To what extent can we trust core inflation measures? The experience of CEE countries

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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.[3]

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[3]   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[4]. 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,[5] 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[6].

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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.

[4]   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).

[5]   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.

[6]   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 grater 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;[7]

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.[8] 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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[7] 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.

[8] 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.[9] 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 (199)9, 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.[10] 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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[9] Silver (2007) provides an extensive review of the criteria proposed for the assessment of core inflation measures.

[10] 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
• Monetary-policy relevant inflation [100%] • Adjusted inflation excluding fuels [55.12%] • Net inflation [83.6%]	• Trend (underlying inflation) • Core inflation [71.1%]	• Core inflation net of food and energy prices [60.1%] • Core inflation net of most volatile prices[11] [80.0%] • Core inflation net of administered prices[12] [87.6%] • 15% trimmed mean [70.0%]

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,[13] which is defined as headline inflation adjusted for first-round effects of changes to indirect taxes.[14] 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.[15] 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".[16] 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.[17] Monetary-policy relevant inflation is also used extensively in

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[11] 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).

[12] 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.

[13] 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).

[14] 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).

[15] 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).

[16] Czech National Bank, http://www.cnb.cz/en/faq/faq_mp/mp_relevant_inflation.html.

[17] 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.[18]

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.[19] However, it seems that this core inflation measure no longer belongs to the set of the CNB's communication tools.[20] 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.[21] 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.[22] 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.[23]

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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[18] 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.*

[19] 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*.

[20] For example, it is no longer discussed in the *Inflation Reports* or mentioned in the *Minutes*.

[21] 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.

[22] Magyar Nemzeti Bank, http://english.mnb.hu/engine.aspx?page=mnben_pressreleases_2001&ContentID=6072

[23] 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[24] 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.[25] Moreover, it was emphasised that the

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[24]   See, for example, the *Monetary Policy Guidelines for the year 2008* or *2009.*

[25]   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.[26] It was anticipated that this move would further influence expectations of inflation, which were shaped rather by headline rather than net inflation developments.[27] 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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[26]   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"*).

[27]   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.[28] 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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[28] 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.
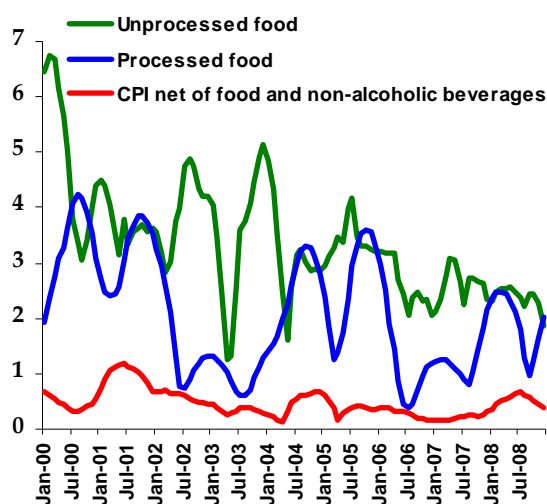
3.3.2 The interpretation of core inflation measures based on the "exclusion approach" in the context of the global food and energy price shock

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.[29] 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.

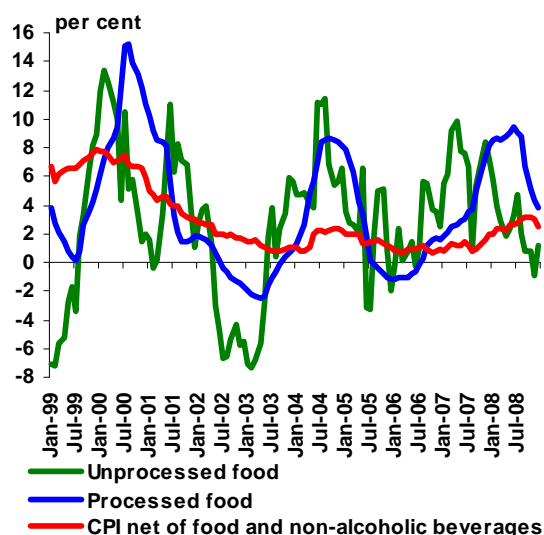*Processed and unprocessed food price changes and core inflation measures*

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.

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[29] 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.[30] 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[31] 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[32] is that such a procedure eliminates not only the "noise"
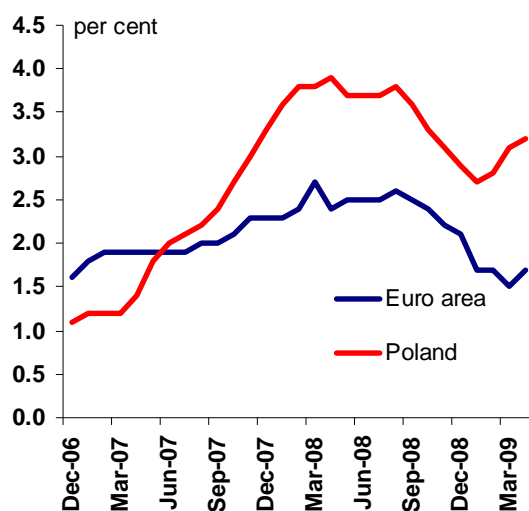
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[30] The changes of unprocessed food prices in Poland provide useful information about the future processed food price changes. The correlation analysis have shown that the lagged values of the processed food inflation are highly correlated with the 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.

[31] 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.

[32] 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
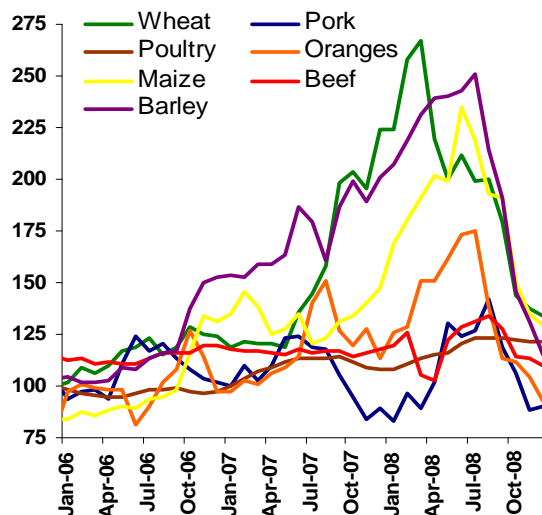
associated with these items but also their contribution to the inflation trend. If the excluded components follow a persistent trend that is divergent from the trend of the remaining headline inflation components, such a procedure can be particularly troublesome.

Chart 3. HICP inflation excluding energy and unprocessed food

Source: Eurostat data.

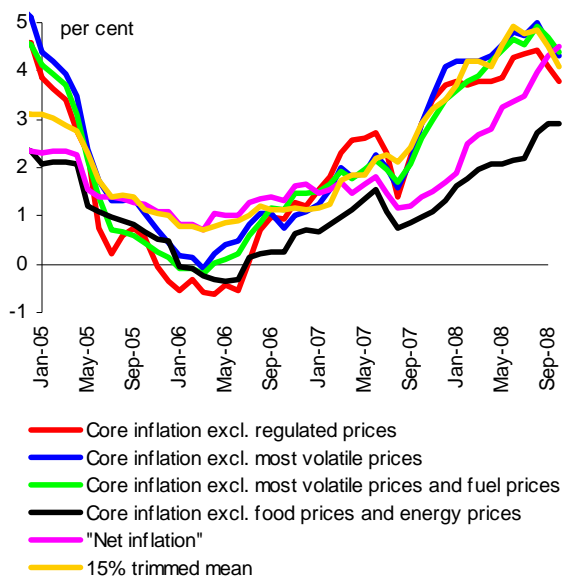**Chart 4. Global food price shock (2006Q1 = 100)**

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

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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).
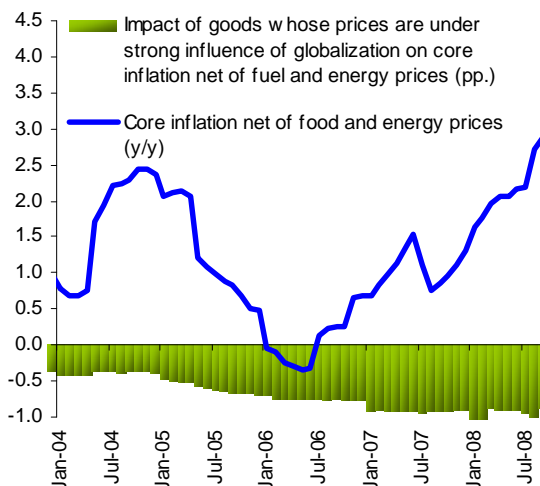
pressures properly, they should also account for the disinflationary effects of globalisation, which are also largely independent of domestic monetary policy.[33]

Chart 5. **Core inflation in Poland**

- Core inflation excl. regulated prices
- Core inflation excl. most volatile prices
- Core inflation excl. most volatile prices and fuel prices
- Core inflation excl. food prices and energy prices
- "Net inflation"
- 15% trimmed mean

Source: Polish CSO data, NBP calculations.

Chart 6. **NBP's core inflation net of food and energy and the disinflationary impact of globalisation**

- Impact of goods whose prices are under strong influence of globalization on core inflation net of fuel and energy prices (pp.)
- Core inflation net of food and energy prices (y/y)

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.[34] 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. The impact of goods whose prices were under a strong influence of globalisation[35] on net inflation rate was quantified to illustrate the

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[33] 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)).

[34] 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 .

[35] 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.[36] 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.[37]

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 theses 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**
Regulated price inflation	3.6	5.7	9.3	4.8	9.3	6.1	3.7	14.6	3.2	3.7	3.3	2.5
CPI inflation	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

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[36] 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.

[37] 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.

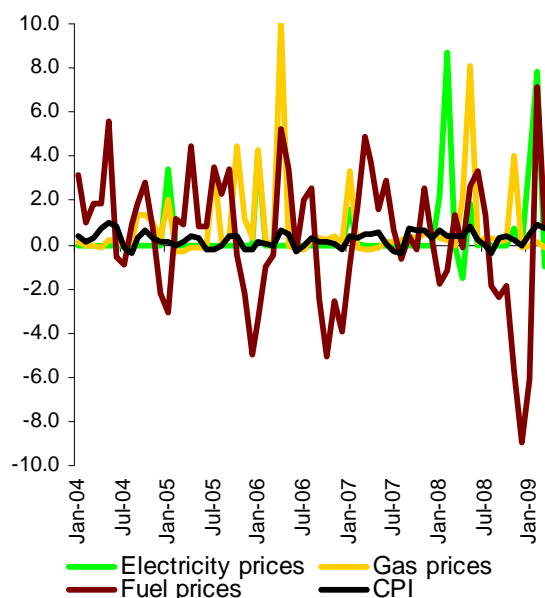problems as the permanent exclusion of food and energy prices, because regulated prices strongly affect the costs of production and comprise a considerable part of the cost of living (see Section 3.3.2). On the other hand, if regulated prices are not fully excluded from core inflation indices, their 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.[38] 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

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[38] 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.[39] 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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[39] 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.

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
	January 1998–March 2009			
Mean	3.6	3.2	2.0*	1.7*
Median	2.8	2.5	1.6	1.5
Standard deviation	2.93	2.70	1.94	1.92
Coefficient of variation	0.81	0.84	0.97	1.13
First difference standard deviation	0.66	0.54	0.28	0.47
	January 2002–March 2009			
Mean	2.6	2.1**	1.2*	1.1*
Median	2.4	1.8	0.9	0.8
Standard deviation	1.94	1.40	0.78	1.21
Coefficient of variation	0.75	0.67	0.65	1.10
First difference standard deviation	0.56	0.47	0.22	0.45

Source: CNB and Czech CSO data, own calculations.

[40] 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)**
January 1998–March 2009		
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
January 2001–March 2009		
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**
January 1998–March 2009					
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
January 2004–March 2009					
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
	January 1998–March 2009									
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
	January 2002–March 2009									
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
	January 1998–March 2009									
Core inflation	1.15	1.50	1.37	1.80	1.68	2.04	1.28	1.63	1.45	1.80
	January 2001–March 2009									
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
January 1998 - March 2009										
Core inflation net of food and energy prices	1.08*	1.43**	1.14	1.41	**1.20**	**1.47**	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	**0.63**	**0.84**	**0.99**	**1.22**	1.37	1.56	**0.93**	**1.11**	1.17	1.40
January 2004 - March 2009										
Core inflation net of food and energy prices	**1.28***	**1.32***	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	**1.04**	**1.14**	**0.71**	0.83	**0.81**	**0.93**
Core inflation net of administered prices	1.02*	1.24*	**1.41***	**1.67***	**1.80***	**2.04***	**1.26***	**1.55***	**1.32***	**1.60***
15% trimmed mean	**0.49**	**0.54**	**0.79**	**0.85**	1.09	1.16	0.75	**0.83**	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) π_t^* (core inflation) is I(1) and π_t^* and π_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 $\Delta\pi_t$ may be written as:
  $$\Delta\pi_t = \sum_{j=1}^{m}\alpha_j\Delta\pi_{t-j} + \sum_{j=1}^{n}\beta_j\Delta\pi_{t-j}^* - \gamma\left(\pi_{t-1} - \pi_{t-1}^*\right) + \varepsilon_t \qquad (*)$$

  3) π_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 γ is significantly different from 0.

  The third condition (exogeneity) was tested by estimating the following equation:
  $$\Delta\pi_t^* = \sum_{j=1}^{r}\delta_j\Delta\pi_{t-j}^* + \sum_{j=1}^{s}\theta_j\Delta\pi_{t-j} - \lambda\left(\pi_{t-1}^* - \pi_{t-1}\right) + \varepsilon_t \qquad (**)$$

  and testing with simple t-test whether we cannot reject the hypothesis that $\lambda = 0$ (weak exogeneity) and, if so, whether $\theta_1 = \theta_2 = ... = \theta_s = 0$ (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[41]), 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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[41] 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 $\theta_1 = \theta_2 = ... = \theta_s = 0$ 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

1)   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 (**).

2)   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.

3)   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 (**).

Bibliography:

Bean, Charles (2006): "Comments on Ken Rogoff: impact of globalization on monetary policy", The Federal Reserve Bank of Kansas City 30th Annual Economic Symposium, Jackson Hole, Wyoming, (www.kc.frb.org/publicat/sympos/2006/PDF/Bean.paper.0904.pdf).

Bryan, Michael F and Stephen G Cecchetti (1993): "The consumer price index as a measure of inflation", Federal Reserve Bank of Cleveland, *Economic Review*, Fourth Quarter.

Bryan, Michael F and Stephen G Cecchetti (1994): "Measuring core inflation", in *Monetary Policy*, ed N Gregory Mankiw, pp 195–215, Chicago: University of Chicago Press.

Clark, Todd E (2001): "Comparing measures of core inflation", Federal Reserve Bank of Kansas City Economic Review, Second Quarter, pp 5–31.

Cockerell, Lynne (1999): "Measures of inflation and inflation targeting in Australia", in *Measures of underlying inflation and their role in the conduct of monetary policy,* proceedings of the Workshop of Central Bank Model Builders, Bank for International Settlements, Basel.

Cogley, Timothy (2002): "A simple adaptive measure of core inflation", *Journal of Money, Credit and Banking*, Blackwell Publishing, vol 34(1), pp 94–113, February.

Czech National Bank (1999), *CNB monetary strategy document*, April.

Czech National Bank (2001), *The setting of the inflation target for 2001,* April.

Czech National Bank, *Inflation report,* various years.

Czech National Bank, *Minutes of the Bank Board meeting,* various years.

Égert, Balázs (2008): *"*Prices and price convergence in emerging Europe: an overview*",* National Institute Economic Review, vol 204(1), pp 66–84*.*

Hogan*,* Seamus, Marianne Johnson and Thérèse Laflèche (2001): "Core inflation", *Technical Reports* 89, Bank of Canada.

Hrnčíř, Miroslav and Katerina Šmídková (2000): "Inflation targeting in the Czech Republic", in *Monetary frameworks in a global context,* ed Mahadeva Lavan and Gabriel Sterne, Routledge, London.

Johnson, Marianne (1999): "Core inflation: a measure of inflation for policy purposes", in *Measures of underlying inflation and their role in the conduct of monetary policy,* proceedings of the Workshop of Central Bank Model Builders, Bank for International Settlements, Basel, February.

Mankikar, Alan and Jo Paisley (2004): "Core Inflation: A Critical Guide", Bank of England Working Paper No. 242.

Marques, Carlos Robalo, Neves, Pedro Duarte and da Silva, Afonso Goncalves (2002): "Why should Central Banks avoid the use of the underlying inflation indicator?" *Economics Letters*, 75(1), pp 17–23, March.

Mishkin, Frederic (2007): "Headline versus core inflation in the conduct of monetary policy", speech at the Business Cycles, International Transmission and Macroeconomic Policies Conference, HEC Montreal, October (www.federalreserve.gov/newsevents/speech/mishkin20071020a.htm).

Motley, Brian (1997): "Should monetary policy focus on 'core' inflation?" *FRBSF Economic Letter*, Number 1997x11, April.

National Bank of Hungary, *Minutes of the Monetary Council meeting,* various years.

National Bank of Hungary, *Press release on the Monetary Council's meeting,* various years.

National Bank of Hungary, *Quarterly Report on Inflation,* various years.

National Bank of Poland, *Inflation Report,* various years.

National Bank of Poland, *Information on the meeting of Monetary Policy Council,* various years.

National Bank of Poland, *Minutes of the Monetary Policy Council decision-making meeting,* various years.

National Bank of Poland, *Monetary policy guidelines,* various years.

National Bank of Poland (2003): *Monetary policy strategy beyond 2003,* Warsaw, February.

Robalo Marques, Carlos, Duarte Neves, Pedro and Morais Sarmento, Luis (2003): "Evaluating core inflation indicators," *Economic Modelling*, 20(4), pp 765–75, July.

Quah, Danny and Shaun Vahey (1995): "Measuring core inflation", *Economic Journal*, 105, pp 1130–44.

Rich, Robert and Charles Steindel (2007): "A comparison of measures of core inflation", Economic Policy Review, Federal Reserve Bank of New York, pp 19-38, December.

Rogers, Scott (1998): "Core inflation: concepts, uses and measurement", Reserve Bank of New Zealand Discussion paper G98/9 (http://www.rbnz.govt.nz/research/discusspapers/g98_9.pdf).

Silver, Mick (2007): "Core inflation: measurement and statistical issues in choosing among alternative measures", *IMF Staff Papers*, 54 (1), pp 163–90.

Smith, Julie K (2005): "Inflation targeting and core inflation", *Canadian Journal of Economics*, 38(3), pp 1018–36, August.

Valkovszky, Sándor and János Vincze (2000): "Estimates and problems with core inflation in Hungary", *NBH Working Paper* 2000-2 (http://english.mnb.hu/Engine.aspx?page=mnben_mnbfuzetek&ContentID=3075).

Woźniak, Przemysław (2002): "Core inflation", CASE – Centre for Social and Economic Research, Warsaw (in Polish only).

Wynne, Mark A (2008): "Core inflation: a review of some conceptual issues", Federal Reserve Bank of St. Louis Review, May/June part 2, pp 205–28 (and previous version from 1999).