural output (real, % change)



Source: Turkstat.

During the convergence process, like other EMEs the Turkish economy has a high growth potential. Household income will grow rapidly on this path. Since income elasticity of food is still significant for EMEs like Turkey, demand for food will also grow. However, the supply of food is not growing that rapidly because of the reasons discussed. Therefore, during the convergence process there will be an upward pressure on food prices in Turkey. To quantify these pressures let us construct a simple model and see the amount of relative price increase this model will imply in equilibrium, given these fundamentals in the Turkish economy. For simplicity let us assume that the Turkish economy is a closed economy for agricultural products. This simple model is given below. Agricultural output function is assumed to be of Cobb-Douglas form. Given this production function, the growth of agricultural products reads as in (1). Let us assume that growth of demand is given by (2). Calibrating for Turkey yields that for the agricultural product market to clear, the relative price of food has to increase by 8.25% a year. This back-of-the-envelope analysis assumes historical input and TFP growth rates on the supply side. To the extent that TFP and input growth are price elastic, this simple analysis overstates the necessary relative price adjustment. However, recent evidence suggests that agricultural output supply in developing countries is not responding strongly enough to price increases. Figure 10 illustrates the

supply response to high prices between 2007 and 2008 in developed and developing economies. Between 2007 and 2008 when food prices increased rapidly, the agricultural output increased by 9.7% in developed economies, whereas it increased by only around 0.9% in developing economies. Another simplification that this model assumes is that the country is a closed economy. In reality, if due to high demand the relative price of food increases at home, the country could import food from abroad, thus eliminating the upward pressure on food prices. However, 4 billion people in the world are emerging at the same time putting similar price pressures globally. Therefore, assuming a closed economy may not be too restrictive.

Figure 10  
A simple model

**Agricultural production function:**  $Y_S = F(A, K, L, N) = AK^{\alpha_K} L^{\alpha_L} N^{1-\alpha_K-\alpha_L}$

$$\gamma_S = \gamma_A + \alpha_K \gamma_K + \alpha_L \gamma_L + (1 - \alpha_K - \alpha_L) \gamma_N \dots (1)$$

$$\gamma_D = \varphi_Y \gamma_Y + \varphi_P \bar{p}_A \dots (2)$$

$$\bar{p}_A = \frac{\gamma_D - \varphi_Y \gamma_Y}{\varphi_P} \dots (3)$$

<b>The Turkish Case:</b>		$\gamma_S = 1 + (0.2)4 + (0.5)(0) + 0.3(-3) = 0.9\%$ $\bar{p}_a = \frac{0.9 - 0.6(7\%)}{-0.4} = 8.25\%$	<b>Increase in relative prices of food products</b>
$\alpha_K = 0.2$	$\alpha_L = 0.5$		
$\gamma_K = 4\%$	$\gamma_L = 0\%$		
$\gamma_N = -3\%$	$\gamma_Y = 7\%$		
$\varphi_Y = 0.6$	$\varphi_P = -0.4$		

Now let us do the same exercise for the world economy. We have shares of food in CPI baskets, income and price elasticities of food for 93 countries. Assuming that food is totally and costlessly tradable across countries, and using historical TFP growth for agricultural production, growth in world food demand is computed. Based on the IMF's growth projections (as of May 2008) for these countries, world food demand growth projections are computed. Assuming that food is totally tradable, using food price elasticity data, the equilibrium relative price increase of food is calculated.

Figure 11

**Supply response to high prices  
mainly in developed countries...**

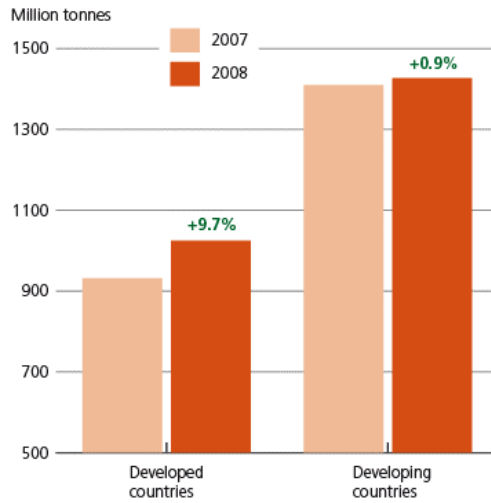


Figure 12

**Change in global food demand,  $D$ :** 
$$D = \frac{\sum_i D_i GDP_i}{\sum_i GDP_i}$$

**Change in food demand  $D_i$  of country  $i$ :** 
$$D_i = \rho_i g_i$$

**Key:**

- $D$ : Change in global food demand
- $D_i$ : Change in food demand  $D_i$  of country  $i$
- $GDP_i$ : GDP of country  $i$  (at market price in USD or at PPP)
- $\rho_i$ : Income elasticity of demand at country  $i$
- $g_i$ : Growth rate of country  $i$  at constant prices

**Note:**

Income elasticities for China and India are interpolated.

Figure 13

**Growth in world food demand**

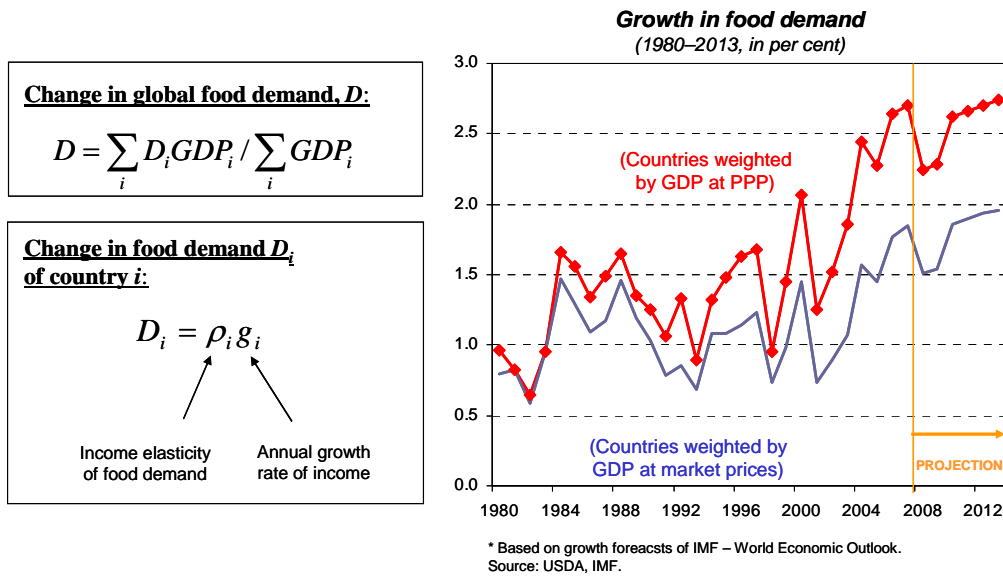


Figure 14

**Growth in world food demand**

	1980–99	2000–07	2008–13*
Growth in food demand (based on GDP at PPP)	1.27	2.10	2.54
Growth in food demand (based on GDP at market prices)	1.02	1.35	1.78

\* Based on growth forecasts of IMF – World Economic Outlook.

Based on GDP at PPP, world food demand will grow at a historically high rate of 2.54% a year from 2008 to 2013. If market prices are used, the growth rate becomes 1.78%. In that projected period, the resulting world relative price of food will increase at 6.18% a year based on PPP prices, and 3.22% a year based on market prices.

Figure 15

**Growth in relative prices of food**

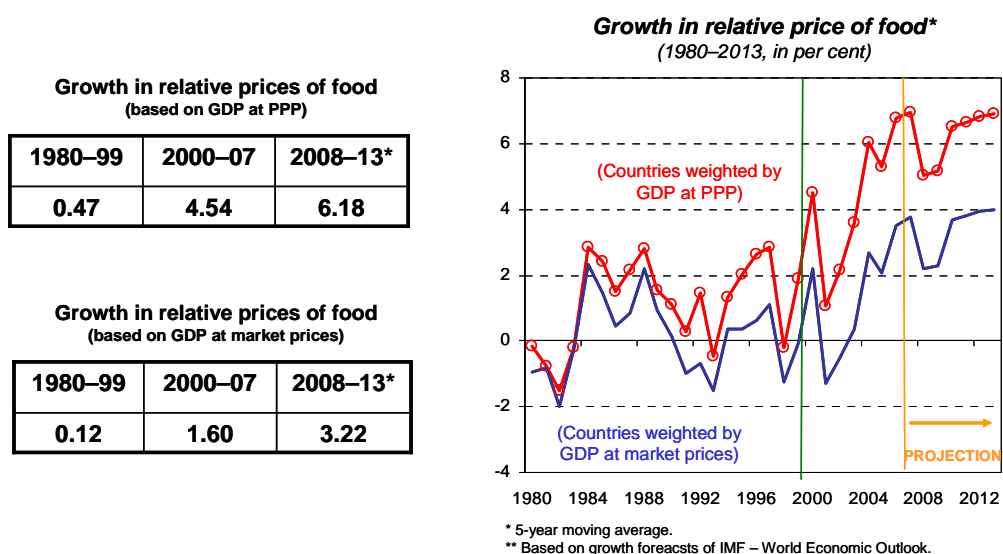
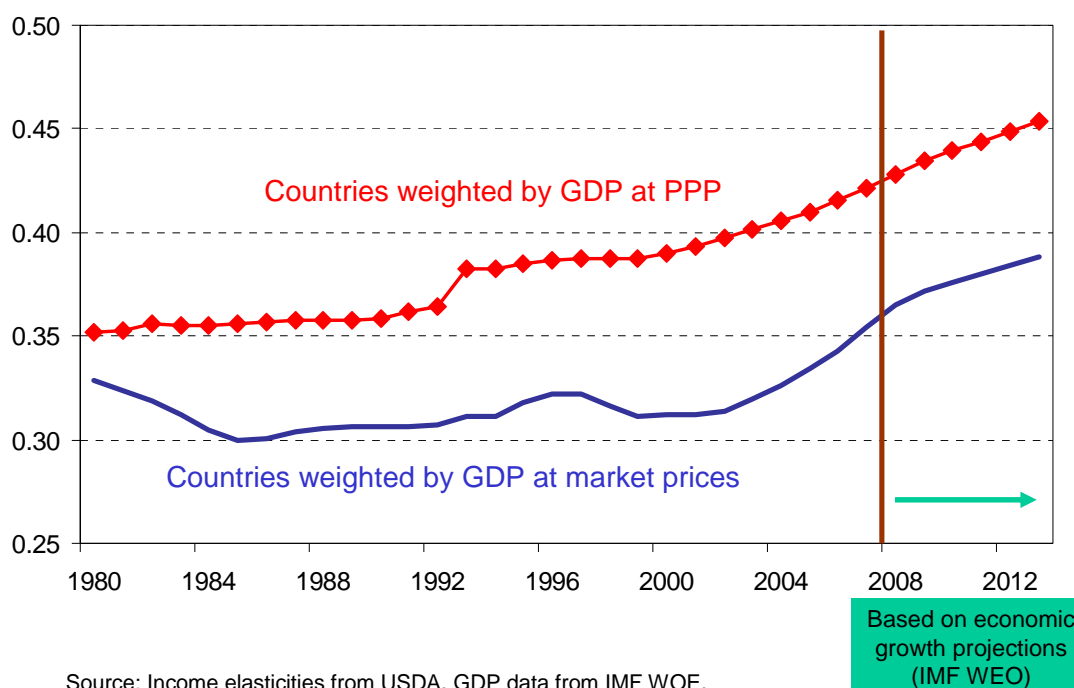


Figure 16

**Global income elasticity of food demand**



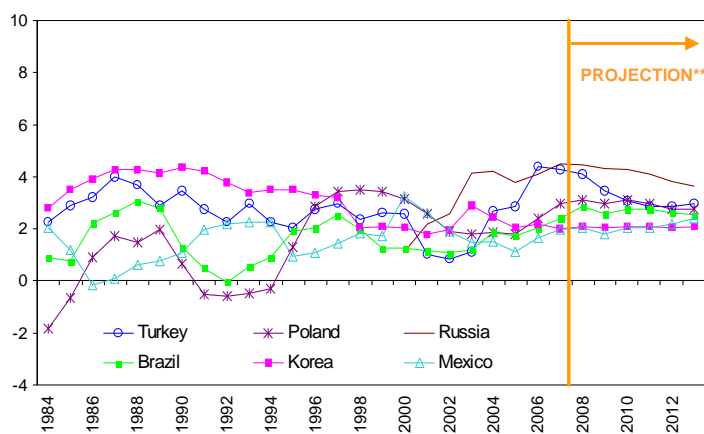
Again based on the IMF’s economic growth projections, global income elasticity of food will increase rapidly in the next five years.

In reality, food and agricultural products are not totally tradable. For some of the food items countries have to rely on their own demand and supply. Now, at the other extreme, let us assume that food is not tradable and that each country is an autarky for agricultural products. Figure 17 plots projections of growth in food demand in six emerging market economies. The highest growth projection for food demand is for Russia, which is around 4%.

Figure 17

### Growth in food demand

Growth in food demand\* – mid-income countries  
(1980–2013, in per cent)



\* 5-year moving average.

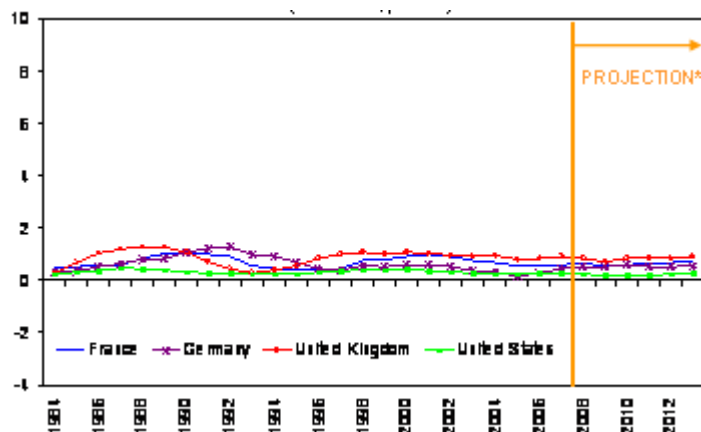
\*\* Based on growth forecasts of IMF – World Economic Outlook.

Figure 18 plots projections of growth in food demand in four developed economies. The projected demand growth paths are all well below 1% a year.

Figure 18

### Growth in food demand

Growth in food demand\* – developed countries  
(1980–2013, in per cent)



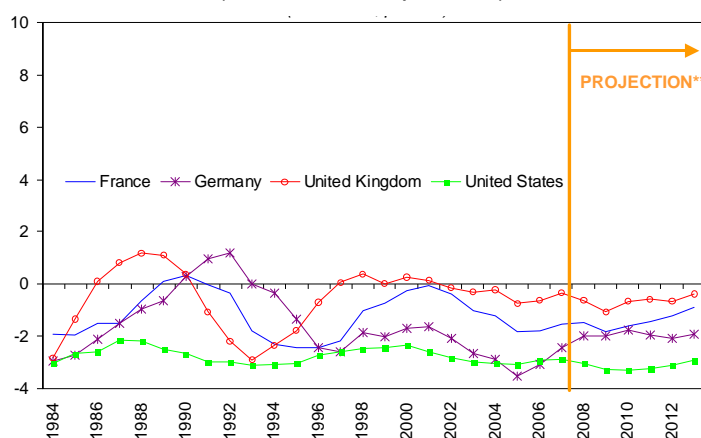
\* 5-year moving average.

\*\* Based on growth forecasts of IMF – World Economic Outlook.

Figure 19

**Growth in relative prices of food**

Growth in relative prices of food\* – developed countries  
(1980–2013, in per cent)



\* 5-year moving average.

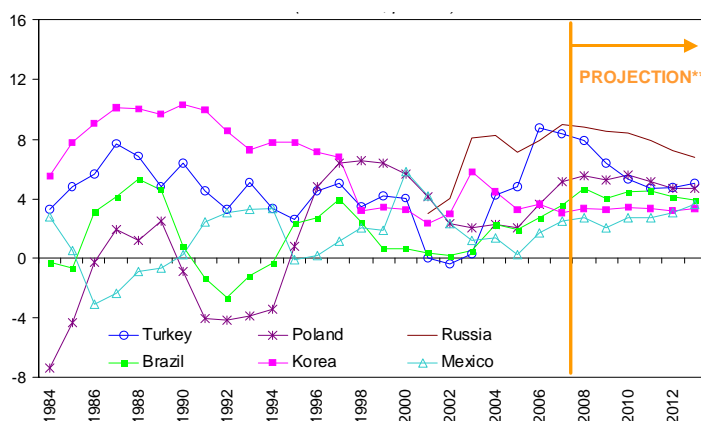
\*\* Based on growth forecasts of IMF – World Economic Outlook.

Figure 19 plots projections of growth in relative price of food for four developed economies. Projections are all negative. For the United States, the projection is around –3% a year.

Figure 20

**Growth in relative prices of food**

Growth in relative prices of food\* – mid-income countries  
(1980–2013, in per cent)



\* 5-year moving average.

\*\* Based on growth forecasts of IMF – World Economic Outlook.

Figure 20 plots projections of growth in relative prices of food for six emerging market economies. Projections are all well above 3% a year. For Russia, the projection is around 7% a year.

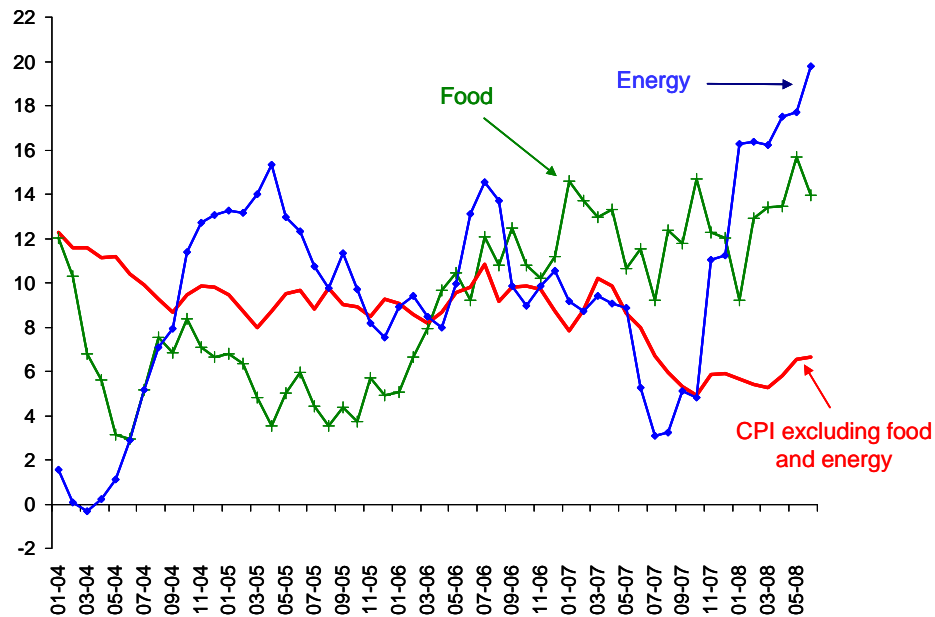
In the last couple of years emerging market economies like Turkey have suffered from high food inflation, partly because of increased global demand for food. The next graph plots inflation developments in Turkey in recent years, for food, energy and other items.



Figure 21

**Inflation developments in Turkey**

Food, energy and core inflation  
(January 2004–June 2008, year-on-year change, per cent)



Source: TURKSTAT, CBT.

The upward pressure in world food prices due to the emergence process is a phenomenon that is likely to last for years. Since the weight of these items in the consumer basket is still very significant in EMEs, it is likely that there will be strong upward pressures in inflation in these countries. However, since demand and prices of food are not interest rate sensitive, these upward pressures in inflation will not be responsive to monetary policy. This is clearly a challenge for monetary policy, especially in EMEs.

Another challenge of rising food prices is the distributional effects they have on households. Since the share of food in the consumer basket is higher for poorer individuals, the effects of rising food prices on poorer households will be more severe. Effective inflation will be significantly higher for poorer citizens.

The simple welfare analysis above (Figure 22) explores the welfare consequences of rising food prices due to the emergence process. The first exercise is calibrated for Turkey and shows that although food prices increase due to fast growth in Turkey, all households are better off, except those for which the share of food in the consumption basket is greater than 0.91; almost everybody in Turkey.

Figure 22

**A simple welfare analysis**

**Change in welfare:**  $\gamma_Y - (s_f \bar{p}_A - (1 - s_f) \bar{p}_A)$

where  $\bar{p}_A = \frac{\gamma_D - \varphi_Y \gamma_Y}{\varphi_P}$ , and  $\gamma_D = \varphi_Y \gamma_Y + \varphi_P \bar{p}_A$ .

An individual will be better off if  $s_f < \frac{\left(\frac{\gamma_Y}{\bar{p}_A} + 1\right)}{2}$ .

<p><b>Turkish example</b></p> <p><math>\alpha_K = 0.2</math>    <math>\alpha_L = 0.5</math>  <math>\gamma_K = 4\%</math>    <math>\gamma_L = 0\%</math>  <math>\gamma_N = -3\%</math>    <math>\gamma_Y = 7\%</math>  <math>\varphi_Y = 0.6</math>    <math>\varphi_P = -0.4</math></p>	<p><math>\bar{p}_a = \frac{0.9\% - 0.6(7\%)}{-0.4} = 8.25\%</math>.</p> <p>An individual will be better off if</p> <p><math>s_f &lt; \frac{\left(\frac{7\%}{8.25\%} + 1\right)}{2} \cong 0.92</math>.</p>
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**Change in welfare:**  $\gamma_Y - (s_f \bar{p}_A - (1 - s_f) \bar{p}_A)$

An individual will be better off if  $s_f < \frac{\left(\frac{\gamma_Y}{\bar{p}_A} + 1\right)}{2}$ .

<p><b>Another example</b></p> <p><math>\gamma_Y = 10\%</math>,    <math>\gamma_S = 1.5\%</math>,    <math>\varphi_Y = 0.8</math>,    <math>\varphi_P = -0.4</math></p>
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<p><math>\bar{p}_a = \frac{1.5\% - 0.8(10\%)}{-0.4} = 16.25\%</math>.</p> <p>An individual will be better off if</p> <p><math>s_f &lt; \frac{\left(\frac{10\%}{16.25\%} + 1\right)}{2} \cong 0.81</math>.</p>
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