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.

[1] 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

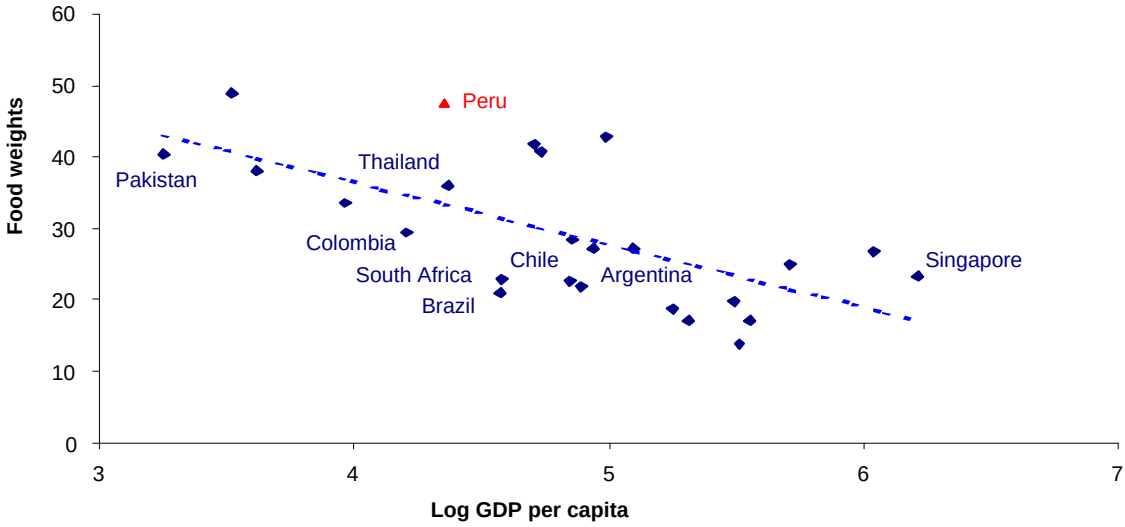


Table 1 gives a record of inflation during the IT regime so far. Until 2006, average inflation was broadly in line with the inflation target.[2] The story changes from 2007 onwards when world food commodity prices started rising dramatically. The hike in food prices increased core and non-core components 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*
Inflation	**100.0**	**1.5**	**2.5**	**3.5**	**1.5**	**1.1**	**3.9**	**6.7**	**5.5**	**2.9**
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.

[2] The inflation target was defined to be 2.5% with a tolerance of ±1% until 2006; from 2007 the central bank lowered the target to 2.0% ±1%.

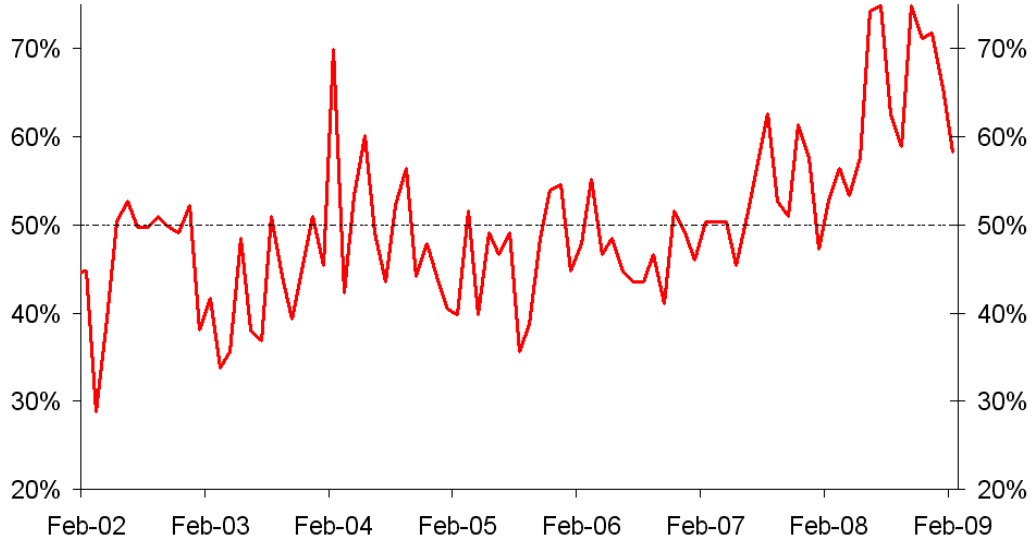
We now discuss some features of the inflationary process in Peru such us the breadth of prices increases, the time-series and cross-sectional volatility of price changes, price stickiness, and inflation expectations.

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*
Inflation	**100.0**	**0.4**	**0.4**	**0.3**	**0.2**	**0.3**	**0.2**	**0.3**	**0.3**
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 π_t is the mean weighted percentage change across all items.[3] 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.

[3] 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)***	0.06 (1.03)	0.12 (3.58)***	0.03 (0.54)
Lagged CPI inflation	0.40 (4.63)***	0.32 (3.58)***	0.36 (4.35)***	0.30 (3.45)***
Cross-sectional variance (CPI)		0.014 (2.43)**		0.013 (2.30)**
Cross-sectional skewness (CPI)			0.025 (2.42)**	0.022 (2.20)**
R^2	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

*** rejection of the null hypothesis at 1% level

** rejection of the null hypothesis at 5% level

* 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.[4] 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.

[4] 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)***	0.12 (3.00)***	0.17 (5.56)***	0.07 (2.06)***
Lagged CPI inflation	0.40 (4.63)***	0.28 (3.21)***	0.33 (3.54)***	0.24 (2.64)***
Cross-sectional variance (WPI)		0.03 (2.39)**		0.054 (4.19)**
Cross-sectional skewness (WPI)			0.017 (1.17)	0.035 (3.82)**
R^2	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

*** rejection of the null hypothesis at 1% level

** rejection of the null hypothesis at 5% level

* 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)

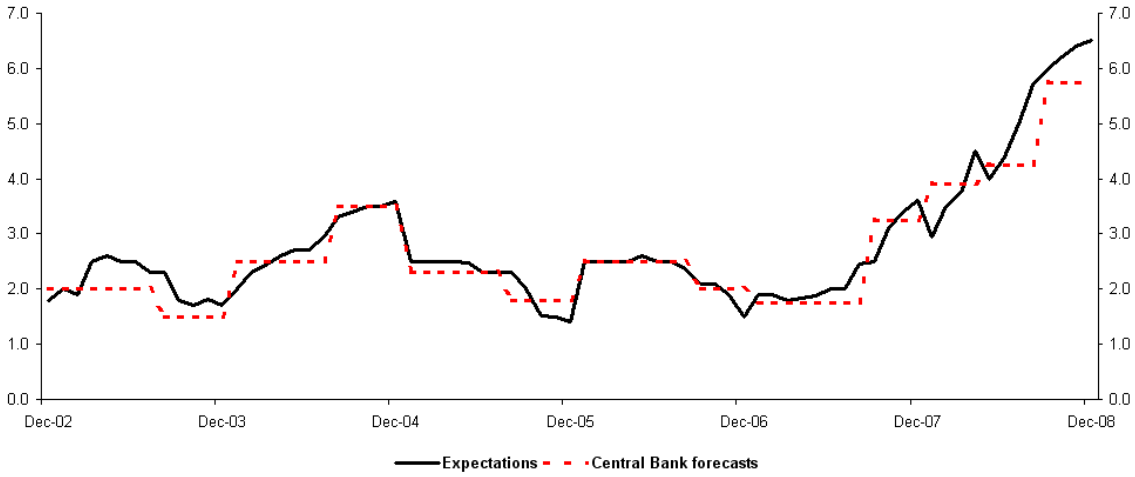
financial institutions. The survey covers current and next-two-years-ahead CPI inflation expectations. The outcome is released during the first week of each month.

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

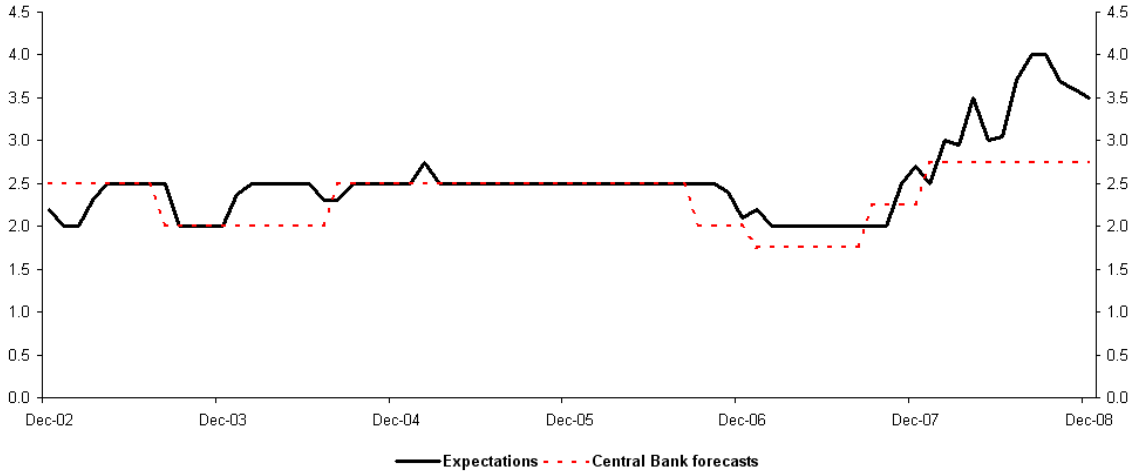
Pairwise Granger causality test between inflation report forecasts for next year calendar and economic analysts' expectations for next year calendar

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)***	0.79 (12.1)***
- Lagged year-on-year inflation	0.04 (2.7)***	0.06 (3.3)***
- Inflation target	0.03 (1.0)	0.16 (2.8)***
R^2	0.94	0.79
Breusch-Godfrey F-stat (null = no serial correlation)	2.14	1.03

Notes: t-statistics in brackets

*** rejection of the null hypothesis at 1% level

** rejection of the null hypothesis at 5% level

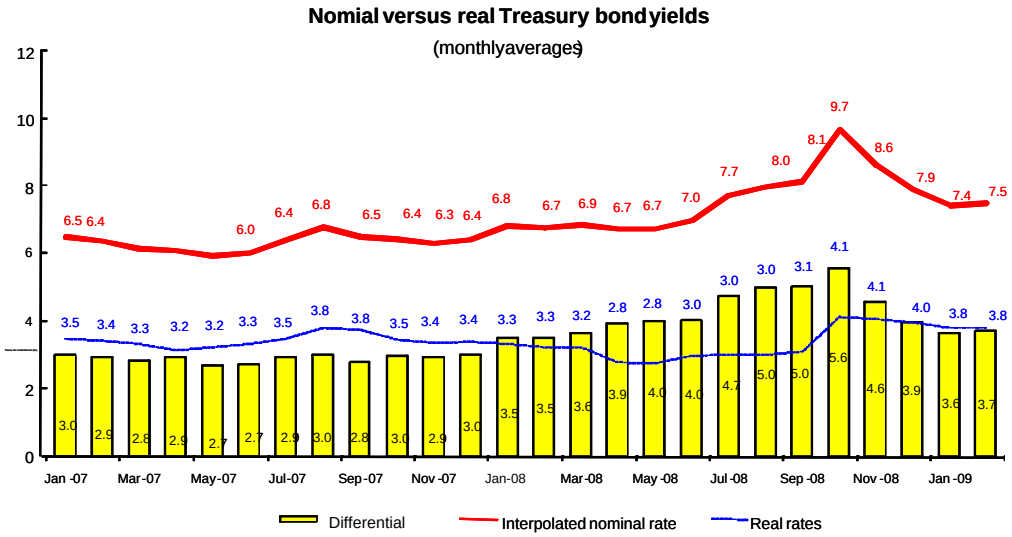
* rejection of null hypothesis at 10% level

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[5] 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 (π^{be}).

π^{be} = *Nominal yield – real yield* [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:

[5] 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.

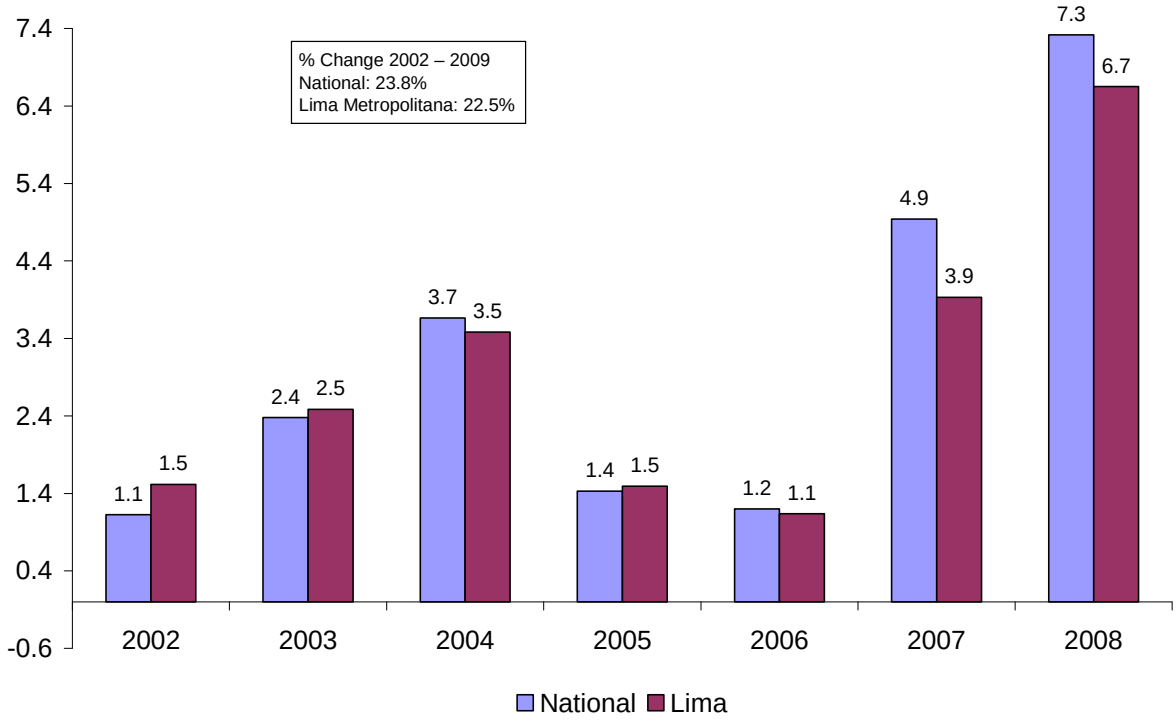
A question that arises here is whether all price indices within the national CPI converge with a common trend. This has been tackled in Monge and Winkelried (2004), where panel unit root techniques are used to discover that discrepancies between the 25 CPI aggregates due to idiosyncratic shocks die out 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

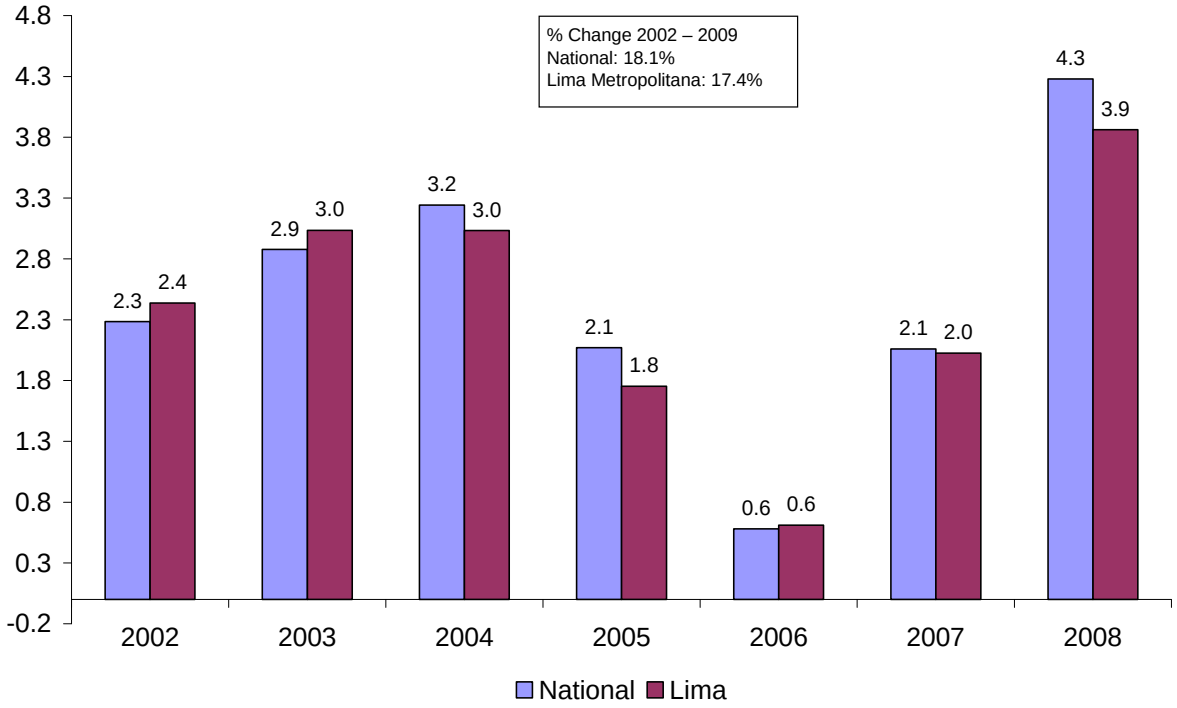


The higher national inflation in 2007 and 2008 was related to the rise in the food and beverages group. In the rest of the cities, the contribution of this group to inflation was larger due to its considerable weight in the respective CPIs. If we exclude foods and beverages from both inflation measures their difference is further reduced.

Figure 7

National and Lima CPI excluding food and beverages

Annual percentage change



National wholesale price index

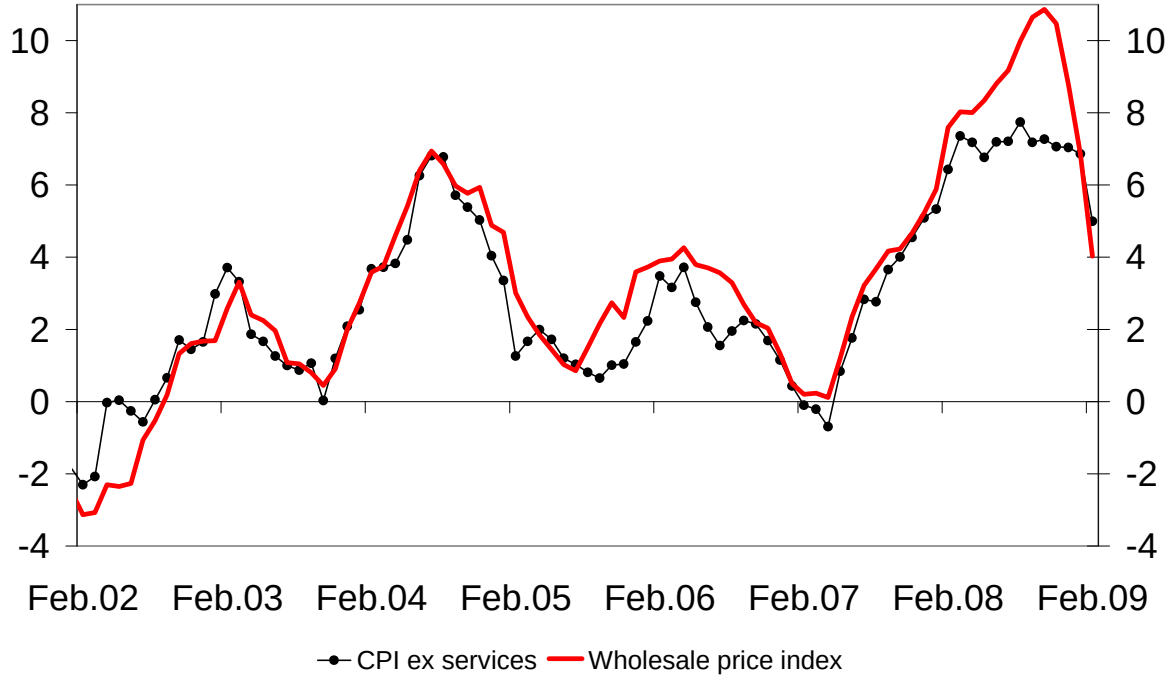
The wholesale price index (WPI) is also compiled by the INEI. It covers the prices of a representative group of goods traded on wholesale markets in 25 major cities. The WPI covers 394 products, classified by sector (agriculture and livestock, fishing, and manufacturing) and by source (domestic and imported). 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

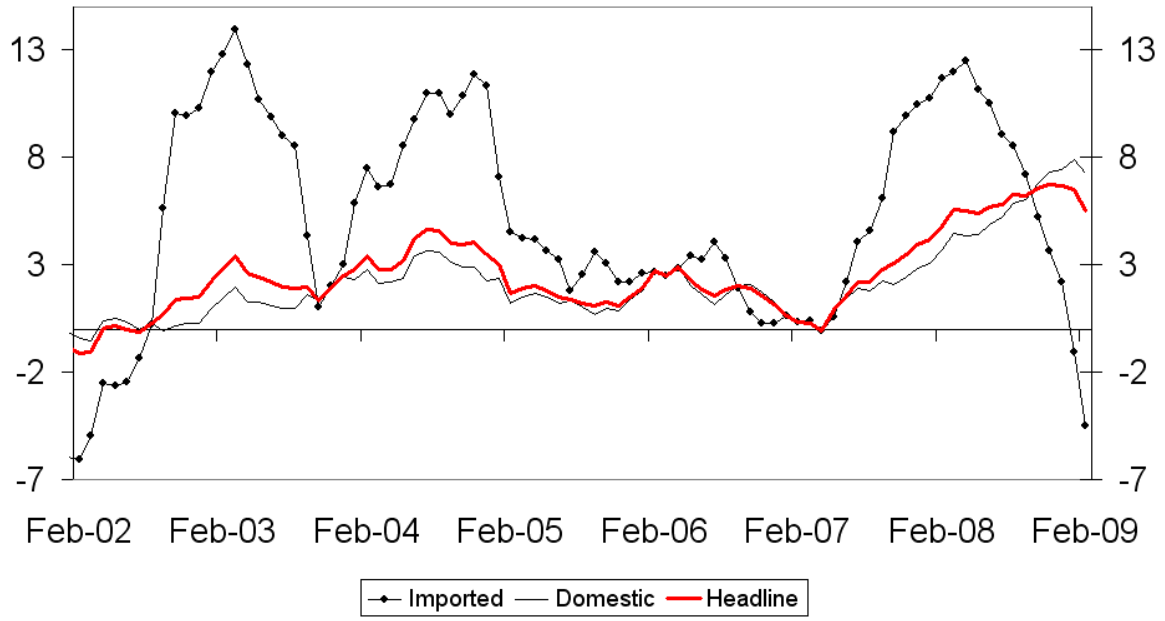


Table 8 shows the domestic and imported drivers of CPI inflation during the inflation-targeting years. The hike in inflation observed over 2007–08 was mainly related to food inflation. In 2007 imported inflation rose to 18.8% while in 2008 domestic food inflation increased by 10.5%. In other words, the 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*
Inflation	**100.0**	**1.5**	**2.5**	**3.5**	**1.5**	**1.1**	**3.9**	**6.7**	**5.5**	**2.9**
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*
Inflation	**100.0**	**1.5**	**2.5**	**3.5**	**1.5**	**1.1**	**3.9**	**6.7**	**5.5**	**2.9**
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

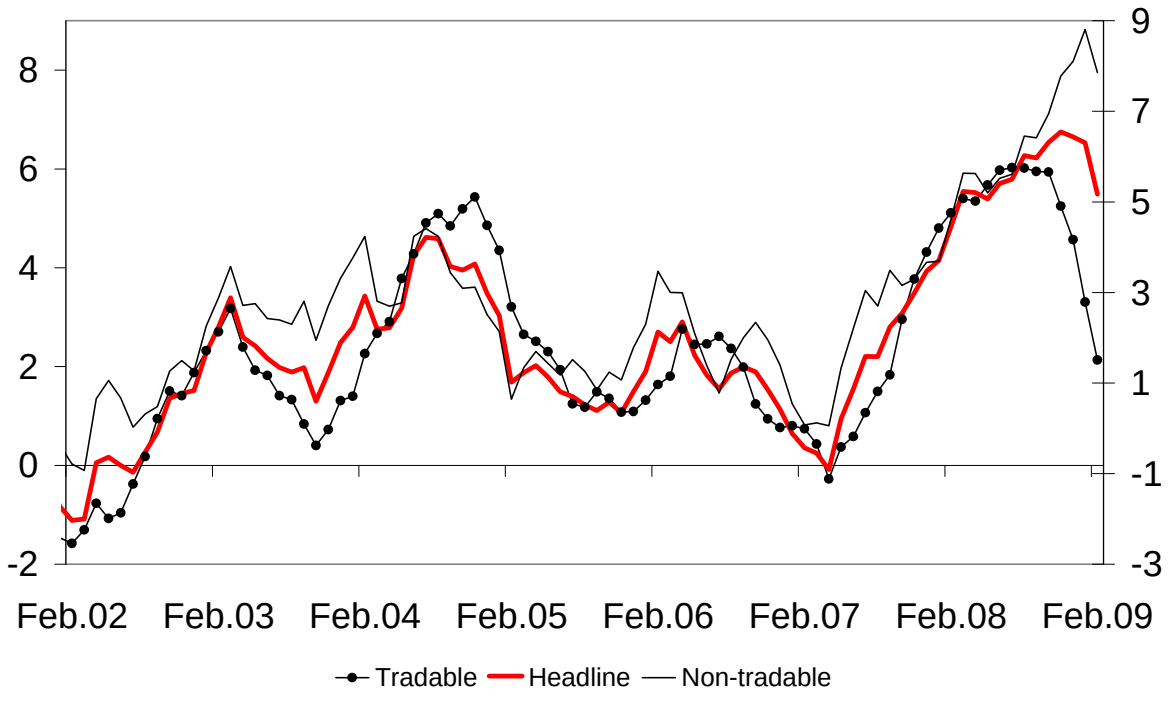
* February 2009.

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,[6] 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.

[6] 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.

Reweighted 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

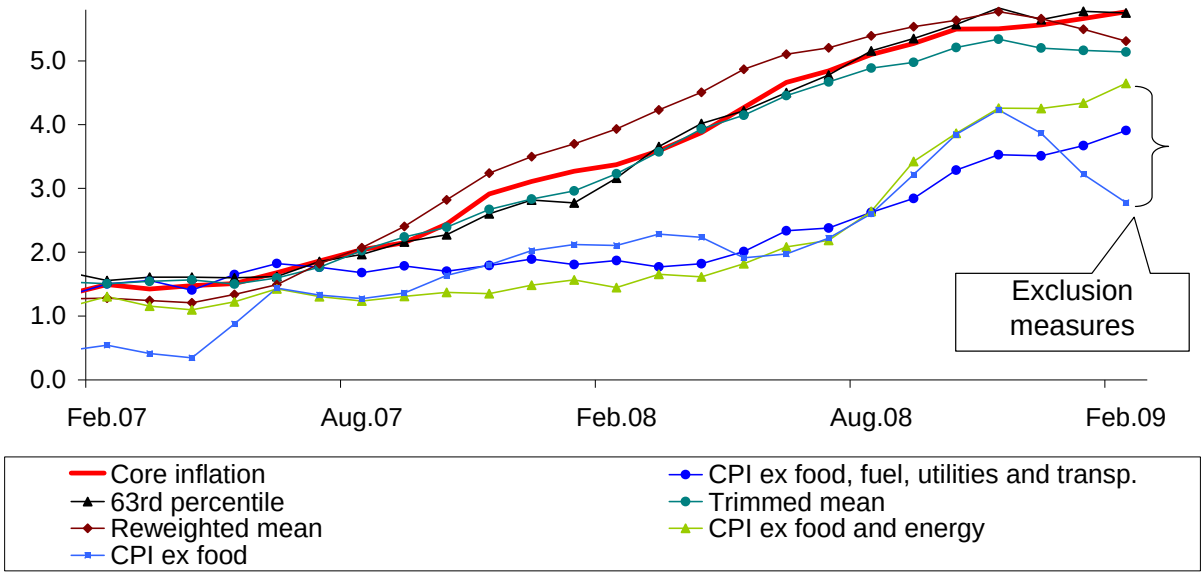
Core year-on-year inflation measures

	2007		2008				2009		% change	Std. dev.
	Jun.	Dec.	Mar.	Jun.	Sep.	Dec.	Jan.	Feb.	annual avg. 95–09	95–09
CPI	**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**
Other core inflation indicators										
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
Reweighted 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

$$rmse_h = \sqrt{\frac{1}{T}\sum_{t}^{T}(\pi_{t+h}^{cpi} - \pi_t^{core})^2} \qquad [5]$$

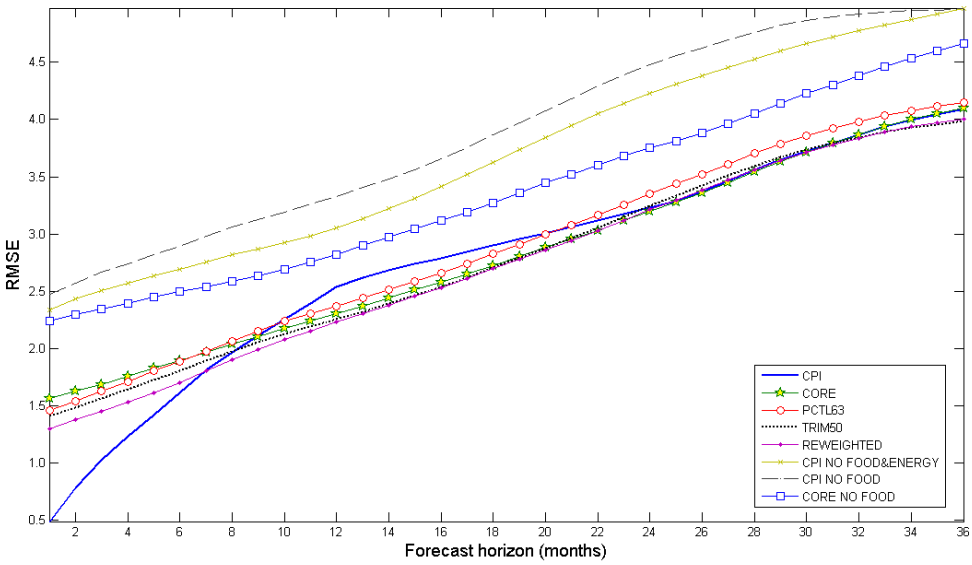
where π_{t+h}^{cpi} is the year-on-year measure of headline inflation in period ***t + h***, ***h*** is a forecast horizon that takes values ***h = 1,2,...36***, π_t^{core} is any particular year-on-year core inflation measured at time t.

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.

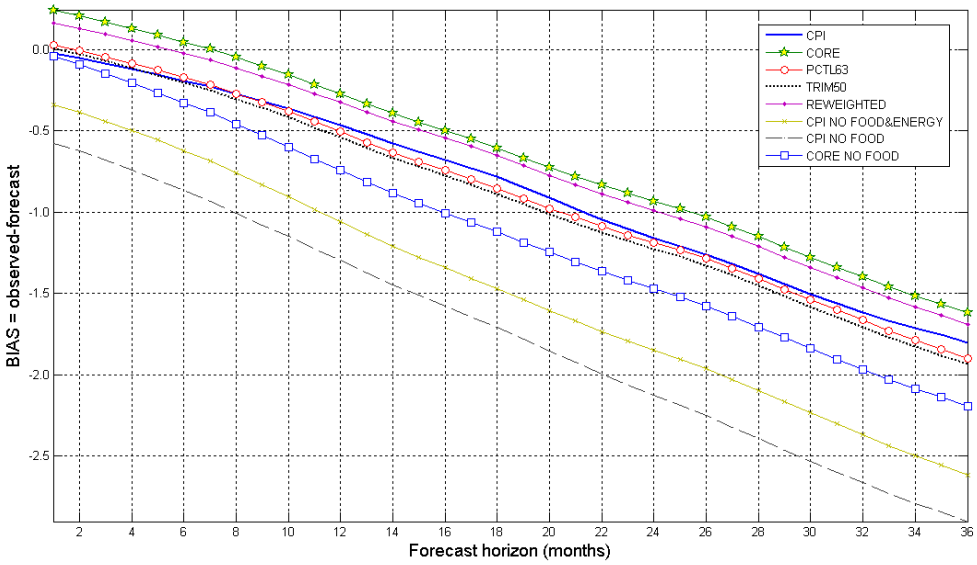
$$bias_h = \frac{1}{T}\sum_{t}^{T}(\pi_{t+h}^{cpi} - \pi_t^{core}) \qquad [6]$$

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 that the outturn, 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[7] 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.

$$\pi_{t+h}^{cpi} - \pi_t^{core} = \alpha_H + \beta_H(\pi_t^{cpi} - \pi_t^{core}) \qquad [7]$$

In terms of equation [7], the coefficient β_H quantifies the degree of the correction mentioned above. If the core inflation measure is a good indicator, then β_H must be statistically lower

[7] If π_{t+h}^{cpi} and π_t^{core} move together, the variance would be close to zero. However when π_t^{core} is too smooth, the variance of π_{t+h}^{cpi} tends to dominate, rendering huge RMSE values.

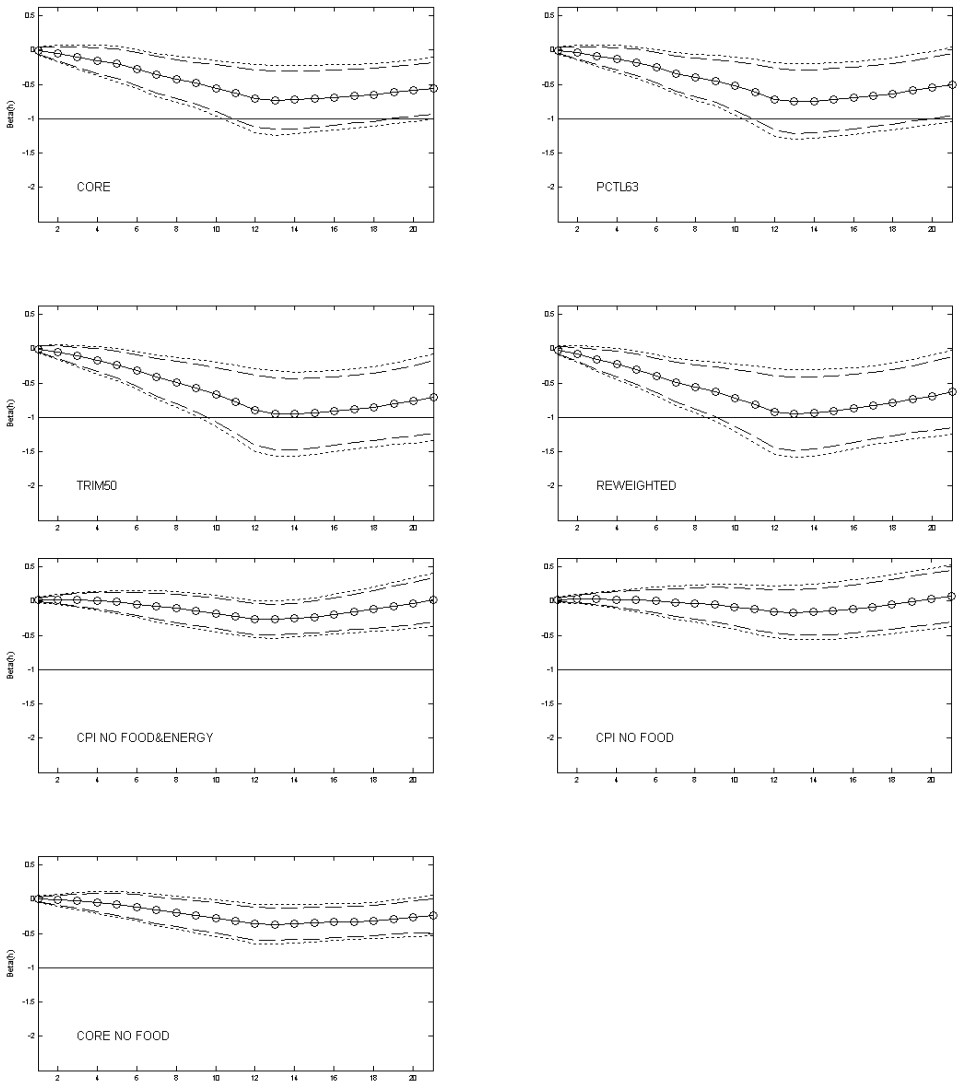
than zero. We can characterise the correction in the following terms: if the coefficient is statistically equal to –1 then the gap between headline and core inflation exactly matches the magnitude of future inflationary corrections, if the parameter is strongly below –1 then the gap underestimates future inflationary corrections, whereas a parameter value above –1 shows that the gap overestimates future corrections.

Figure 14 shows the different values of parameter β_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 β_H is basically zero for all horizons and therefore they are of no use in guiding future inflationary corrections.

Figure 14

Values of β_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

$$\begin{bmatrix} \pi_t^{cpi} \\ \pi_t^{core} \end{bmatrix} = A(L) \begin{bmatrix} \pi_t^{cpi} \\ \pi_t^{core} \end{bmatrix} + \varepsilon_t \qquad [8]$$

where A(L) is a matrix polynomial that considers at least 13 lags and e_t is a vector of corresponding reduced-form shocks. The impulses are computed with standard Cholesky representations.

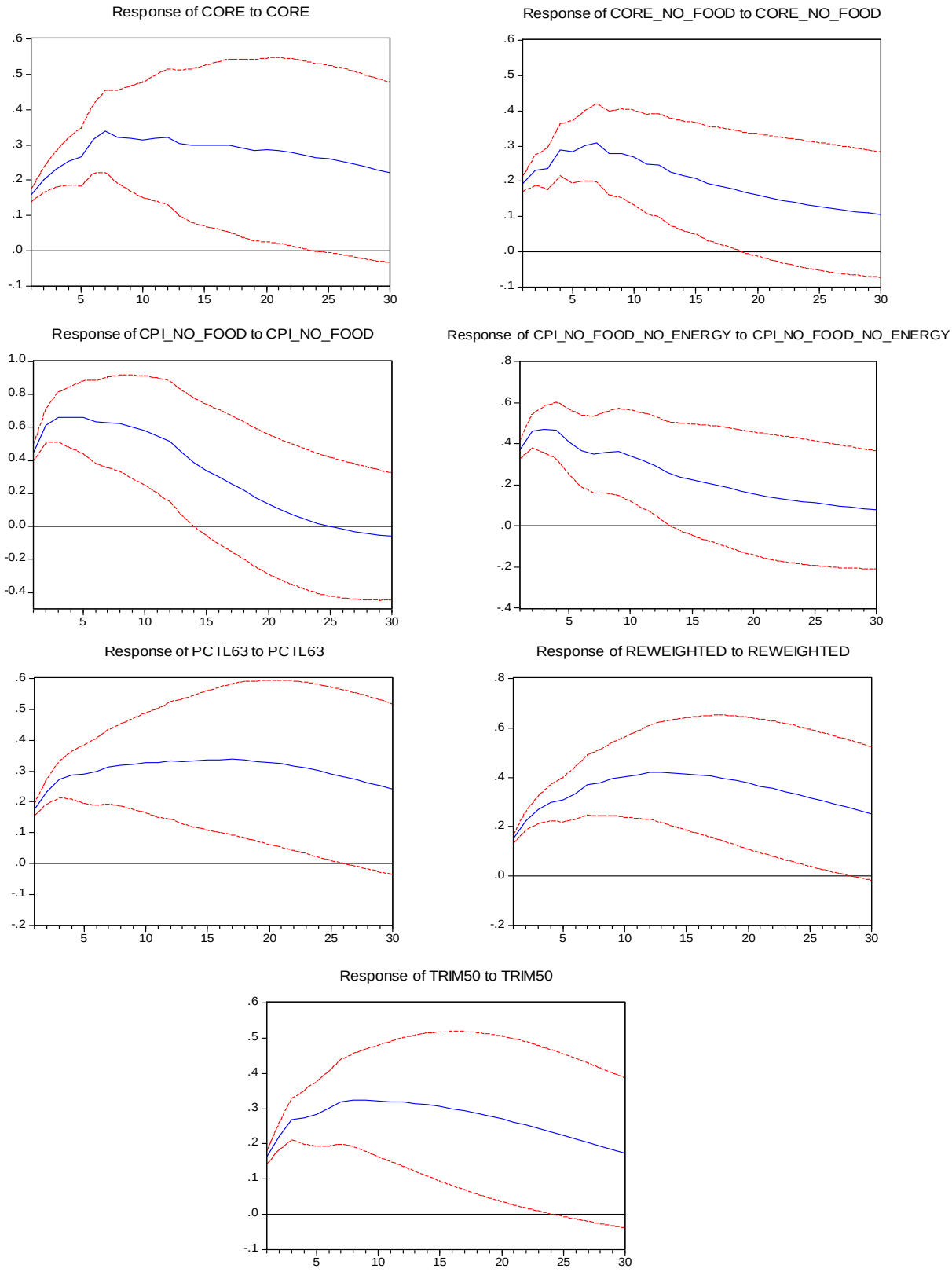
The results provided here are broadly in line with what we should expect about core inflation movements. Mishkin (2007) is clear about this feature:

> *"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

Measure	Null hypothesis	Prob
CORE		
	CPI does not Granger-cause CORE	0.671
	CORE does not Granger-cause CPI	0.0587*
CORE_NO_FOOD		
	CPI does not Granger-cause CORE_NO_FOOD	0.0175**
	CORE_NO_FOOD does not Granger-cause CPI	0.215
CPI_NO_FOOD_NO_ENERGY		
	CPI does not Granger-cause CPI_NO_FOOD_NO_ENERGY	0.0136**
	CPI_NO_FOOD_NO_ENERGY does not Granger-cause CPI	0.905
CPI_NO_FOOD		
	CPI does not Granger-cause CPI_NO_FOOD	0.0685*
	CPI_NO_FOOD does not Granger-cause CPI	0.836
PCTL63		
	CPI does not Granger-cause PCTL63	0.0989*
	PCTL63 does not Granger-cause CPI	0.0614*
REWEIGHTED		
	CPI does not Granger-cause REWEIGHTED	0.361
	REWEIGHTED does not Granger-cause CPI	0.324
TRIM50		
	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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