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How Should Central Banks Define Price Stability? *

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Abstract

It is now generally accepted that the primary objective of central banks should be the maintenance of price stability. This paper considers the question of how central banks should define price stability. I address three specific questions. First, should central banks target broad or narrow measures of inflation? Second, should central banks target headline or core measure of inflation? And third, should central banks define price stability as prevailing at some positive measured rate of inflation?

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1. Introduction

It is now widely accepted that price stability should be a (if not the) primary objective of central banks. Even for central banks with dual mandates, such as the Federal Reserve, the achievement of price stability is often seen as a key prerequisite to the attainment of other mandated objectives such as maximum employment. In this paper I look at how central banks should define price stability, starting with current practices. I consider three questions. First, should price stability be defined in terms of a relatively broad price index, such as the deflator for Gross Domestic Product, or in terms of a narrower measure, such as a Consumer Price Index? Second, should price stability be defined in terms of a headline measure of inflation, or in terms of a core measure that routinely excludes or downweights the prices of certain goods and services? And third, should price stability be defined as no change in the chosen price index, or as a positive rate of increase in the chosen price index? The choice of the horizon over which price stability is to be maintained is arguably as important as the manner in which price stability is defined, but I will not address that question here. I will touch briefly on the question of how asset prices should figure in the definition of price stability, but I will not visit the well-trodden ground of how monetary policy should respond to asset price developments.

The Federal Reserve is perhaps unique among the major central banks in that it does not have an explicit numerical price objective. Former Federal Reserve Chairman Alan Greenspan famously defined price stability in qualitative terms as a situation in which "…households and businesses need not factor expectations of changes in the average level of prices into their decisions." (Greenspan, 1994a) [1] However, as **Table 1** shows, many central banks, even those that would eschew the label of "inflation targeter" do have explicit numerical price objectives. In all cases, these price objectives are specified in terms of a measure of consumer price inflation. Furthermore, almost all are defined in

[1] Greenspan's definition echoed the earlier definition of Paul Volcker : "A workable definition of reasonable "price stability" would seem to me a situation in which expectations of generally rising (or falling) prices over a considerable period are not a pervasive influence on economic and financial behavior. Stated more positively, "stability" would imply that decision-making should be able to proceed on the basis that "real" and "nominal" values are substantially the same over the planning horizon – and that planning horizons should be suitably long." (Volcker, 1983)

terms of the headline rather than a core measure, although that was not always the case. The Reserve Bank of New Zealand (RBNZ), which pioneered inflation targeting, switched from defining its target in terms of core to headline CPI in 1997.[2] In 1998, the Reserve Bank of Australia's inflation target was also changed from referring to "underlying inflation" (which removed volatile components of the CPI such as the prices of unprocessed food, as well as prices that were heavily influenced by non-market developments, such as tobacco prices) to headline CPI inflation (but again excluding mortgage interest costs). The switch was made following changes to the construction of the CPI. And of course the Bank of England's inflation target, which was originally defined in terms of the Retail Price Index excluding mortgage interest payments (the RPIX, a core-like measure) was redefined in terms of the headline CPI or HICP in 2003. Perhaps the only central bank (that I am aware of) to have gone from targeting a headline measure to targeting a core measure is the Bank of Korea. After adopting inflation targeting in 1998, and targeting a headline measure of the CPI for two years, the Bank of Korea switched to a core measure (CPI inflation excluding non-cereal agricultural products and petroleum-based products) in 2000. In 2006 the target was redefined in terms of headline CPI inflation.

While almost all inflation targeting central banks define their objective in terms of a headline measures of inflation, many if not all also assign an important role to measures of core inflation in their deliberations and communications with the general public. The importance assigned to core measures varies across countries. Some central banks, such as the Federal Reserve System, which does not have a formal definition of price stability, regularly publish forecasts of core inflation. Others, such as the Bank of England, which has a formal inflation target expressed in terms of a headline measure of inflation, completely eschew the publication of core measures in the regular communications.[3] Yet others such as the Sveriges Riksbank, which has a formal inflation target defined in terms

[2] Note that the measure of headline that RBNZ targets excludes mortgage interest rates, and thus might under some definitions be considered a measure of core inflation.
[3] The last mention of "core inflation" in a Bank of England *Inflation Report* was in the November 2000 *Report*.

of a headline measure, publish a wide variety of core measures in its regular *Monetary Policy Report*.[4]

The last point to note from **Table 1** is that all of the central banks listed define price stability as prevailing at a positive measured rate of inflation. Usually some reference is made to measurement problems in justifying this choice, but there are often additional reasons, such as the desire to provide some safety margin against the risks of deflation.

2. Broad versus narrow measures

In practice, the debate over whether central banks should define price stability in terms of a broad of a narrow measure of inflation often comes to down to the choice between using a broad measure such as a GDP deflator to quantify the price objective, or a somewhat narrower measure such as a consumer price index. None of the central banks listed in **Table 1** defined price stability in terms of a GDP deflator.[5] The reasons for this may well differ across countries, but one fundamental argument against defining price stability in terms of a GDP deflator is the fact that due to its definition, the GDP deflator could rise even as all prices are falling, since import prices enter the GDP deflator with a negative weight (Diewert, 2002). It is worth noting that this is not just a hypothetical concern: in the third quarter of 2007, inflation as measured by the GDP deflator was 1.04 percent on an annualized basis, its lowest level in nine years, due in no small part to a 47.48 percent (annualized) increase in the price of imports of petroleum and petroleum products during eth quarter. It is possible to define price stability in terms of more of the

[4] The UND1X measure of core inflation (which excludes mortgage interest expenditure and the direct effects of changes in indirect taxes and subsidies) is the one that receives the most attention it the Riksbank's *Report*. Other measures of core that appear in the Report include UNDINHX (which excludes the price of imports), UND1X excluding energy, UND24 (an Edgeworthian measure that weights prices by the (inverses) of their historical standard deviations) and TRIM85 (which excludes the price changes in the top and bottom 7.5 percent of the distribution.

[5] To the extent that the indexes that the members of the FOMC forecast twice a year in the *Monetary Policy Report to the Congress* might be construed as the Fed's price objective, the Fed had an implicit GNP deflator objective up until 1989. The *Monetary Policy Report to the Congress* submitted in February 1989 switched from reporting projections of the implicit GNP deflator to reporting projections of the CPI. And it is worth recalling that the original specification of the Taylor Rule was stated in terms of a GDP deflator rather than a measure of consumer price inflation, although almost all subsequent variants have employed a measure of inflation at the consumer level. (Taylor, 1993).

components of final demand than consumption expenditures, but in practice central banks seem to limit themselves to final consumption expenditures. The deflator for consumption expenditures in the national accounts are conceptually distinct from the cost of living based CPI, but the two tend to track each other fairly closely in most countries. The attractiveness of the cost of living based CPI as a price objective is due in part to the fact that it has a solid welfare theoretic basis (although a surprising number of national statistical agencies seem to go out of their way to claim that the CPIs they produce are not intended to measure changes in the cost of living). Consumption is the final objective of all economic activity, so why not use a measure of the cost of consumption as the objective for monetary policy? In practice many governments and central banks seem to have settled on the consumer price index as the preferred price objective for very practical reasons: it tends to be the measure which is produced with the greatest frequency, gets the most attention and with which most voters are most familiar.[6]

The issue of how best to combine individual prices in a single measure of the price level has been addressed by many economists over the years (see the excellent review by Diewert (2001) or the discussion in Afriat (2005)). The early literature vacillated between the objectives of measuring prices for the purposes of assessing changes in living standards, and measuring prices for the purposes of monetary policy. (Although of course at the time many of these early contributions were made, much of the world was on a commodity standard, and monetary policy to the extent that it existed, was rule based.) One of the clearest statements about the appropriate domain of measurement for monetary policy purposes was made by Irving Fisher in his treatise on *The Purchasing Power of Money*:

> "We are brought back …to the conclusion that on the whole the best index number for the purpose of a standard of deferred payments in business is the same index number which we found the best to indicate the changes in prices of all business done; - in other words, it is the P on the right hand side of the equation of exchange." (Fisher, 1920, p. 225)

Arguing from a classic quantity theory of money perspective, Fisher was suggesting that for the purposes of monetary policy, the prices of all goods and services exchanged

[6] See, for example Svensson (1999) or Issing (2001).

through monetary transactions ought to be included in the price index. However, he then went on to note

> "It is, of course, utterly impossible to secure data for all exchanges, nor would this be advisable. Only articles which are standardized, and only those the use of which remains through many years, are available and important enough to include. These specifications exclude real estate, and to some extent wages, retail prices, and securities, thus leaving practically nothing but wholesale prices of commodities to be included in the list of goods, the prices of which are to be compounded into an index number. These restrictions, however, are not as important as might be supposed." (Fisher, 1920, pp. 225-226)

Here Fisher was anticipating the measurement problems posed by quality adjustment and the arrival of new goods in measuring aggregate inflation. His solution was to focus simply on a very narrow set of goods, arguing that these standardized commodities should give us a good sense of where the overall price level was headed. Note that Fisher is here arguing against the inclusion of real estate and financial asset prices on very practical grounds rather than on the basis of any *a priori* economic theory. Anticipating the later contributions of Bryan and Pike (1991) and Bryan and Cecchetti (1994), Fisher then went on to note that "For practical purposes the median is one of the best index numbers. It may be computed in a small fraction of the time required for computing the more theoretically accurate index numbers, and it meets many of the tests of a good index number remarkably well." (p. 230)

However, even if one is reluctant to embrace the quantity theory perspective that informed Fisher's argument, a case can perhaps be made for looking at a wider range of prices when thinking about inflation measurement for the purposes of monetary policy. Consider the following basic identity:

$$\begin{matrix} Units\ of\ numeraire \\ per\ unit\ of\ good \end{matrix} = \begin{matrix} Units\ of\ numeraire \\ per\ unit\ of\ basket \end{matrix} \times \begin{matrix} Units\ of\ basket \\ per\ unit\ of\ good \end{matrix} \tag{1}$$

Mathematically we can write this in terms of rates of change as

$$\pi_{i,t} = \pi_t + \varepsilon_{i,t} \quad (2)$$

where $\pi_{i,t}$ denotes the rate of change in the (numeraire denominated) price of good *i*, π_t denotes the rate of change in the overall price level (units of numeraire per unit of the basket of goods) and $\varepsilon_{i,t}$ captures the idiosyncratic (relative) movements in the price of good *i*. The raw data generated by a monetary economy are the $\pi_{i,t}$. The object that is of interest to the central bank and ultimately controlled by it is π_t.

To measure the rate of change in the numeraire, π_t, some identifying assumptions must be made. The simplest is to assume that the relative price changes are all uncorrelated with each other and have a mean value of zero. Then it is straightforward to show that a simple average of individual price changes will be a maximum likelihood estimator of the rate of change of the numeraire.[7] This was the measure of general inflation proposed by Jevons (1865). Of course, the assumption of independent relative price changes strains credulity, as Keynes (1930) pointed out. In recent years, more elaborate identifying assumptions have been proposed. Bryan and Cecchetti (1993) proposed specifying simple time series processes for π_t and $\varepsilon_{i,t}$, while Reis and Watson (2007) use a somewhat more elaborate set of identifying assumptions.[8]

It is worth noting that the recent attempts to estimate the rate of change of the numeraire have limited the domain of measurement to consumer prices, components of the CPI in the case of Bryan and Cecchetti (1993), components of the deflator for personal consumption expenditure in the case of Reis and Watson (2007).[9] Of course, if we are

[7] See the discussion of the stochastic approach to index numbers in Chapter 16 of International Labour Office et al. (2004).

[8] See also Cecchetti and Wynne (2003) for an application of this approach to euro area data and an interpretation of the inflation series thus estimated as "monetary inflation.".

[9] Another point that should be kept in mind when using this approach to estimate changes in the value of the numeraire is that it is very important that the raw price series measure pure price changes only, and not some combination of price changes and shifts in expenditure patterns. This is not an issue when actual price data are used, which is almost never the case. Rather, indexes of individual price changes are used, and this may pose a problem: Fixed weight indexes will capture pure price changes, but chain weighted or superlative indexes generally will not.

interested in changes in the value of the numeraire, there is no reason to limit attention to just consumer prices. The logic of measuring changes in the value of the numeraire suggests that one should include all prices that are denominated in terms of the numeraire: consumer prices, producer prices, intermediate goods prices, even asset prices.[10] [11]This way of thinking about inflation measurement also suggests some important differences with the traditional cost of living perspective that underlies the calculation of consumer price indexes. For example, for the purposes of measuring changes in the value of the numeraire, one might want to look at the prices of houses, and not try to impute the value of the service flow from owner occupied housing. Second, whereas the cost of living perspective provides a natural way to deal with the arrival of new goods (due to Hicks (1940)), the numeraire or monetary approach does not. The dynamic factor models are usually estimated using data from the sub-components of an aggregate consumer price index with new goods simply linked in. Third, it is not clear how one ought to deal with quality changes. This applies to the prices of goods and services that are routinely included in a consumer price index, but also to the prices of assets that might also be included in calculating the value of the numeraire.

3. Headline versus "core"

According to **Table 1**, few central banks define their price objective in terms of a measure of core inflation. Nevertheless, the contemporary literature on the theory of monetary policy argues that a core measure of some sort is the appropriate objective for monetary policy. However, the concept of core inflation that the recent literature suggests is the appropriate target for monetary policy is slightly different from the concept as it is currently commonly used. I start by reviewing some of the arguments for traditional measures of core before proceeding to a discussion of the more recent literature.

[10] There are a few papers that take this more comprehensive approach to measuring inflation. One early example is the unpublished paper of Dow (1993). See also the Bryan, Cecchetti and O'Sullivan (2001, 2002). Bryan, Cecchetti and O'Sullivan (2001) extend the earlier dynamic factor model of Bryan and Cecchetti (1993) to include the prices of houses, stocks and bonds. Bryan, Cecchetti and O'Sullivan (2002) include in addition the prices of commodities, money and gold.

[11] But to the extent that all prices (or their rates of change) tend to move together over long periods of time, as Becsi (1994) suggests, focusing on a narrow set of well-measured prices might not be misleading.

3.1 The traditional case for core inflation

One argument that is occasionally made to support the use of traditional measures of core inflation in monetary policy deliberations is that the central bank does not control the price of energy or the price of food, and therefore should not be charged with stabilizing food or energy prices, or at least measures of inflation that include these prices. But just as central banks do not control the price of food or energy, nor do they control the price of clothing, entertainment, furniture or indeed any other individual component of the CPI. The most widely used measures of core inflation simply exclude the prices of specific goods, usually the prices of food and energy, on the grounds that these prices tend to be very volatile and convey little information about underlying inflation trends.[12] However, as many authors have pointed out, it is not always the case that food or energy prices are the most volatile or least informative about underlying trends. Not infrequently, large changes in monthly inflation rates occur that can be attributed to one-time shocks associated with tax changes, or other obviously transitory events. A common response is to simply discard these price changes and report the change in the index without them. Part of the motivation for the limited influence estimators of core inflation proposed by Bryan and Cecchetti (1994) is to put some discipline on the process of deciding which price signals to discard each month in computing core inflation. Indeed, this work has been very influential, and many central banks have explored the usefulness of trimmed mean or weighted median measure of core inflation.

However, these measures are not without their shortcomings. One of the most obvious is their inability to distinguish between transient and persistent extreme price movements. For example, the prices of electronic goods are routinely excluded from trimmed mean measures of core inflation, as the prices of these goods almost always show largest declines every month. Dolmas (2005) finds that, after the prices of fresh vegetables and eggs, the prices of computers and peripherals are the ones most frequently excluded from

[12] It goes without saying that measures of core inflation that simply exclude the prices of food and energy cannot be interpreted as providing an answer to the counterfactual question "What would inflation have been if the prices of food and energy had not increased?"

his (optimally) trimmed mean measure of PCE inflation. Also included in the 20 most-often-excluded components are the prices of software, video equipment and TVs. Arguably these prices should not be excluded to the extent that they are persistent and likely to occur the following month, and by excluding the trimmed mean measures of core arguably overstate the true trend rate of inflation.[13]

There are other good reasons why traditional measures of core inflation are unattractive for monetary policy purposes. To begin with, the traditional approaches lack a clear theoretical framework. As has been noted elsewhere, there are almost as many measures of core inflation as there are authors who have written on the topic. What criterion should be used to choose between them? One commonly used criterion is the ability to predict future headline inflation.[14] But if this is the objective of core inflation measurement, why limit oneself to the information in the cross section distribution of prices or the time series properties of prices. Why not use all available information? For example, Giannone and Matheson (2006) show that while their proposed new core inflation indicator (based on a dynamic factor model applied to disaggregated consumer price data) for New Zealand outperforms traditional measures in terms of its ability to predict future headline inflation, it is dominated by forecasts generated using a wider array of information. I would venture to suggest that this finding holds more generally.

Alternatively it is sometimes argued that measures of core inflation are intended to give real time estimates of the underlying trend of headline inflation. But again we might ask, why are such estimates of interest to policymakers? Perhaps a discrepancy between the headline rate of inflation and the underlying trend gives us a signal of where headline inflation might be headed in the future: headline inflation that is above trend might be

[13] A number of refinements of the trimming approach have been suggested in recent years o try to get around this problem. Pedersen (2005) suggests trimming the most volatile components of the cross-section distribution of prices rather than just the extremes. While this may address the immediate problem, it makes the core measure even more complex and difficult to explain to the general public.

[14] For example, Khettry and Mester (2006) evaluate several measures of core in terms of their ability to predict future headline CPI inflation and find that the traditional ex food and energy measure performs better than other measures. Rich and Steindel (2005) also find substantial predictive power for measures of core inflation, but only within sample. Out of sample they find that no single measure of core outperforms the others.

expected to fall in the future. But again, why not use all available information to asses the outlook for future headline inflation?

Finally, there is the problem that households consume the entire basket of consumer goods and not just some subset. There is the very real risk that a central bank that focuses on a measure of core inflation can be perceived as being out of touch, especially at times when there are large and persistent movements in the prices of the commodities that are excluded from the core measure.

In short, I would argue that there is little to support the use of traditional measures of core inflation as targets for monetary policy. There may be some merit in using them as part of central bank communications, but even there the case is less than overwhelming.[15] The best available measures are the cost of living based measures of inflation at the consumer level, although it is worth exploring alternative rationales for measures designed for monetary policy purposes. The Harmonized Index of Consumer Prices (HICP) that is used by the European Central Bank to quantify its mandate for price stability goes some of the way in this direction by taking as its measurement objective the cost of household final monetary consumption, although it too is not without problems.[16]

3.2 The newer case for core inflation

The literature on optimal monetary policy that has emerged in the past decade or so has produced a new set of rationales for monetary policy to focus on a measure of core inflation, albeit a measure that is quite distinct from the traditional measures. One of the more succinct statements of this view is in Woodford's (2003) *Interest and Prices*:[17]

[15] Issing (2001) argues against the use of core measure on the ground s that such measures are "…less transparent and more remote from the prices actually paid by the general public" (p. 193) and comes down strongly in favor of the traditional consumer price index as "…being familiar to the average consumer, easily understood, published regularly and in a timely fashion and infrequently revised." (p. 193)
[16] See the excellent review by Diewert (2002).
[17] See also Goodfriend and King (1997) and Mankiw and Reis (2003).

> "The prices that monetary policy should aim to stabilize are the ones that are infrequently adjusted and that consequently can be expected to become misaligned in an environment that requires these prices to move in either direction. Large movements in frequently adjusted prices – and stock prices are among the most flexible – can instead be allowed without raising such concerns, and if allowing them to move makes possible greater stability of the sticky prices, such instability of the flexible prices is desirable….central banks should target a measure of "core" inflation that places greater weight on those prices that are stickier. Furthermore, insofar as wages are also sticky, a desirable inflation target should take account of wage inflation as well as goods prices." (Woodford, 2003, 13-14)

A natural question to ask, therefore, is, How well do existing measures of core inflation measure the concept of core implicit in the new literature on monetary policy? The best known and most widely used measures of core inflation are the so-called exclusion measures, such as the CPI Ex. Food and Energy measure in the U.S. Almost all national statistical agencies compute a core measure of this type, with the details differing slightly from country to country. It is instructive, therefore, to compare these traditional measures of core with measures constructed so as to give greater weight to prices that change less frequently.

Our understanding of the frequency of price changes has been greatly enhanced in recent years by the work of Bils and Klenow (2004) and the various researchers associated with European Central Bank's inflation persistence network whose work is summarized by Dhyne et al. (2005, 2006). Bils and Klenow (2004) report statistics on the frequency of price changes for a large fraction of the US CPI at the level of Entry Level Items (ELIs) for the years 1995-1997. The 350 ELIs they report on cover 68.9 percent of consumer spending.[18] Examination of their Table A1 reveals that, sure enough, the ELI with the greatest frequency of price changes is "Regular unleaded gasoline" (ELI 47014), with a frequency of price change of 78.9 percent. Changes in the prices of gasoline are excluded from the traditional "Ex. Food & Energy" measure of core consumer price inflation. The ELI with the lowest frequency of price change was "Coin-operated apparel laundry and

[18] The major omissions are owner's equivalent rent and household insurance (which together had a relative importance in the CPI in December 1996 of 20.0 percent), renters costs (residential rent and other costs, which had a relative importance of 8.0 percent), used cars (which had a relative importance in the CPI in December 1996 of 1.3 percent).

dry cleaning" (ELI 44012)), with a frequency of price change of just 1.2 percent. Such prices are routinely included in the traditional "Ex. Food & Energy" measure of core consumer price inflation. And indeed inspection of Bils and Klenow's Table A1 reveals that many of the ELIs with the most frequent price changes are in the food or energy categories that would be discarded by a traditional "Ex. Food and Energy" measure of core inflation, while many of the ELIs with the least frequent price changes would be included.

However, further inspection of the same table also reveals that the traditional measure of core would include the prices of a lot of items for which price changes are quite frequent, such as "Airline fares" (ELI 53011), with a frequency of price changes of 69.1 percent, "Automobile rental" (ELI 52051), with a frequency of price change of 56.8 percent, and "Girls dresses and suits" (ELI 39012), with a frequency of price change of 55.1 percent. Likewise, the prices of many items that are typically discarded by the traditional "Ex. Food and Energy" measure of core change relatively infrequently, such as "Breakfast or brunch" (ELI 19032), "Lunch" (ELI 19011) or "Dinner" (ELI 19021), all components of the "Food away from home" component of the CPI, the components of which are well known to change infrequently.

Similarly detailed information on the frequency of price changes in the euro area has been compiled as part of the Eurosystem's Inflation Persistence Network. Dhyne et al. (2005, 2006) summarize the results of that research. The level of detail is not as great as in Bils and Klenow (2004), but the features of the data are similar to what was found in the US, namely that some, but not all, food and energy prices do change quite frequently. According to data presented in Table A8 of Dhyne et al. (2005), the three components of the euro area HICP with the greatest frequency of price changes are "Fuel type 1" (representative of COICOP 0722011100), "Fuel type 2" (representative of COICOP 0722013100) and "Lettuce" (representative of COICOP 0117110100). All are products that would typically be excluded from a traditional measure of core inflation. However, the same table also shows that a traditional measure of core would include the prices or a

number of goods whose prices change almost as frequently as some of the excluded items, such as “Fax machines”, “Television sets” and “Men’s shirts”.

Using the data from Bils and Klenow (2004) and Dhyne et al. (2005), we can construct alternative measures of core inflation that weight prices by the (inverse of the) frequency with which they change and compare the performance of these measures with traditional measures of headline and core inflation. Specifically, we construct a measure of core price level defined as follows

$$\tilde{P}_t = \sum_{i=1}^{I} \frac{\frac{1}{\varpi_i}}{\sum_{i=1}^{I} \frac{1}{\varpi_i}} p_{i,t} \qquad (3)$$

where ϖ_i is the frequency with which the prices of good i change, and $p_{i,t}$ is the price of good i at date *t*. We then use this measure of the core price level to compute measures of core inflation at the one-and twelve-month horizons. **Table 2** reports the weights we use for the US, along with the weights (relative importances) of the eight major expenditure categories in the US CPI. We see that weighting prices by the frequency with which they change leads to a significant decline in the weight attached to Housing and Transportation, and a significant increase in the weights assigned to Medical care and Education and communication.[19] **Figure 1** shows 12-month inflation rates for the headline CPI, the traditional core CPI excluding food and energy and the frequency weighted measure of core. Sticky price inflation in the US (labeled in the Figure as single weighted) is somewhat different from the traditional ex food and energy measure of core inflation.[20] The pairwise correlation between the two series is only 0.52 at the 12-month horizon. Both measures appear to be about equally volatile, and both are less volatile than headline inflation. (**Table 4**). **Figure 1** certainly suggests that a monetary policy rule that responded to sticky price inflation would look quite different from one that responded to a traditional measure of core.

[19] While Bils and Klenow’s dataset does not include information on the owner’s equivalent rent or household insurance components of housing, it does include information on other components of housing costs, such as fuel and utilities, and household furnishings and operation.

[20] The double weighted series in the Figures weight the components of the CPI using both the expenditure share weights and the weights reflecting the frequency of price changes.

Table 3 reports the same weights for the twelve major expenditure categories of the euro area HICP, and **Figure 2** plots the time series of the 12-month inflation rates along with the headline and traditional core measures. For the euro area there appears to be a much higher correlation between sticky price inflation and the traditional core measure than is the case in the US.[21] (**Table 5**) Sticky price inflation is about as volatile as headline inflation in the euro area, but the differences between both measures and the traditional measure of core are not that great, and one would have to conclude that a monetary policy rule based on sticky price inflation would probably not look too different from one based on a traditional measure of core.

These calculations are indicative of how one might go about constructing a measure of sticky price core inflation, and can certainly be improved upon. It would be worth exploring how the results change if we use more disaggregated data rather than the major expenditure categories, and if we included wage data as suggested by Woodford (2003).

4. Zero or …?

Table 1 shows that no central bank that has formally quantified its price stability objective has defined price stability as prevailing at a zero measured rate of inflation. If one had to pick an average rate of inflation that most central banks see as being consistent with price stability, 2 percent or something very close to it would be the obvious choice. One of the arguments most commonly made for defining price stability as prevailing at some positive measured rate of inflation is the possibility or probability that measured inflation rates overstate the true rate of inflation due to the failure of price statisticians to properly correct for improvements in the quality of goods over time, the arrival of new goods and the substitution of cheaper goods and services (and retail outlets) for more expensive ones.[22]

[21] Eurostat publishes several measures of core inflation for the euro area. Here I use the HICP excluding food, energy, alcohol and tobacco, but the result seems robust to the use of other measures.
[22] Other arguments commonly advanced for defining price stability as prevailing at some positive rate of inflation include the existence of downward rigidities in labor markets, and the desire to avoid the zero

The interest of the economics profession in the issue of measurement bias in price indexes seems to wax and wane. One of the earliest reviews of the accuracy of price statistics in the US was produced by the so-called Stigler Commission in 1961 (Price Statistics Review Committee (1961)). Introducing the discussion of the problems posed by quality changes, the Commission noted:

> "If a poll were taken of professional economists and statisticians, in all probability they would designate (and by a wide majority) the failure of the price indexes to take full account of quality changes as the most important defect in these indexes. And by almost as large a majority, they would believe that this failure introduces a systematic upward bias in the price indexes – that quality changes have on average been quality improvements.
>
> We have very little evidence at our disposal with which to support – or deny – the belief in progressive quality improvement. Indeed we are impressed with how little empirical work has been done on so widely held a view and potentially so important a problem. Changes in buyer's tastes will lead to the appearance of new goods – an uncontroversial example would be fashionable apparel – which are not improvements judged by either previous or subsequent tastes, and the line separating taste changes form quality improvements will depend on the time span invoked." (Price Statistics Review Committee, 1961, p. 35)

The Stigler committee's characterization of the prior beliefs of many economists remains as true today as when it was written nearly half a century ago. The prior of many economists seems to be predicated on a view that statistical agencies do not make <u>any</u> adjustments for quality changes when computing inflation statistics which in many, if not all, cases is simply not true. The real issue has to do with how adequately the procedures the statistical agencies employ correct for quality changes. We do know a bit more about the potential biases in measures of inflation today than was the case forty five years ago, but despite the progress there is arguably more that we don't know.

In the 1990s there was something of a resurgence of interest in the issue price measurement. The extraordinary rates of decline in the prices of high tech goods that accompanied the information technology revolution highlighted the problems associated

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bound on nominal interest rates. I will not touch on these arguments here, but instead focus on the measurement issues.

with the use of fixed weight indexes for the measurement of prices and quantities in the US national income and products accounts and ultimately led to the adoption of the Fisher chain-weighted indexes in the national accounts in 1996. Federal Reserve Chairman Alan Greenspan drew the attention of US lawmakers to the measurement problems posed by rapid innovation.[23] Questions about the accuracy of the CPI generated more interest when it was pointed out that, due the widespread use of the CPI for indexation of taxes and benefit payments, measurement error had potentially significant fiscal implications. The consequence was the creation of the Boskin Commission, which issued its final report in December 1996 (Boskin et al. (1996)), concluding that the CPI as then constructed overstated the rate of increase in the true cost of living index by about 1.1 percentage points a year, with a range of plausible values between 0.8 and 1.6 percentage points a year.

Subsequent to the publication of the Boskin report there were a number of improvements to the US CPI, including more frequent updating of upper level weights, a change in lower level weights and the introduction of the chained CPI (C-CPI-U) series. The debate over the accuracy of the US CPI also led the Federal Reserve to shift away from the CPI to the deflator for personal consumption expenditures (PCE) as its preferred measure of inflation. The shift occurred with the publication of the February 2000 *Monetary Policy Report to the Congress*.[24] [25]

[23] See Greenspan (1994b, 1995).

[24] In explaining the switch the Board of Governors noted "The chain-type price index for PCE draws extensively on data from the consumer price index but, while not entirely free of measurement problems, has several advantages relative to the CPI. The PCE chain type index is constructed from a formula that reflects the changing composition of spending and thereby avoids some of the upward bias associated with the fixed-weight nature of the CPI. In addition, the weights are based on a more comprehensive measure of expenditures. Finally, historical data used in the PCE price index can be revised to account for newly available information and for improvements in measurement techniques, including those that affect source data from the CPI; the result is a more consistent series over time. This switch in presentation notwithstanding, the FOMC will continue to rely on a variety of aggregate price measures, as well as other information on prices and costs, in assessing the path of inflation." (Board of Governors of the Federal Reserve System, 2000).

[25] In July 2004, the FOMC again changed its preferred measure of inflation to the so called core PCE deflator (i.e. the price index for personal consumption expenditures excluding food and energy) on the grounds that the Committee believed it was "…better as an indicator of underlying inflation trends than …the overall PCE price measure previously featured." (Board of Governors of the Federal Reserve System, 2004).

The publication of the Boskin Commission report in the US prompted similar reviews of the accuracy of measures of consumer price inflation in other countries. Wynne and Palenzuela (2004) summarized state of knowledge for the countries of the EU as of early 2000s, and concluded that there was not much hard evidence to base an assessment on one way or another. Indeed, many of the reviews of the accuracy of price statistics in countries other than the US seemed to reach surprisingly sanguine conclusions, given the limited amount of research available. Since Boskin and the mini-literature it spawned, the issue of measurement bias in price statistics seems to have declined. One recent contribution is Broda and Weinstein (2007), who critically assess the accuracy of the Japanese CPI and argue that the measurement problems are a lot more severe than previous studies have suggested, on the order of magnitude of 2 percentage points a year relative to a true cost of living index, that is, more than twice the 0.9 percent estimate of Shiratsuka (1999).

Nevertheless, the fact remains that our knowledge of the extent of measurement bias in measures of consumer price inflation is at best limited. Research has shown that the widespread perception that the biases are all in one direction (causing measured inflation to always overstate the true rate of inflation) is simply wrong. Work by Gordon (2004) and Gordon and vanGoethem (2004) found evidence of significant downward biases in major components of the US CPI. Røed Larsen's (2007) application to Norwegian data of Hamilton's (2001) approach to estimating bias using Engel Curve estimates led him to conclude that the CPI in Norway understates the rate of increase in the cost of living.[26] Of course it only makes sense to talk about measurement bias when there is a well defined theoretical ideal which the measured index is supposed to approximate: in the case of the US CPI, the measurement objective is the cost of living index, but many statistical agencies explicitly eschew this as the measurement objective, the HICP being one of the more prominent examples.[27]

[26] Beatty and Røed Larsen (2005) apply the same approach to the Canadian CPI and find that it overstates the rate of increase in the cost of living.

[27] As noted by the European Commission "The HICPs can all be said to meet their purpose of "measuring inflation faced by consumers" to a degree which is unknown (and perhaps unknowable) because there is no reference by which to determine the extent of any bias." (Commission of the European Communities, 1998, p. 11)

Finally, it is worth asking just how costly it might be for a central bank to tolerate a long-run measured inflation rate of 2 percent per annum if there was no measurement error. Feldstein (1997) estimated the net benefits of going from 2 percent inflation to zero inflation, and found that they were substantial. The benefits for the US were on the order of magnitude of 1 percent of GDP a year, against which one has to offset one-time costs on the order of magnitude of 5 percent of GDP. The present discounted value of gains equal to 1 percent of GDP in perpetuity is equal to 38.5 percent of initial GDP (if we discount using an average growth rate for GDP of 2.5 percent, and a discount factor of 5.1 percent) so the benefits clearly outweigh the costs. Subsequent research employing Feldstein's methodology by Tödter and Ziebarth (1999), Dolado, González-Páramo and Viñals (1999) and Bakhshi, Haldane and Hatch (1999) found that the benefits of going from 2 percent to zero inflation were on the order of 1.4 percent of GDP for German, 1.7 percent of GDP for Spain but only 0.2 percent of GDP for the UK.[28]

5. Asset prices again

Finally, I want to return to the issue of whether the prices of assets should be included in the measure of inflation used to define price stability. There are well-known differences of opinion among leading central bankers on whether monetary policy should respond to changes in asset prices, whether the prices of financial assets or real assets such as housing. Woodford (2003), for example, argues against the inclusion of asset prices in the measure of inflation targeted by central banks:

> "The near-optimal policy stabilizes an inflation measure that puts more weight on prices in the sector where they are stickier…this provides theoretical justification for a policy that targets core inflation rather than the growth of a broader price index, and offers a theoretical criterion for the construction of such an index. It also explains why it is not appropriate to target an inflation measure that includes "asset-price inflation" along with goods-price increases, as is sometimes proposed: even if asset prices are also prices and can also be affected by monetary

[28] Our confidence in the estimates of the size of the benefits of going from 2 percent to zero is enhanced by the fact that Abel (1997, 1999) arrives at very similar estimates using a very different (general equilibrium model) approach.

> policy, they are among the prices that are the most frequently adjusted in response to new market conditions, and so their movements do not indicate the kind of distortions that one seeks to minimize." (Woodford, 2003, pp. 440-441)

Others argue against the inclusion of asset prices on the grounds that it can be difficult when movements in such prices are excessive or not justified by fundamentals (a variant of the quality adjustment problem). The counterargument is that rapid growth in asset prices can be indicative of loose monetary conditions and should be responded to by monetary policy.[29] I am not going to resolve that debate here, but I do want to offer a provocative hypothesis.

As noted above all central banks with explicit numerical price objectives have defined price stability in terms of a measure of inflation at the consumer level. In some cases, the measure of consumer price inflation does not include the cost of owner occupied housing (for example the euro area and the UK). In those countries where the cost of owner occupied housing is included in the measure of inflation at the consumer level, it is only the cost of the service flow. The question I want to pose is, Have asset price booms (and busts), and in particular, house price booms, been more common in countries that have focused on inflation (as measured by a conventional CPI) over the past decade than elsewhere? For example, in the UK home prices are estimated to have tripled over the past 15 years, during which time the Bank of England has been practicing orthodox inflation targeting. A number of countries in the euro area, such as Ireland and Spain, have also experienced large increases in house prices in recent years. Is it possible that by focusing on too narrow a measure of inflation, central banks have contributed to these booms?

In **Table 6** I report the results of a simple least squares regression of the average annual increase in house prices on real GDP growth, the share of trade in GDP, a measure of long term real interest rates and a dummy variable for the presence of an inflation target. Real GDP growth is included as a key fundamental variable driving house prices: faster

[29] See, for example, Cecchetti, Genberg, Lipsky and Wadhwani (2000).

income growth is usually associated with faster house price appreciation, other things being equal. Indeed the elasticity of house prices with respect to real disposable income is often estimated to be greater than 1 (Girouard et al. (2006)). However, over the past decade we have seen a growing number of countries experiencing extraordinarily rapid increases in house prices. Girouard et al. (2006) show the number of countries in their 17-country sample experiencing house price increases in excess of 25% over the previous five years steadily increasing since the mid 1990s. Over that same period, globalization has emerged as a major influence on inflation dynamics, and inflation targeting has become increasingly popular as a framework for monetary policy. Is it possible that the favorable supply shock that globalization represented (at least until recently) acting in conjunction with an emphasis on inflation measures at the consumer level in many countries helped spark a house price boom that might not otherwise have occurred had central banks taken a broader perspective on inflation? The simple results in **Table 6** suggest that there may be something to this. While the coefficient on the importance of foreign trade is not significant, the coefficient on the inflation targeting dummy is. That is, house price inflation appears to have been greater in countries with formal inflation targets or explicit numerical price objectives, even when we control for the rate of growth and the level of real interest rates. Perhaps house price appreciation would have been more in line with overall inflation developments if central banks in these countries adopted a more comprehensive definition of price stability.

6. Conclusions

Central banks ought to be leaders in the area of price measurement, given the importance of the issue to their objectives. It behooves the staffs of central banks around the world to have a better understanding of how the measures of inflation which guide theory policy decisions are constructed and to be engaged in an ongoing constrictive dialog with eth statisticians who produce these indexes to find ways to improve them. It is probably going too far for central banks to take a lead role in the production of the price statistics by which their performance will be judged, although if they were to be sufficiently transparent about what they do this need not pose a major conflict of interest.

The accurate measurement of inflation for monetary policy purposes will continue to be a challenge going forward. Measures of headline inflation at the consumer level that take as their measurement objective the cost of living are probably the best for defining price stability, given the current state of knowledge, but there are potential alternatives. Ideally, price stability should be defined in terms of the price index that best captures the cost of inflation to society. The cost of living index is a welfare based measure, but it could conceivably be too narrow for monetary policy purposes. The proposed approach of Reis and Watson (2007) deserves further examination. But even within the cost of living framework, there will be significant challenges going forward. The accurate measurement of service prices will grow in importance, as will the need to figure out how best to deal with the costs of owner occupied housing.[30] The proper treatment of the gains from the arrival in the marketplace of new goods, whether domestically produced or imported, will continue to pose challenges. And these challenges have to be addressed. Defining price stability at a positive measured rate of inflation is costly to society if measurement error is not as significant as some believe.

I have argued that it is inappropriate for central banks to target measures of core inflation for a variety of reasons. However, the modern theory of monetary policy suggests that central banks should target sticky price inflation, which some have interpreted as being the same as core inflation. Above I presented some preliminary estimates of sticky price inflation using the data on the frequency of price changes in Bils and Klenow (2004) and Dhyne et al. (2005). For the US at least, there seem to be some notable differences between sticky price inflation, at least as I calculated it, and a more traditional measure of core inflation. There is clearly scope for further exploration of the concept of sticky price inflation. My simple estimates only used data on the frequency of price changes. Some argue that the appropriate index should also include wages, but the relevant data on the frequency of wage changes is not readily available.

[30] McCarthy (2007) documents the problems posed by the treatment of owner-occupied housing in the Irish CPI.

Recent experience underlines the need for a better understanding of how asset prices ought to be treated in defining price stability. One of the central challenges facing statisticians is coming up with an appropriate treatment of the cost of the service flow from owner occupied housing in measures of consumer price inflation. But there might be grounds for taking a broader perspective on what constitutes price stability. I reported some simple statistical results that suggest that house price booms have been greater in countries that have explicit numerical price objectives. It is worth exploring further whether this is a robust result, and if so, what explains it.

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Table 1 Numerical definitions of price stability		
Country	**Target Definition**	**Target Index**
Australia	2 – 3	CPI
Brazil	4.5 ± 2	CPI
Canada	2 ± 1	CPI
Chile	2 – 4	CPI
Colombia	3 – 4.5	CPI
Czech Republic	3	CPI
Hungary	3	CPI
Iceland	2.5 ± 1.5	CPI
Israel	1 – 3	CPI
Mexico	3 ± 1	CPI
New Zealand	1 – 3	CPI
Norway	2.5	CPI*
Peru	2 ± 1	CPI
Philippines	4 – 5	CPI
Poland	2.5 ± 1	CPI
South Korea	3 ± 1	CPI
South Africa	3 – 6	CPI
Sweden	2 ± 1	CPI
Thailand	2 ± 1	CPI core
United Kingdom	2	CPI (HICP)
Euro area	< 2	CPI (HICP)
Japan	0-2	CPI
Switzerland	< 2	CPI

Notes to Table: Definitions as of mid-2007. Sources: Berg (2005), Truman (2003) and national central bank websites.* The legislation defining Norway's inflation targets states that "In general, the direct effects on consumer prices resulting from changes in interest rates, taxes, excise duties and extraordinary temporary disturbances shall not be taken into account." Many countries have changed their target definition over time. Canada: 1991 -- 3, 1992 -- 2.5. Chile: 1990-1999 -- unknown, 2000 -- 3.5. Colombia: 2000 – 9, 2001 – 8, 2002 – 6, 2003-2004 – 5-6, 2006 – 4-5. Czech Republic: 1998 – 5.5-6.5, 1999 – 4-5, 2000 – 3.5-5.5, 2001 – 2-4, 2002-2005 – 3-5 to 2-4 (rolling band). Hungary: 2001 – 7±1, 2002 – 4.5±1, 2003-2004 – 3.5±1, 2005 – 4±1, 2006 – 3.5±1. Iceland: 2001 – 2.5±3.5, 2002 – 2.5±2. Israel: 1992 – 14-15, 1993 – 10, 1994 – 8, 1995 – 8-11, 1996 – 8-10, 1997-1998 – 7-10, 1999 – 4, 2000 – 3-4, 2001 – 2.5-3.5, 2002 – 2-3. Mexico: 1995-2003 – unknown. New Zealand: 1990-1995 – 0-2, 1996 – 0-3, 1997-1998 – 0-3 (indexed to CPIX), 1999-2001 – 0-3. Peru: 2002-2006 – 2.5±1. Philippines: 2002 – 5-6, 2003 – 5.5-6.5, 2004 – 4.5, 2005 – 5-6. Poland: 1998 – 9.5, 1999 – 8-8.5, 2000 – 5.4-6.8, 2001-2002 – 6-8, 2003 – below 4. South Korea: 1998 – 9±1, 1999 – 8-8.5, 2000 – 2.5±1, 2001

– 3±1 2002 – 2.5, 2003-2006 – 2.5-3.5. United Kingdom: 1992-1994 – 1-4, 1995-1996 – equal to or below 2.5, 1997-2002 – 2.5 (RPIX until 2003).

Table 2 Alternative weights for measures of US inflation		
	CPI-U	**Frequency weighted measure**
Food and beverages	0.16	0.06
Housing	0.41	0.10
Apparel	0.04	0.07
Transportation	0.17	0.07
Medical care	0.06	0.21
Recreation	0.06	0.15
Education and communication	0.06	0.18
Other goods and services	0.04	0.15

Notes to table: Weights for CPI-U are averages of the relative importances of the expenditure category over 19970-2007. Frequency weights are based on the frequency of price changes reported in Table A1 of Bils and Klenow (2004).

Table 3 Alternative weights for measures of euro area inflation		
	HICP weight	**Frequency**
Food & non-alcoholic beverages	0.17	0.03
Alcohol & tobacco	0.04	0.06
Clothing	0.08	0.12
Housing	0.16	0.05
Household equipment	0.08	0.14
Health	0.03	0.00*
Transport	0.16	0.03
Communications	0.03	0.07
Recreation & culture	0.10	0.15
Education	0.01	0.00*
Hotels and Restaurants	0.09	0.20
Miscellaneous	0.07	0.14

Note to table: Frequency weights based on the data reported in Table A8 of Dhyne et al. (2005). * No data on the frequency of price changes for the Health or Education expenditure categories are reported by Dhyne et al. (2005).

Table 4 Alternative measures of US inflation Descriptive statistics				
	Core	**Headline**	**Inverse-frequency weighted**	**Inverse-frequency and CPI weighted**
Mean				
12 month	2.20	2.56	2.56	2.60
1 month	0.18	0.21	0.21	0.21
Std Dev				
12 month	0.40	0.84	0.37	0.57
1 month	0.08	0.25	0.14	0.18
AR (1)				
12 month	0.95	0.89	0.85	0.88
1 month	-0.02	0.25	0.01	0.18
Correlation with inverse-frequency weighted				
12 month	0.52	0.84		
1 month	0.41	0.79		
Correlation with inverse-frequency and CPI weighted				
12 month	0.28	0.98		
1 month	0.25	0.96		

Notes to Table: Sample period: 1990:01 to 2007:08. Core defined as CPI-U less food and energy.

Table 5 Alternative measures of euro area inflation Descriptive statistics				
	Core	**Headline**	**Inverse-frequency weighted**	**Inverse-frequency and CPI weighted**
Mean				
12 month	1.63	1.93	1.49	1.68
1 month	0.14	0.16	0.13	0.14
Std Dev				
12 month	0.44	0.49	0.49	0.44
1 month	0.29	0.23	0.37	0.30
AR (1)				
12 month	0.96	0.92	0.94	0.93
1 month	-0.01	0.08	-0.13	-0.05
Correlation with inverse-frequency weighted				
12 month	0.94	0.59		
1 month	0.98	0.84		
Correlation with inverse-frequency and CPI weighted				
12 month	0.78	0.87		
1 month	0.95	0.92		

Notes to Table: Sample period: 1995:01 to 2007:09. Core defined as HICP excluding food, energy, alcohol and tobacco.

Figure 1
Alternative Measures of United States Inflation

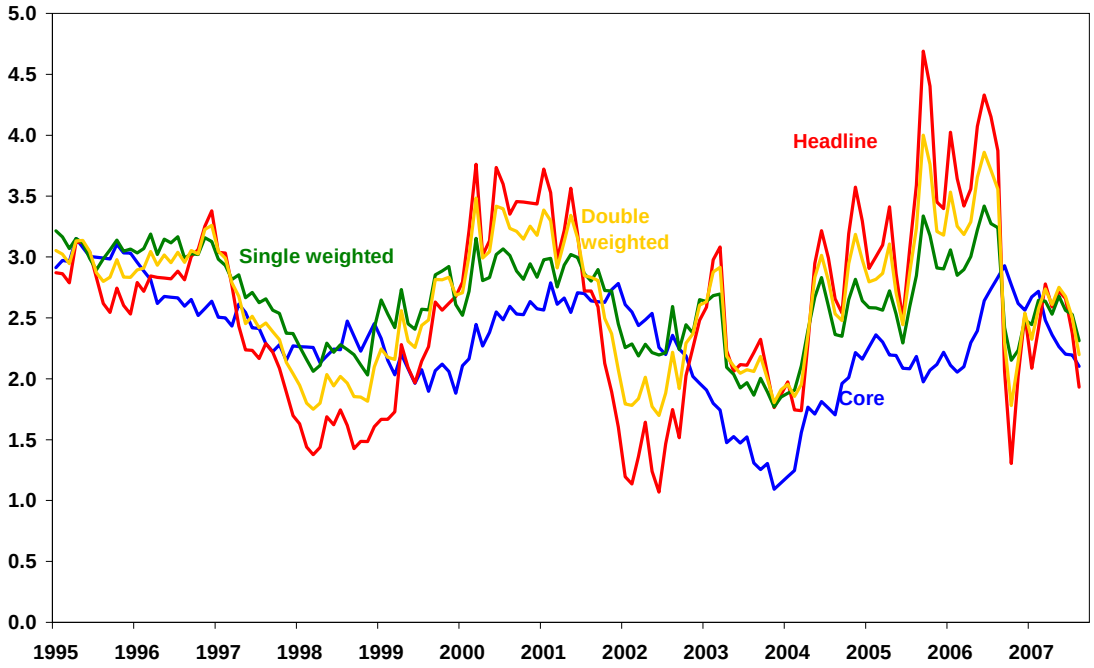

Figure 2
Alternative Measures of Euro-area Inflation

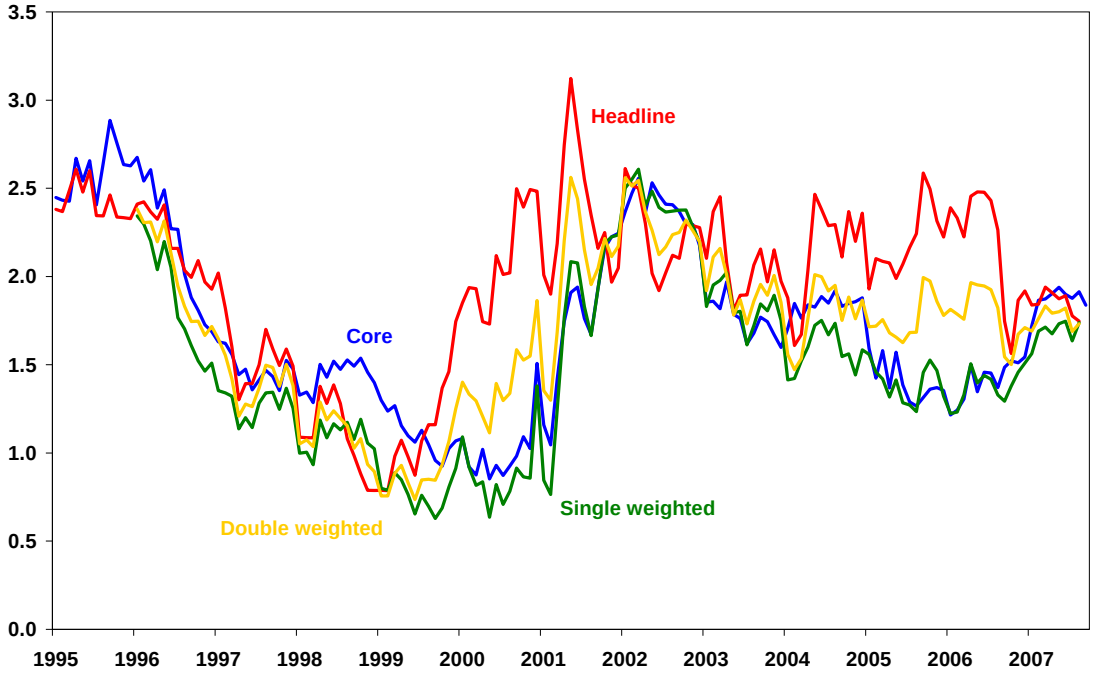

Table 6

	Coefficient	Std. Error	t-Statistic	Prob.
CONSTANT	-2.681909	1.352301	-1.983219	0.0517
GDP GROWTH	2.083364	0.315563	6.602049	0.0000
INFLATION TARGET	2.878636	0.865352	3.326550	0.0015
TRADE SHARE	0.009643	0.015066	0.640074	0.5244
INTEREST RATE	-0.600004	0.224206	-2.676132	0.0095

R-squared	0.558238	Mean dependent var	2.455882
Adjusted R-squared	0.530190	S.D. dependent var	4.743523
S.E. of regression	3.251339	Akaike info criterion	5.266697
Sum squared resid	665.9861	Schwarz criterion	5.429896
Log likelihood	-174.0677	Hannan-Quinn criter.	5.331362
F-statistic	19.90268	Durbin-Watson stat	2.188279
Prob(F-statistic)	0.000000		

Notes to Table: Dependent variable: Average annual increase in house prices. Countries included: US, Japan, Germany, France, Italy, UK, Canada, Australia, Denmark, Finland, Ireland, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland. Data from Box I.3 of OECD Economic Outlook 79, June 2006, which are in turn updated series from Girouard et al. (2006). Data averaged over 1970-1990, 1990-95, 1995-2000, 2000-2005. Inflation target dummy is 1 for periods during which countries have an inflation target or explicit numerical price objective.