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Asset Prices as Indicators of Euro Area Monetary Policy: An Empirical Assessment of Their Role in a Taylor Rule*

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Abstract: This paper estimates forward-looking and forecast-based Taylor rules for France, Germany, Italy, and the euro area. Performing extensive tests for over-identifying restrictions and instrument relevance, we find that asset prices can be highly relevant as instruments in policy rules. While asset prices improve Taylor rule estimates, different assets prove most relevant across countries and this result could be seen as complicating the tasks of the European Central Bank. Encompassing tests show that forecast-based outperform forward-looking Taylor rules. A policy implication is that central banks ought to release their own forecasts and the basis upon which they are generated.

Keywords: Monetary policy reaction functions, Asset prices, Instruments, European Central Bank

JEL Codes: E52, E58, C52

1. Introduction

The creation of the European Central Bank (ECB), followed by the start of European Monetary Union (EMU), resulted in a historic transfer of responsibility for monetary policy from many central banks to a single supra-national authority. The creation of a single monetary policy took place at a time when central banks were becoming increasingly pre-occupied with the behavior of financial asset prices.

It is unlikely that all economic shocks had the same impact in each of the prospective euro area member states before, or even after, EMU. Moreover, at least until the end of 1998, it is likely that these shocks might have elicited different monetary policy responses. The behavior of short-term interest rates around 1999 reveals that while convergence in interest rates took place, it only becomes visually apparent the year before the ECB took over responsibility for monetary policy in the euro area. Prior to that time, interest rate spreads are sizeable and variable. Even if interest rate convergence is assumed to have taken place, there is still considerable inflation divergence (e.g., Busetti et al. 2006). This may create difficulties in the long-run for a common currency area and complicate the implementation of a single monetary policy.

It is now standard practice to evaluate monetary policy based on Taylor rules, a device that explains central banks' reactions to inflation and the output gap. Whereas inflation performance used to be interpreted through the behavior of consumer prices alone, more questions are being asked about whether asset prices may indirectly have also played a role in the conduct of monetary policy (e.g., Bernanke 2004, European Central Bank 2001, 2005).

Yet, central bankers are also unsure about how much, if any, information is contained in asset prices beyond that which can be derived from the past history of inflation and output.[1]

It is unclear whether monetary authorities worry over perceived excesses in asset prices relative to some equilibrium or fundamental value, as opposed to their volatility. The transition to EMU may also have prompted some of the candidate national central banks to voice concerns over specific asset prices, depending on their perceived importance in potentially influencing inflation or output growth in their respective national economies. Consequently, whereas real exchange rate considerations may have mattered relatively more in the conduct of monetary policy for some countries, housing or equity price developments likely loomed larger in others.

Not to be forgotten is the role of monetary aggregates. The ECB has been criticized for its emphasis on 'money', as part of its two pillars strategy of monetary policy (e.g., Gerlach and Svensson 2003, but see Scheller 2004). However, a long-run view of the role of money as a determinant of inflation might wish to treat money seriously (von Hagen and Hofmann

[1] Bernanke (2005) suggests that "Central bankers naturally play close attention to interest rates and asset prices, … [they] are potentially valuable sources of timely information about economic and financial conditions … [and] should embody a great deal of investors' collective information and beliefs about the future course of the economy." Others, including Alan Greenspan, have suggested either that asset prices have only an indirect effect on interest rates or were largely ignored in the past (Norris 2005). Greithner (2006), President of the New York Fed, is somewhat more emphatic about the role of asset prices in monetary policy: "… monetary policy still has to take into account the impact of significant movements in asset values on output and inflation."

2007). Indeed, evincing a concern for other types of asset prices could signal a form of "tunnel vision" in the conduct of monetary policy (European Central Bank 2005). The best that can be said then about the link between asset prices and interest rates is that central bankers are conflicted about their role in influencing policy.[2] In any event, whether asset price developments play a role in interest rate developments in the euro area prior to and since the creation of the ECB is an empirical question. In this paper, we are primarily interested in the indicator properties of different asset prices.

It is widely assumed that policy-making is forward-looking. Depending on the form of the reaction function, this requires variables that are unobservable. Current best practice involves estimating forward-looking Taylor rules using instrumental variables approaches. Our approach asks whether asset prices are relevant instruments in an econometric sense. Currently, relatively little attention is paid to choosing instruments, and still less whether they are statistically relevant in an estimated reaction function. We are the first to report a series of instrument relevance tests for monetary policy rules, and the results shed light on the potential dissimilar concerns faced by euro area central banks prior to EMU.[3] Hence,

[2] "It is far from obvious that bubbles, even if identified early, can be preempted at a lower cost than a substantial economic contraction and possible financial destabilization – the very outcomes we would be seeking to avoid." (Greenspan 2004). Gruen, Plumb, and Stone (2005) show that the informational requirements needed to support an activist response to asset price bubbles are quite substantial.

[3] We are not, of course, the first or the only authors of a study to consider asset prices as instruments. For example, see Chadha, Sarno, and Valente (2004).

while estimated rules may look alike across the countries considered, the information sets that produce the seemingly comparable outcomes differ.

An alternative approach asks how central banks set interest rates in response to forecasts published by private and public agencies, other than central banks themselves. These are viewed as proxies for central bank forecasts. Such forecasts, at least indirectly, may incorporate asset price developments if they are indicators of future inflation and output developments (e.g., Svensson 2003). There have been comparatively fewer attempts to estimate, and empirically evaluate, forecast-based Taylor rules. Since forward-looking and forecast-based policy rules are non-nested hypotheses of interest rate determination, we also report encompassing tests to decide whether one type of rule is capable of statistically dominating the other.

The plan of the paper is as follows. The next two sections discuss the potential role of asset prices as indicators of monetary policy actions as well as the estimation and testing strategy. We then report estimates of forward-looking and forecast-based Taylor rules for three core euro area countries, namely France, Germany, and Italy.[4] The paper concludes with a summary and conclusions are drawn.

Briefly, adding assets prices as instruments in forward-looking Taylor rules produces not only more plausible reaction functions but ones that achieve a better fit. However, the asset

[4] Policy rules for smaller euro area members including Austria, Belgium, Finland, and the Netherlands were also examined. As these did not materially affect the conclusions reported below, we do not discuss them any further. Also see Eleftheriou, Gerdesmeier, and Roffia (2006). The real GDP of the three core area countries considered in this paper accounts for roughly three-quarters of euro area-wide real GDP.

price found to be most relevant in a statistical sense differs across the countries considered. For example, a monetary aggregate usually performs well for most countries considered but estimates can be improved by taking into account equity or housing prices. We interpret these results to mean that asset price developments influenced expectations of inflation and the output gap in core euro area countries. However, as different asset prices appeared to influence monetary policy setting behavior in individual euro area countries this could be construed as complicating the task of the ECB. Finally, forecast-based Taylor rules encompass forward-looking Taylor rules in each country, as well as for the euro area as a whole. A policy implication is that central banks that possibly have some comparative informational and technical advantage in the production of such forecasts, should routinely make such forecasts publicly available.[5]

2. Asset Prices as Indicators in Taylor Rules

While tradition, and a considerable amount of empirical evidence, points to inflation, output, and a desire to minimize interest rate volatility as chief among the concerns of most central banks (e.g., Favero and Rovelli 2003, but see Rudebusch 2002 and Lansing 2002), recent events have prompted some researchers to consider the possibility that asset prices

[5] Since 2003, the ECB publishes the Survey of Professional Forecasters (http://www.ecb.int/stats/spf). The data only go back to 1999. Note that these are not the ECB's forecasts. When using central bank forecasts there is potentially an additional complication for the consumers of such forecasts (Goodhart 2005). Also published semi-annually are the Eurosystem staff macroeconomic projections for the euro are (http://www.ecb.int.mopo/html/index.en.html).

also play a role in a policy reaction function.[6] Asset prices have been considered by some as a separate determinant of interest rates while others have argued against the notion that a central bank might indirectly react to such variables. For example, Bernanke and Gertler (1999) make the case against including a reaction to asset prices whereas Cecchetti et al. (2000) argue in favor of adding equity returns to a standard Taylor rule. Filardo (2004) points out that if non-fundamental asset price movements can have real economic effects, then they should be incorporated into the central bank's policy rule.

Since the debate partly centers on the information content of asset prices for the future course of the economy, this paper tackles the issue from a different angle.[7] There is little doubt that central bankers monitor asset price developments, though it is unclear whether this is a long standing practice or a more recent development. It is also debatable whether some asset prices (e.g., exchange rates) attract more attention than others (e.g., equity or housing prices) from the monetary authorities. In any event, as argued by Clarida (2001, p. 318), the guiding principle implicit in the forward-looking Taylor rule concept, is that "…central banks look at everything but only to the extent that "everything" is useful in forecasting inflation and possibly output."

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[6] While part of the debate has turned on whether the monetary authority should target asset price developments, central banks have argued against this position because they treat asset prices as forward-looking indicators of inflation and/or the output gap.

[7] Still another alternative, not considered in this paper, is to broaden the definition of inflation. Goodhart (2001), for example, advocates a measure of inflation that goes beyond merely incorporating the effects of changing prices for goods and services to also include the impact of equity and housing prices.

Since asset prices are obvious candidates for addressing this issue we examine their role as instruments for inflation and the output gap in forward-looking Taylor rules. For most euro area economies one might well argue that policy makers have undoubtedly been concerned with real exchange rate movements (Leitemo 1999, Leitemo and Røisland 1999, Medina and Valdés 2002). In the past several years, however, attention has turned to the behavior of equity, housing, or some other asset price indicators, as central banks are increasingly seen as having to stem the cycle of booms and busts in asset prices. Indeed, central banks can be thought of as reacting to some weighted average or linear combination of asset prices (Smets 1997).

Financial innovations since the 1980s, and the shift in emphasis in the conduct of monetary policy toward reliance on an interest rate instrument, have reduced the predictive role of monetary aggregates for inflation in the long-run and output in the short-run. Nevertheless, monetary aggregates play a role in the operational framework of the ECB (see http://www.ecb.int/mopo/html/index.en.html), and its key progenitor prior to 1999, namely the Deutsche Bundesbank. Hence, as did Clarida, Gali, and Gertler (1998), and Gerdesmeier and Roffia (2004), we also consider a monetary aggregate.

Theories that treat asset price movements as indicators of future inflation or economic activity have a long tradition but empirical evidence has had a more difficult time reaching anything approaching a consensus (Stock and Watson 2003, 2007). Even if it is deemed desirable to incorporate a role for asset prices, the investigator faces a number of additional difficulties. In particular, there is no widespread agreement on how best to define equilibrium real exchange rate or asset price levels though these problems seem no less intractable than defining the "trend" in output used in deriving an output gap measure.[8] Following most authors, we rely on variations of standard filters to approximate the variables of interest.

Table 1 presents a selection of published estimates of Taylor rules, primarily for euro area countries. Only estimates of forward-looking and forecast-based reaction functions are shown though several backward-looking Taylor rule estimates have also been published. The steady-state estimates for inflation tend to be consistent with the Taylor principle, according to which a larger than unit nominal interest rate response is required for any unit increase in inflation. Table 1 also reveals considerable variation in the estimated weights on the inflation and output gap objectives, the role of asset prices is usually not investigated, nor is the robustness of results or the relative suitability of forward- or forecast-based models extensively analyzed.[9]

Table 1 about here

Bernanke and Gertler (1999) examine how stock prices affect interest rate determination in the U.S. and Japan. Cecchetti (2003) also reports that the Fed reacted to stock market developments relying again on a Taylor rule. Clarida, Gali, and Gertler (1998) add a real exchange rate, as do Gerdesmeier and Roffia (2004), with mixed results at best. While a real exchange rate variable in a Taylor rule can be statistically significant, it is generally economically small (also see Taylor 2001, and Leitemo and Söderström 2001). Indeed,

[8] In the case of equity and possibly housing prices, matters are complicated still further because there is possibly an element of "irrational exuberance" or a "bubble" component that is difficult to measure empirically. This paper does not address all of these issues.

[9] Gerdesmeier and Roffia (2004) perform an extensive comparison of forward- versus backward-looking Taylor rules for the euro area.

Clarida, Gali, and Gertler (2001) argue that closed and open economy policy rules ought to be qualitatively the same (also see Clarida 2001).

3. Estimation and Testing Strategy

We begin with a standard version of Taylor's rule:

$$i_t = \bar{i} + \gamma_{\tilde{\pi}} \tilde{\pi}_t + \gamma_{\tilde{y}} \tilde{y}_t + \rho i_{t-1} + \upsilon_t , \tag{1}$$

where i_t is the nominal interest rate instrument of monetary policy, $\bar{i} = (1-\rho)\alpha$ the sum of the steady-state real interest rate and the annual inflation target (also see equation (2) below), $\tilde{\pi}$ and $\tilde{y}$ denote, respectively, the inflation and output gap, ρ is the interest rate persistence or smoothing term, and υ_t denotes a residual term. The inflation gap is the difference between expected and targeted inflation rates, $E_t(\pi_{t+j}) - \pi^*$. The output gap is the percentage deviation of real GDP from its potential level. $\gamma_{\tilde{\pi}} = (1-\rho)\beta$ and $\gamma_{\tilde{y}} = (1-\rho)\theta$ are weights policy makers place on inflation and output gap objectives while the central bank's steady-state reactions are captured via estimates of β and θ, respectively.[10] Therefore, the interest rate target is:

$$i_t^* = \alpha + \beta_n E_t(\tilde{\pi}_{t+j}) + \theta_n E_t(\tilde{y}_{t+k}) , \tag{2}$$

[10] In an optimizing framework (Clarida, Gali, and Gertler 2000), these weights also reflect to some extent the underlying structure of the economy and the persistence of economic shocks.

where $E_t(\tilde{\pi}_{t+j})$ and $E_t(\tilde{y}_{t+k})$ are the conditional expectations of inflation and the output gap, j or k periods ahead, $j, k \geq 0$.[11]

Since $E_t(\tilde{\pi}_{t+j})$ and $E_t(\tilde{y}_{t+k})$ are unobservable, proxies must be used. The standard practice is to resort to instrumental variable estimation. Alternatively, the central bank could be viewed as setting monetary policy on the basis of inflation and output growth forecasts. Since internal central bank forecasts are unavailable, we rely on public and private sector forecasts as proxies.[12] We can write a forecast-based Taylor rule, where we set $j = k = n$, as follows:

$$i_t = \bar{i} + \gamma^*_{\tilde{\pi}} \tilde{\pi}^f_{t+n,t} + \gamma^*_{\tilde{y}} \tilde{y}^f_{t+n,t} + \rho i_{t-1} + \upsilon_t, \qquad (1a)$$

where $\tilde{\pi}^f_{t+n,t}$ and $\tilde{y}^f_{t+n,t}$ are, respectively, published forecasts of inflation (or the inflation gap) and the output gap n periods ahead made at time t.[13]

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[11] In equation (2) the inflation target has been normalized to zero. Equation (1) is then derived from the relation $i_t = \rho i_{t-1} + (1-\rho) i^*_t + \upsilon_t$. Moreover, while there is no requirement that $j = k$, this is the general practice followed in empirical work.

[12] Goodhart (2005), Jansson and Vredin (2003), Siklos (2002), and Siklos and Wohar (2006) also estimate policy rules relying on central bank forecasts.

[13] Siklos, Werner, and Bohl (2004) consider the estimation of extended Taylor rules with asset prices as a separate determinant of nominal interest rates. In this paper we do not follow this estimation strategy primarily because, according to many central bankers, asset prices are best thought of as indicators of future inflation or output rather than variables they might directly target. They also consider the implications for Taylor rules using real-time data for

A difficulty with forecasts is, first, that it is not immediately clear whether the published forecasts are based on the assumption that interest rates are unchanged.[14] Second, depending on the source of the forecast, updating is done at different intervals, namely monthly, quarterly, or even semi-annually. Third, forecasts are for inflation (or real GDP growth) covering a calendar year. Yet it is conceivable that, as the forecast period approaches, the arrival of additional data are used to change forecasts. As a result, we assume that the data available to the forecaster is augmented as far as possible to reflect the data that would be used to generate inflation and real GDP growth forecasts for the relevant calendar year. Clearly, we do not know exactly the information set used by the various forecasters. Hence, our attempt to control for the changing span of time between the forecast period and the data that would be available in generating the forecast is only an approximation.

There is an additional issue that arises in the estimation of forecast-based Taylor rules (and, to some extent, forward-looking Taylor rules). The available span of data is relatively

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Germany and the euro area, as opposed to the revised data as done in the present study. Unfortunately, real-time data for France and Italy are not of the same caliber as what is available for Germany and the euro area. Hence, we do not address the relevant issues any further in what follows. See, however, Eleftheriou, Gerdesmeier, and Roffia (2006) for empirical evidence dealing with some of the relevant issues for the pre-euro era.

[14] Fuhrer and Tootell (2004) point out that if the correlation between the contemporaneous asset price and lagged interest rate changes is significant, this will tend to bias the coefficient on the asset price variable in the estimated policy rule away from zero. Goodhart (2005) shows for UK data that using forecasts conditioned on known interest rate decisions, results in a potentially serious misspecification.

short and covers a period when interest rates were falling. Furthermore, measurement problems concerning the output gap, for example, may be exacerbated in forecast-based Taylor rules since with one exception we rely on forecasts of real GDP growth and not those of the output gap. As Walsh (2003) and others have noted, first differencing of such time series mitigates the problem. Consequently, estimates of forecast-based Taylor rules are provided for a version of (1a) in first differences:

$$\Delta i_t = \gamma^*_{\Delta\tilde{\pi}} \Delta\tilde{\pi}^f_{t+n,t} + \gamma^*_{\Delta\tilde{y}} \Delta\tilde{y}^f_{t+n,t} + \rho \Delta i_{t-1} + \xi_t \,, \tag{1b}$$

where all the variables have been defined, Δ is the difference operator, and ξ_t is the residual of the forecast-based Taylor rule in first differences.[15]

As noted previously, there is some evidence about the desirability of incorporating a mix of forward- or even forecast-based elements. Goodhart (2005, p. 1) points out that while the past history of output and inflation may be important determinants of the future course of these variables, "…they will surely never be the *only* determinants of those forecasts" [italics in original]. One way of evaluating the relative contributions of forward-looking versus forecast-based Taylor rules, not heretofore considered elsewhere, is to ask whether one type of reaction function statistically encompasses the other. In this fashion, we test whether it might be preferable to estimate such rules as linear combinations of each other.

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[15] It is conceivable that nominal interest rates have a unit root. Siklos and Wohar (2006) consider the implications for estimating Taylor rules. The unit root property suggests the possibility of cointegration but no such property was found in the data, again likely because of the span of the sample. Estimates of (1b) include a constant. Variants of (1b) were also estimated with lags of various asset prices. See the discussion in the next section.

Next, the question arises how to proxy the inflation target. Usually, the inflation target is assumed to be a constant (say 2%). Since our conclusions were unaffected by the type of inflation gap proxy used, we only report results which assume a constant inflation objective.[16] This has the slight advantage of allowing for a comparison with the bulk of the literature on Taylor rules. Similarly, estimation of the output gap has been problematic. As with the inflation gap, we utilize an HP filter and various standard detrending schemes, as there are no practical alternatives for the output gap for the countries in our sample.[17]

Following much of the empirical literature we estimate (1), and its variants, via GMM, in spite of questions about its reliability (e.g., Mavroeidis 2004, Jondeau, Le Bihan, and Galles 2004). A crucial issue concerns the choice of instruments and, more importantly, their

[16] We used an HP filter with a standard smoothing parameter (1600) as well as a larger smoothing parameter (4800). In addition, we also estimated an inflation target evaluated as the mid-point of the spread between the average annual inflation rate in the euro area countries and the average annual inflation rate in the three lowest inflation rate countries in the euro area plus 1.5%, as specified in the Maastricht Treaty. The conclusions are robust to all these alternatives.

[17] Stock and Watson (2003) recommend a one-sided HP filter. Much of the literature uses a two-sided HP filter for convenience, or an alternative measure of the economy's capacity, but comparable time series are not available for the vast majority of euro area countries. We also generate, but do not report here, estimates of the output gap based on a Blanchard-Quah type decomposition with no impact on our conclusions.

relevance. Typically, the *J*-test for goodness of fit is reported without much comment.[18] Nevertheless, focusing on such a test alone also poses problems because one risks choosing a model with theoretically implausible coefficients in the rule. Therefore, we augment the tests for over-identifying restrictions by reporting Andrews' (1999) GMM information criterion. This test indicates whether the chosen instruments are orthogonal to the error term. Hall and Peixe (2003) propose the canonical correlation instrument relevance test (also see Hall 2005).

We also consider a test for instrument relevance based on two stage least squares (TSLS). Shea (1997) points out that regressing the endogenous variables against the chosen instruments can be misleading if there is more than one endogenous variable in the estimated specification. Jondeau, Le Bihan, and Galles (2004) report simulation evidence suggesting even small mis-specifications can lead to implausibly large coefficients for forward-looking variables estimated via GMM. Godfrey (1999) develops a simple measure for computing instrument relevance based on a TSLS estimation specification.[19] With this in mind, we use

[18] Some authors rely on the *J*-test to determine the horizon used by the policy makers. As we shall see, it is difficult to reject the null of the validity of chosen instrument sets and difficult to discriminate among competing versions of the same estimated policy rule.

[19] While the test for instrument relevance is based on TSLS it has the advantage that it can accommodate more than one endogenous variable and does not rely on GMM. Recent tests for instrument relevance are more complex when there is more than one endogenous variable. Jim Stock's weak instruments web page updates information on this topic (ksghome.harvard.edu/~jstock/ams/websupp/index.htm).

asset prices, among other variables, as instruments and test both their impact on the fit of estimated policy rules, as well as their relevance as instruments.[20]

Once the reaction functions are estimated we can back-out the implied target interest rates i_t^* over time to determine how well a reaction function fits with actual interest rate developments in the individual countries considered. Finally, we report statistical encompassing tests to determine which of the two kinds of reaction functions, if any, provides the best fit overall (Chong and Hendry 1986).

4. Data and Empirical Evidence

4.1 Data and Preliminaries

Data are quarterly at the source, or converted to the quarterly frequency by taking monthly averages where necessary. For real GDP, seasonally unadjusted data were used and adjustment was made using X-11. To generate the output gap we use the HP filter (also see footnote 16, 17). For the euro area we rely on estimates of the output gap used in the euro

[20] An objection that can be raised is that GMM is a non-linear estimation technique while the tests of instrument relevance used here are based on TSLS estimates. Since GMM is the estimation technique of choice we retain its use. Furthermore, relying on other tests of instrument relevance (e.g., the F-test as in Stock, Wright, and Yogo 2002) we obtain comparable results. Gerdesmeier and Roffia (2004) report few substantive differences between their GMM and TSLS estimates for the euro area. We also consider whether the volatility of asset prices serve as superior instruments in forward-looking rules (results not shown). Our conclusions are unchanged.

area-wide model.[21] Information about the construction of euro area wide data is available from the ECB (www.ecb.int), and the International Monetary Fund (http://dsbb.imf.org/Applications/web/euronote/). Anderson et al. (2006) also explain and criticize the construction of historical euro area-wide data.

The Bank for International Settlements (BIS) made available its aggregate asset price index. Therefore, we can get some idea of the potential impact of relying on a weighted average of key asset prices.[22] The individual asset prices we consider are housing prices, equity prices, the real exchange rate, a measure of financial conditions proxied by the financial conditions index,[23] and a broad monetary aggregate. For the euro area, as there were no financial conditions index weights, we used instead a measure of wealth available from the Euro Area Business Cycle Network. We also consider an "all asset prices" case. This means that a monetary aggregate, equity returns, the real exchange rate, and housing prices enter jointly. Next, we transform all variables, except the nominal interest rate, measured in

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[21] Data were obtained from the Bank of Finland. However, members of the Euro Area Business Cycle Network at www.eabcn.org may also access the relevant time series.

[22] The empirical results rely on the nominal measure. The BIS asset price index is essentially a weighted average of equity, residential and commercial property prices, where the weights are their respective shares in private sector wealth. The calibration of weights has changed over time (Borio and Lowe 2002, Borio, Kennedy, and Prowse 1994).

[23] The estimated weights reported in Goodhart and Hofmann (2000) are used. The financial conditions index can be thought of as an extension of the monetary conditions index, representing a linear combination of interest rates and exchange rates, to include housing and equity prices.

percent, into 100 times the fourth order log difference, i.e., $(\log X_t - \log X_{t-4})$, where X is the variable of interest.

Turning to forecast-based Taylor rules, these rely on one year-ahead forecasts of inflation, real GDP growth, or the output gap. The relevant data were obtained from Consensus Economics, The *Economist*, and the OECD. The first two are private sector forecasts while the OECD is a public agency supported by several governments. Consensus and *Economist* forecasts are monthly and were converted to the quarterly frequency via simple averaging. OECD forecasts are semi-annual and linear interpolation was used to generate quarterly forecasts. Forecasts are for the CPI or the HCPI, in the case of the euro area, and real GDP growth except OECD forecasts where output gap forecasts were employed.

Figure 1 plots estimated gaps in housing prices, equity prices and in the BIS's aggregate asset price index based on different filtering techniques. To gain additional perspective, the gaps are shown alongside periods of "booms and bust" cycles, as defined by Bordo and Jeanne (2004) as well as Detken and Smets (2004), and dated using a type of moving average of the relevant asset price shown. There appear to be few differences between HP filtering and quadratic or cubic de-trending, the most commonly used techniques in this context, though the amplitudes are larger when de-trending is used or when a larger smoothing parameter is chosen for the HP filter. No "bust" period in equity prices were identified by Bordo and Jeanne (2004) for Germany and France, at least for the period covered here. Yet, both HP filtering as well as cubic detrending reveal substantial stock price declines on more than one occasion. For Italy, the two bust periods identified by Bordo and Jeanne (2004) appear broadly consistent with either filter used. However, in this setup, comparable price declines at the beginning of the sample and during the later 1990s did not make the grade.

Figure 1 about here

Turning to housing prices (middle panel in Figure 1), downturns identified via various filters broadly match those reported in Bordo and Jeanne (2004) but only one boom period shown here across the three countries considered. Finally, when we use the BIS's nominal aggregate asset price index, and compare its behavior with the so-called high and low cost booms reported in Detken and Smets (2004), we find general agreement with the application of an HP filter to the data.

Gaps in the BIS's aggregate asset price index (bottom of Figure 1) reveal some differences relative to gaps in housing and equity prices. For example, for France, there are two large positive gaps in asset prices around 1990, and then again in 2000/2001, which are not entirely mirrored in the other asset price movements depicted in the same figure. Much the same can be said for the development of asset prices in Germany and Italy. While our results could be sensitive to the choice of filters, the empirical evidence shown below relies on the standard menu of detrending filters used in the available literature.

Using published forecasts in a forecast-based Taylor rule may be misleading if forecasts are inefficient or unbiased (Fuhrer and Tootell 2004). A simple test of forecast efficiency consists in estimating the following regression:

$$z_{t+j} = \delta_0 + \delta_1 z^f_{t+j} + \sum_{k=1}^{n} \delta_{2k} x_{t-k} + \xi_t \,, \tag{3}$$

where z_{t+j} is inflation or the output gap, z^f_{t+j} are the forecasts from Consensus Economics, The Economist, and the OECD Economic Outlook. Forecasts are generally for four and eight quarters $j = 4,8$. x_{t-k} includes the BIS aggregate asset price index, the rate of change in housing prices, equity prices, or the real exchange rate, where k is set either to 1 or 4. Forecast efficiency implies that the forecasts are not influenced by lags of some, or all, asset prices, i.e., the non-rejection of the null hypothesis $\delta_{2k} = 0$, for all $k = 1,...,n$. Unbiasedness requires not only forecast efficiency, but the non-rejection of the joint null $\delta_0 = 0$, $\delta_1 = 1$.

Estimation results (not shown but available on request) reveal that, for inflation, neither lags in the BIS index nor housing prices improve the explanatory power of equation (3). The results are somewhat more mixed for the equity and real exchange rate variables. For example, The Economist's forecasts for inflation in France and Italy appear inefficient. Otherwise all other forecasts are efficient. When all asset prices are considered jointly, only OECD forecasts display some inefficiency. Turning to the output gap, there is almost no evidence of forecast inefficiency regardless of the source of the forecast.[24] Our findings show strong evidence of forecast efficiency for the BIS index and when all asset prices enter equation (3) jointly. The available forecasts do, however, appear to be unbiased.

Equation (3) is the usual test of forecast efficiency. Filardo (2004) suggests that, lagged forecasts should also be insignificantly related to z_t. When we re-estimate (3) adding lags of z_t^f the results (not shown but available on request) are mixed. Therefore, conditional on x_{t-k}, at least some forecasts of z_{t+j} could be improved by the addition of the past history of

[24] Other than for the OECD, where forecasts of the output gap are available, forecasts are for real GDP growth. Whether (3) uses GDP growth or a proxy for the output gap does not change the outcome of the forecast efficiency tests.

z_t. Since x_{t-k} consists of asset prices alone, this is suggestive of a non-fundamental component. We leave the implications of this result for future research.

4.2 Instrument Selection and Relevance

Panel A of Table 2 shows *J*-test statistics for the non-rejection rates for the null that the over-identifying restrictions are acceptable. Since it is unclear how forward-looking central banks are, equation (2) is estimated for $j,k = 0,...,8$. Examining the results for France, Germany, and Italy, it is difficult to discriminate among the different combinations of horizons in spite of the relatively large number of instrument sets considered and the inclusion of a wide variety of asset prices as instruments. Interestingly, the situation changes dramatically when euro area-wide data are considered. While the non-rejection rates are modest at short horizons, the *J*-test rejects the over-identifying restrictions at horizons of a year or longer.

Table 2 about here

Panel B of Table 2 considers Andrews' (1999) GMM information criterion. To conserve space, results are shown only for the cases where inflation and the output gap enter the forward-looking Taylor rules either contemporaneously or four quarters ahead. Regardless of the specification considered the instrument set most orthogonal to the error term consists of a combination of individual asset prices, namely the real exchange rate, housing prices, and equity returns. Nevertheless, if an investigator were to choose a common asset price for all cases considered, a monetary aggregate is a fairly good choice most of the time.

As argued in Hall and Peixe (2003), Andrews' (1999) test represents a necessary but not a sufficient condition for determining the suitability of the chosen instrument set. Panel C of Table 2 shows their canonical correlation test of instrument relevance. The conclusions reached earlier are generally unchanged. However, it is interesting to note that if a more parsimonious instrument set is desired, the BIS asset price index would be chosen for Germany and the euro area while housing price inflation, or a monetary aggregate, would be good choices for France and Italy.

4.3 Steady-State Taylor Rule Coefficient Estimates and the Role of Asset Prices

Table 3 presents estimates of the steady-state parameters in forward-looking Taylor rules for a variety of instrument sets. Previous instrument tests were based on GMM estimation and these are known to be sensitive to the chosen specification. Accordingly, we supplement GMM-based tests with instrument relevance tests based on TSLS estimates of (2). Additionally, we show the root mean squared error (RMSE) for the difference between actual and implied nominal interest rates for each specification of equation (2).

Table 3 about here

Generally, the various diagnostic tests find evidence in favor of the instrument set consisting of a combination of individual asset prices. This result certainly fits well with the notion that central banks take into account a variety of indicators when setting the instrument of monetary policy. Not surprisingly perhaps, the real exchange rate is a close second, at least based on the RMSE criterion.

The impact of using different instrument sets is clearly seen from the steady-state parameter estimates on the inflation and output gap variables. The coefficients on inflation range from 0.94 to 1.93 across the three countries considered, with responses smallest for France and largest for Germany. Indeed, for Germany and Italy, the responses are typically significantly above one, as required by the Taylor principle. Interestingly, if the policy rule is chosen on the basis of instrument relevance, the coefficient on inflation is generally smaller than when the standard set of instruments is used. This could mean that asset price developments led some central banks to respond more cautiously. These estimates are also well within the range of earlier published results, as can be seen by comparing our estimates with those shown in Table 1. Finally, the estimates also convey the notion that the core euro area members may well have responded differently to inflation over the sample considered.

Turning to the output gap, the steady-state coefficients are generally insignificant, at least if a 5% critical value is adopted, but become positive and statistically significant when the instrument set is one of the preferred ones, based on the various diagnostic tests previously considered. The significance of the output gap is clearly a function of instrument choice.

Estimates for the euro area shown in Table 4. The most striking result is the difference between estimates that alternatively include and exclude the era since the ECB took over sole responsibility for the conduct of monetary policy. Based on full sample estimates, the ECB appears to react more aggressively to inflation and the output gap than for a sample that ends in 1998. When the standard set of instruments is used, the ECB appears to react less aggressively to the output gap for the full sample compared to the short sample. In contrast, the ECB reacts positively and significantly to the output gap, and somewhat less aggressively to inflation, when different asset prices enter as instruments. Nevertheless, based on the additional instrument relevance tests, and the RMSE criterion, that either a euro area-wide wealth measure or the money gap, are the additional instruments that appear to improve estimates of the policy rule. Table 4 also highlights instances where the coefficients are jointly statistically different for the two periods. Forward-looking Taylor rules are significantly different in the 1978 - 2003 sample relative to the pre-EMU sample in every case except when wealth is used as an instrument. Hence, there is considerable evidence of a change in the policy response since the start of EMU.

Table 4 about here

Table 5 presents RMSE estimates for the forecast-based Taylor rule (1b) in first differences. The results are clear-cut. Paralleling the findings for forward-looking Taylor rules, specifications that rely on one year forecasts of the output gap and inflation, and are augmented by lags in a combination of the four asset prices considered, provide the best overall fit among the various specifications. Furthermore, Consensus one year forecasts outperform slightly those based on The Economist while OECD forecasts, which are published only semi-annually, perform most poorly of all. Lastly, there is little deterioration in the in-sample forecasting performance between one and two year-ahead Consensus forecasts. The latter is typically the horizon mentioned by central banks when deciding the appropriate stance for monetary policy.

Table 5 about here

To gauge the comparative advantage of one type of policy rule over another, Table 6 presents encompassing tests that rely on the best performing forward-looking and forecast-based policy rule estimates.[25] At the 5% level of significance, the results reveal a clear-cut preference for forecast-based over forward-looking Taylor rules. Of course, one must be mindful of the potential information advantage embedded into the published forecasts. In a sense the encompassing test confirms this result. It is tempting, therefore, to conclude overall in favor of the forecast-based Taylor rule as the preferred specification. However, as we know relatively little about the model or methods used to generate the published forecast, it is

[25] Sample begins in 1991 (1996 for the euro area) due to data limitations in the forecast data.

too early to reach a definitive conclusion on this score. Nevertheless, the performance of forecast-based Taylor rules, and existing evidence suggesting that central bank forecasts may be superior to private sector forecasts (e.g, see Romer and Romer 2000), suggests that more central banks ought to release their own forecasts and inform the public about the basis upon which these are generated.

Table 6 about here

5. Conclusions

It is commonplace to estimate forward-looking policy rules. Relatively little effort has been devoted to ascertaining the performance and relevance of different instrument sets used in generating a central bank's response to inflation and the output gap. Instrument relevance tests suggest that asset prices, typically a combination that includes a real exchange rate, equity returns, and housing prices, are part of the information set used by the ECB in determining the responses to inflation and the output gap in the euro area.

More importantly, the choice of instruments has a significant impact on the steady-state response of central banks to inflation and the output gap. Any improvements in estimating forward-looking Taylor rules must confront the fact that forecast-based rules typically outperform them. Whether this result is partly, or largely, due to the possibility that some forecasts incorporate the effects of changes in the stance of monetary policy is unclear but clearly warrants additional research. Indeed, if our findings hold up, a policy implication is that central banks ought to be encouraged to release their own forecasts.

References

Anderson, H., M. Dungey, D. Osborn, and F. Vahid (2006), "Constructing Historical Euro Area Data", working paper, April.

Andrews, D. (1999), "Consistent Moment Selection Procedures for Generalized Method of Moments Estimation", *Econometrica* 67, 543 - 564.

Bernanke, B. S. (2005), "Implementing Monetary Policy", Remarks at the Redefining Investment Strategy Education Symposium, Dayton, available at: www.federalreserve.gov.

Bernanke, B. S. (2004), "What Policymakers Can Learn from Asset Prices", Remarks before the Investment Analysts Society of Chicago, available at: www.federalreserve.gov.

Bernanke B. S. and M. Gertler (1999), "Monetary Policy and Asset Price Volatility", *Economic Review*, Federal Reserve Bank of Kansas City (Fourth Quarter), 17 - 51.

Bordo, M. D. and O. Jeanne (2004), "Booms-Busts in Asset Prices, Economic Stability, and Monetary Policy", in R. C. K. Burdekin and P. L. Siklos (Eds.), *Deflation: Current and Historical Perspectives*, Cambridge: Cambridge University Press, 131 - 165.

Borio, C. and P. Lowe (2002), "Asset Prices, Financial and Monetary Stability: Exploring the Nexus", BIS Working Paper 114.

Borio, C., N. Kennedy, and S. Prowse (1994), "Exploring Aggregate Asset Price Fluctuations Across Countries: Measurement, Determinants and Monetary Policy Implications", BIS Economic Papers 40.

Busetti, F., L. Forni, A. Harvey, and F. Venditti (2006), "Inflation Convergence and Divergence within the Monetary Union", European Central Bank working paper 574, January.

Cecchetti, S. (2003), "What the FOMC Says and Does When the Stock Market Booms", in T. Richards and T. Robinson (Eds.), *Asset Prices and Monetary Policy*, Sydney: Reserve Bank of Australia.

Cecchetti, S., H. Genberg, J. Lipsky, and S. Wadhwani (2000), "Asset prices and Central Bank Policy", Geneva Reports on the World Economy, Vol. 2, Geneva: International Center for Monetary and Banking Studies; London: Centre for Economic Policy Research.

Chadha, J. S., L. Sarno, and G. Valente (2004), "Monetary Policy Rules, Asset Prices and Exchange Rates", *IMF Staff Papers* 51, 529 - 552.

Chong, Y. Y. and Hendry, D.F. (1986), "Econometric Evaluation of Linear Macroeconomic Models", *Review of Economic Studies* 53, 671 - 690.

Clarida, R. J. (2001), "The Empirics of Monetary Policy Rules in Open Economies", *International Journal of Finance and Economics* 6, 315 - 323.

Clarida, R., J. Gali, and M. Gertler (2001), "Optimal Monetary Policy in Open versus Closed Economies: An Integrated Approach", *American Economic Review* 91, 248 - 252.

Clarida, R., J. Gali, and M. Gertler (2000), "The Science of Monetary Policy: A New Keynesian Perspective", *Journal of Economic Literature* 37, 1661 - 1707.

Clarida, R., J. Gali, and M. Gertler (1998), "Monetary Policy Rules in Practice: Some International Evidence", *European Economic Review* 42, 1033 - 1067.

Clausen, V. and B. Hayo (2003), "Monetary Policy in the Euro Area: Lessons from the First Years", ZEI Working Paper B09.

Detken, C. and F. Smets (2004), "Asset Price Booms and Monetary Policy", in H. Siebert (Ed.), *Macroeconomic Policies in the World Economy*, Berlin: Springer.

Eleftheriou, M., D. Gerdesmeier, and B. Roffia (2006), "Monetary Policy Rules in the Pre-EMU Era – Is There a Common Rule?", ECB working paper 659.

European Central Bank (2005), "Asset Price Bubbles and Monetary Policy", *Monthly Bulletin*, April, 47 - 60.

European Central Bank (2001), *The Monetary Policy of the ECB*, Frankfurt: European Central Bank, August.

Favero, C. and R. Rovelli (2003), "Macroeconomic Stability and the Preferences of the Fed: A Formal Analysis, 1961 - 98“, *Journal of Money, Credit, and Banking* 35, 545 - 556.

Faust, J., J. H. Rogers, and J. H. Wright (2001), "An Empirical Comparison of Bundesbank and ECB Monetary Policy Rules", Board of Governors of the Federal Reserve System, International Finance Discussion Papers, No. 705.

Filardo, F. (2004), "Monetary Policy and Asset Price Bubbles: Calibrating the Monetary Policy Trade-Offs", BIS Working Paper 155, June.

Fuhrer, J. and H. Tootell (2004), "Eyes on the Prize: How Did the Fed Respond to the Stock Market?", Public Policy Discussion Paper No. 04-2, June.

Gerdesmeier, D. and B. Roffia (2004), "Empirical Estimates of Reaction Functions for the Euro Area", *Swiss Journal of Economics and Statistics* 140, 37 - 66.

Gerlach, S. and G. Schnabel (2000), "The Taylor Rule and Interest Rates in the EMU Area", *Economics Letters* 67, 165 - 171.

Gerlach, S. and L. E. O. Svensson (2003), "Money and Inflation in the Euro Area: A Case for Monetary Indicators?" *Journal of Monetary Economics* 50, 1649 - 1672.

Gerlach-Kristen, P. (2003), "Interest Rate Reaction Functions and the Taylor Rule in the Euro Area", ECB Working Paper No. 258.

Godfrey, L.G. (1999), “Instrument Relevance in Multivariate Linear Models”, *Review of Economics and Statistics* 81, 550 - 552.

Goodhart, C. A. E. (2005), “The Monetary Policy Committee’s Reaction Function: An Exercise in Estimation”, *B.E. Journals in Macroeconomics: Topics in Macroeconomics* 5, 1 - 40.

Goodhart, C. A. E. (2001), “What Weight Should be Given to Asset Prices in the Measurement of Inflation?” *Economic Journal* 111, 335 - 356.

Goodhart, C. A. E. and B. Hofmann (2000), “Do Asset Price Help Predict Consumer Price Inflation”, *The Manchester School* 68, 122 - 140.

Greithner, T. F. (2006), “Some Perspectives on U.S. Monetary Policy”, Remarks at the New York Association for Business Economics in New York City, available at: www.ny.frb.org.

Greenspan, A. (2004), “Risk and Uncertainty in Monetary Policy”, Remarks given at the meetings of the American Economic Association, available at: www.federalreserve. gov.

Gruen, D., M. Plumb, and A. Stone (2005), “How Should Monetary Policy Respond to Asset Price Bubbles?”, *International Journal of Central Banking* 1, 1 - 32.

Hall, A. (2005), *Generalized Methods of Moments,* Oxford: Oxford University Press.

Hall, A. and F. Peixe (2003), “A Consistent Method for the Selection of Relevant Instruments”, *Econometric Reviews* 22, 269 - 287.

Hayo, B. and B. Hofmann (2003), “Monetary Policy Reaction Functions: ECB versus Bundesbank”, ZEI Working Paper B24.

Jansson, P. and A. Vredin (2003), "Forecast-Based Monetary Policy: The Case of Sweden", *International Finance* 6, 349 - 380.

Jondeau, E., H. Le Bihan, and C. Galles (2004), "Assessing GMM Estimates of the Federal Reserve Reaction Function", *Journal of Business and Economic Statistics* 22, 225 - 239.

Kuttner, K. (2004), "A Snapshot of Inflation Targeting in Adolescence", in *The Future of Inflation Targeting*, Edited by C. Kent and S. Guttmann (Sydney: Reserve Bank of Australia).

Lansing, K. (2002), "Real-Time Estimation of Trend Output and the Illusion of Interest Rate Smoothing", Federal Reserve Bank of San Francisco *Economic Review*, 17 - 34.

Leitemo, K. and U. Söderström (2001), "Simple Monetary Policy Rules and Exchange Rate Uncertainty", *Journal of International Money and Finance* 24, 481 - 507.

Leitemo, K. (1999), "Inflation Targeting Strategies in Small Open Economies", Working Paper, Norges Bank.

Leitemo, K. and Ø. Røisland (1999), "Choosing a Monetary Policy Regime: Effects on the Traded and Non-Traded Sectors", University of Oslo and Norges Bank.

Mavroeidis, S. (2004), "Weak Identification of Forward-Looking Models in Monetary Economics", *Oxford Bulletin of Economics and Statistics* 66, 609 - 635.

Medina, J.P. and R. Valdés (2002), "Optimal Monetary Policy Rules when the Current Account Matters", in *Monetary Policy: Rules and Transmission Mechanisms,* Santiago: Central Bank of Chile, 65 - 94.

Norris, F. (2005), "Watching the Bubble Bounce?", *International Herald Tribune*, 11 March.

Romer, C. and D. Romer (2000), "Federal Reserve Information and the Behavior of Interest Rates", *American Economic Review* 90, 429 - 457.

Rudebusch, G. (2002), "Term Structure Evidence on Interest Rate Smoothing and Monetary Policy Inertia", *Journal of Monetary Economics* 49, 1161 - 1187.

Scheller, H. (2004), *The ECB: History, Role and Functions*, Frankfurt/Main: European Central Bank.

Shea, J. (1997), "Instrument Relevance in Multivariate Linear Models: A Simple Measure", *Review of Economics and Statistics* 79, 348 - 352.

Siklos, P. L. (2002), *The Changing Face of Central Banking* (Cambridge: Cambridge University Press).

Siklos, P. L. and M. E. Wohar (2006), "Estimating Taylor Rules: An Unbalanced Regression?", in T. B. Fomby and D. Terrell (Eds.), *Advances in Econometrics*, Volume 20, Part 2 (Amsterdam: North Holland), 239 - 276.

Siklos, P. L., T. Werner, and M. T. Bohl (2004), "Asset Prices in Taylor Rules: Specification, Estimation, and Policy Implications for the ECB", Discussion Paper Series 1: Studies of the Economic Research Centre, 22/2004, Deutsche Bundesbank.

Smets, F. (1997), "Financial Asset Prices and Monetary Policy: Theory and Evidence", BIS Working Paper 47, September.

Stock, J. H. and M. W. Watson (2007), "Has Inflation Become Harder to Forecast?", *Journal of Money, Credit, and Banking* 39, 3 - 33.

Stock, J. H. and M. W. Watson (2003), "Forecasting Output and Inflation: The Role of Asset Prices," *Journal of Economic Literature* 41, 788 - 829.

Stock, J. H., J. H. Wright, and M. Yogo (2002), “A Survey of Weak Instruments and Weak Identification in Generalized Methods of Moments”, *Journal of Business and Economic Statistics* 20, 518 - 529.

Svensson, L. E. O. (2003), “What Is Wrong with Taylor Rules? Using Judgment in Monetary Policy through Targeting Rules”, *Journal of Economic Literature* 41, 426 - 477.

Taylor, J. B. (2001), “The Role of the Exchange Rate in Monetary Policy Rules”, *American Economic Review* 91, 263 - 267.

von Hagen, J. and B. Hofmann (2007), “Monetary Policy Orientation in Times of Low Inflation“, in D. Altig and E. Nosal (Eds.), *Monetary Policy in Low Inflation Economies*, Cambridge: Cambridge University Press, forthcoming.

Walsh, C. E. (2003), “Speed Limit Policies: The Output Gap and Optimal Monetary Policy”, *American Economic Review* 93, 265 - 278.

Table 1: Selected Estimates of Taylor Rule Parameters

Author	Steady-State Coefficient Estimates			Countries, Sample
	Inflation	Output Gap	Other Variables	
Forward-Looking Taylor Rules				
Bernanke and Gertler (1999)	1.12 - 2.21 1.60 - 1.71	0.20 - 0.33 0.14 - 0.20	0.19 - 0.29 -0.08	Japan, 1968 - 1989 U.S., 1968 - 1989
Chadha, Sarno, and Valente (2004)	1.69 - 2.39 0.98 - 1.46 1.10 - 2.37	-0.72 - 1.07 -0.61 - 0.60 -0.02 - 0.05	0.07 - 0.02 0.01 - 0.89 0.02 - 0.002	U.S., 1979 - 2000 U.K., 1979 - 2000 Japan, 1979 - 2000
Clarida, Gali, and Gertler (1998)	1.10 - 1.37 1.81 - 2.04 1.05 - 2.20 0.48 - 0.98 0.59 - 1.33 0.59 - 0.91	0.25 - 0.35 0.03 - 0.10 0.14 - 0.52 0.17 - 0.28 -0.07 - 0.88 -0.03 - 0.22	0.05 - 0.12 0.06 - 0.09 -0.78 - 0.53 0.09 2.91 -0.03	Germany, 1979 - 1989 Japan, 1979 - 1989 U.S., 1979 - 1989 U.K., 1979 - 1989 France, 1979 - 1989 Italy, 1979 - 1989
Clausen and Hayo (2003)	2.28 2.89 2.02	1.73 0.49 2.46	n.a. n.a. n.a.	France, 1979 - 1996 Germany, 1979 - 1996 Italy, 1979 - 1996
Faust, Rogers, and Wright (2001)	1.31	0.18	n.a.	Germany, 1985 - 1998
Gerdesmeier and Roffia (2004)	1.82 1.86	0.77 0.26	n.a. 0.41	Euro area, 1985 - 2002
Gerlach and Schnabel (2000)	0.98 - 1.62	0.22 - 0.32	-0.03 - (-0.56)	Euro 11, 1990 - 1998
Gerlach-Kristen (2003)	2.73	1.44	n.a.	Euro area, 1988 - 2002
Hayo and Hofmann (2003)	1.25	0.32	n.a.	Germany, 1990 - 1998
Forecast-Based Taylor Rules				
Jansson and Vredin (2003)	2.13	0.13	n.a.	Sweden, 1994 - 2001
Kuttner (2004)	2.83	1.35	n.a.	Sweden, 1994 - 2003

Table 2: Testing Over-Identifying Restrictions

	France		Germany		Italy		Euro Area	
Panel A: Rejection Frequencies								
							1978 - 1998	1978 - 2003
$j=0, k=0,...,8$	25.4		23.8		19.0		47.6	41.2
$j=0,...,8, k=0$	23.8		22.2		25.4		36.5	41.3
$j,k=3$	71.4		28.6		42.9		57.1	100.0
$j,k=4$	14.3		14.3		28.6		85.7	100.0
$j,k=5$	14.3		28.6		14.3		100.0	100.0
Panel B: GMM Information Criterion								
Instrument Set	$k=0$							
	$j=0$	$j=4$	$j=0$	$j=4$	$j=0$	$j=4$	$j=0$	$j=4$
All Asset Prices	-100.9	-99.1	-99.7	-99.7	-98.0	-97.7	-100.4	-101.0
BIS Index	-67.3	-66.7	-63.8	-64.9	-66.7	-63.2	-70.1	-70.0
Equity Prices	-66.9	-65.5	-69.5	-67.1	-68.2	-65.8	-67.2	-68.8
FCI/Wealth	-67.7	-68.7	-64.8	-65.2	-65.4	-65.3	-69.5	-70.3
Housing Prices	-68.1	-67.7	-65.2	-65.9	-65.8	-64.5	n.a.	n.a.
RER	-66.0	-68.4	-65.6	-67.0	-67.4	-66.3	-65.2	-68.7
Money	-68.1	-67.3	-65.7	-65.1	-69.3	-66.6	-65.1	-66.0
Standard	-51.3	-51.3	-48.7	-51.8	-52.6	-50.8	-54.4	-55.0
	$j,k=4$							
All Asset Prices	-100.0		-99.0		-97.8		-104.4	
BIS Index	-67.8		-64.7		-62.9		-72.8	
Equity Prices	-67.5		-66.4		-65.9		-71.2	
FCI/Wealth	-66.9		-64.6		-66.6		-73.1	
Housing Prices	-67.9		-64.4		-64.9		n.a.	
RER	-66.2		-67.2		-67.4		-69.5	
Money	-66.1		-67.2		-67.4		-68.7	
Standard	-50.3		-50.8		-51.2		-54.8	

Table 2 (Continued): Testing Over-Identifying Restrictions

Instrument Set	France	Germany	Italy	Euro Area
Panel C: Canonical Correlation Information Criterion				
All Asset Prices	-95.14	-94.96	-93.76	-110.98
BIS Index	-60.38	-60.27	-59.51	-77.72
Equity Prices	-60.35	-60.22	-59.53	-76.71
FCI/Wealth	-60.39	-60.22	-59.50	-74.52
Housing Prices	-60.42	-60.22	-59.53	n.a.
RER	-60.40	-60.23	-59.50	-76.73
Money	-60.36	-59.60	-59.54	-75.17
Standard	-60.35	-60.17	-59.50	-61.78

Note: j and k denote the number of quarters ahead in inflation and the output gap, respectively, as specified in equation (2). All Asset Prices means that a monetary aggregate, equity returns, the real exchange rate, and housing prices enter jointly. BIS Index denotes the aggregate asset price index provided by the BIS, FCI the financial conditions index, RER the real exchange rate, and Money a monetary aggregate. Standard refers to the Taylor rule (2) with a conventional instrument set consisting of a constant, 3 lags of the interest rate, 4 lags of inflation and the output gap, and 4 lags of the rate of change of oil prices. All other variables have been previously defined. Due to data availability a wealth measure is used for the euro area and the FCI for the individual countries. The frequencies in panel A refer to the fraction of times the null hypothesis of a valid over-identifying restriction cannot be accepted at the 5% level. For France, Germany and Italy all results are for the sample 1978 - 1998. All data are quarterly.

Table 3: Steady-State Coefficient Estimates of Taylor Rules and Additional Instrument Relevance Tests for the Individual Countries

Instrument Set	β	θ	ρ	$R^2_{\tilde{\pi}}$	$R^2_{\tilde{y}}$	RMSE	F-test	
							$\tilde{\pi}$	$\tilde{y}$
France								
All Asset Prices	1.12 (0.52)	3.88 (0.01)	0.89	0.60	0.97	0.97	294	5.40
BIS Index	0.97 (0.88)	2.50 (0.17)	0.90	0.70	0.26	0.99	292	4.06
Equity Prices	0.98 (0.93)	-1.43 (0.54)	0.87	0.51	0.07	1.00	279	4.29
FCI	1.09 (0.00)	2.15 (0.19)	0.90	0.73	0.21	0.95	266	5.89
Housing Prices	1.04 (0.91)	7.30 (0.24)	0.92	0.03	0.43	1.07	365	1.62
RER	1.02 (0.00)	1.14 (0.28)	0.88	0.81	0.34	0.95	277	6.60
Money	1.47 (0.30)	0.95 (0.17)	0.86	0.12	0.42	0.54	233	4.28
Standard	0.94 (0.76)	-0.36 (0.91)	0.87	0.45	0.05	0.99	360	5.15
Germany								
All Asset Prices	1.52 (0.01)	1.36 (0.00)	0.89	0.99	0.94	0.52	32.33	4.84
BIS Index	1.89 (0.00)	0.39 (0.29)	0.85	0.46	0.45	0.58	38.44	6.92
Equity Prices	1.84 (0.01)	1.44 (0.00)	0.88	0.49	0.36	0.59	43.90	6.59
FCI	1.83 (0.00)	0.41 (0.11)	0.78	0.43	0.45	0.60	35.70	6.36
Housing Prices	1.93 (0.00)	0.89 (0.03)	0.86	0.02	0.63	0.59	38.27	2.96
RER	1.43 (0.00)	1.03 (0.00)	0.88	0.95	0.49	0.51	41.81	5.88
Money	1.13 (0.78)	3.99 (0.52)	0.91	0.26	0.26	0.94	36.17	8.23
Standard	1.93 (0.00)	0.69 (0.10)	0.85	0.35	0.30	0.59	50.31	7.58
Italy								
All Asset Prices	1.25 (0.01)	1.04 (0.05)	0.81	0.18	0.56	0.94	228	3.41
BIS Index	1.37 (0.04)	2.21 (0.11)	0.81	0.14	0.26	1.01	251	4.84
Equity Prices	1.45 (0.06)	3.15 (0.09)	0.85	0.12	0.16	1.02	266	4.90
FCI	1.38 (0.00)	2.15 (0.02)	0.82	0.15	0.36	1.00	289	4.87
Housing Prices	1.30 (0.02)	1.54 (0.10)	0.80	0.00	0.39	0.98	268	1.94
RER	1.26 (0.00)	1.10 (0.16)	0.79	0.14	0.37	0.95	298	4.83
Money	1.64 (0.27)	4.44 (0.38)	0.86	0.44	0.42	1.05	303	5.66
Standard	1.53 (0.06)	3.85 (0.09)	0.84	0.13	0.18	1.10	336	6.42

Table 3 (Continued): Steady-State Coefficient Estimates of Taylor Rules and Additional Instrument Relevance Tests for the Individual Countries

Note: See the note to Table 2 for variable and instrument set definitions. Reported are the GMM estimates of steady-state parameters for the case $j,k = 4$. β is the steady state inflation parameter, θ is the steady state parameter on the output gap, and ρ is the interest rate smoothing parameter. p-values are in parenthesis for the null $\beta = 1$ (except for the real exchange rate and the FCI where the null is $\beta = 0$) and $\theta = 0$. Wald tests (F-version) that the coefficients on lagged values of relevant asset prices are jointly insignificant. An F-statistic of at least 10 is normally required to conclude that the instruments are adequate. $R^2_{\tilde{\pi}}$ and $R^2_{\tilde{y}}$ are partial R-squared measures developed by Godfrey (1999). They are calculated as $(se^{OLS} / se^{GMM})(rsd^{GMM} / rsd^{OLS})$ where se is the standard error estimates for the coefficients on the endogenous variables $(\tilde{\pi}, \tilde{y})$, and rsd is the residual standard deviation for the regressions estimated either via OLS or GMM. Partial R-squared need not add up to 1 across columns. Estimates use GMM with a Bartlett kernel, Newey-West bandwidth, and HAC weighting matrix. RMSE denotes root mean squared error. The sample is quarterly and covers the 1978 - 1998 period.

Table 4: Steady-State Estimates of Taylor Rule

and Additional Instrument Relevance Tests for the Euro Area

Instrument Set	β	θ	ρ	$R^2_{\tilde{\pi}}$	$R^2_{\tilde{y}}$	RMSE	F-tests		
							$\tilde{\pi}$	$\tilde{y}$	Equality
1978 - 1998									
All Asset Prices	1.44 (0.02)	3.72 (0.00)	0.87	0.34	0.30	0.60	463	6.88	
BIS Index	1.32 (0.19)	2.71 (0.00)	0.89	0.30	0.86	0.55	541	9.71	
Equity Prices	1.42 (0.05)	3.73 (0.00)	0.88	0.16	0.16	0.59	533	7.77	
Wealth	1.26 (0.00)	5.06 (0.07)	0.93	0.47	0.44	0.67	449	11.36	
RER	1.38 (0.00)	3.14 (0.00)	0.87	0.34	0.29	0.58	587	8.23	
Money	-0.03 (0.86)	0.11 (0.77)	0.98	0.34	0.30	0.47	360	10.89	
Standard	1.38 (0.45)	4.97 (0.34)	0.95	0.33	0.17	0.72	534	13.76	
1978 - 2003									
All Asset Prices	1.90 (0.01)	6.49 (0.01)	0.91	0.40	0.32	0.62	500	9.84	3.12 (0.03)
BIS Index	1.67 (0.07)	4.86 (0.03)	0.93	0.28	0.81	0.54	542	13.81	4.26 (0.00)
Equity Prices	1.90 (0.07)	6.51 (0.09)	0.92	0.14	0.11	0.61	568	11.34	4.51 (0.00)
Wealth	1.61 (0.00)	8.43 (0.23)	0.95	0.47	0.35	0.67	531	14.90	1.70 (0.16)
RER	1.78 (0.00)	5.20 (0.01)	0.90	0.38	0.30	0.59	600	11.64	3.13 (0.02)
Money	1.20 (0.92)	0.11 (0.64)	0.98	0.49	0.37	0.47	336	17.33	2.71 (0.03)
Standard	2.28 (0.63)	0.24 (0.63)	0.97	0.31	0.14	0.75	636	18.35	8.93 (0.00)

Note: See the note to Table 3. Wealth is the deviation of the log of real wealth for the euro area from its HP filtered level. Data were obtained from the euro area wide model. The F-test "Equality" investigates the null that all coefficients in the Taylor rule are jointly significantly different in the 1978 - 2003 period from the 1978 - 1998 sample.

Table 5: Root Mean Squared Errors in Forecast-Based Taylor Rules

	Consensus (one year ahead)	Consensus (two year ahead)	OECD	Economist
France				
All Asset Prices	0.59	0.60	0.91	0.58
BIS Index	0.73	0.78	0.96	0.76
Equity Prices	0.72	0.77	0.95	0.76
FCI	0.64	0.68	3.23	0.68
Housing Prices	0.72	0.76	0.96	0.74
RER	0.67	0.67	0.98	0.70
Money	0.70	0.76	3.42	0.73
Standard	0.75	0.79	0.99	0.78
Germany				
All Asset Prices	0.21	0.23	0.41	0.19
BIS Index	0.28	0.31	0.59	0.30
Equity Prices	0.28	0.32	0.59	0.30
FCI	0.24	0.30	1.58	0.25
Housing Prices	0.30	0.31	0.57	0.31
RER	0.29	0.32	0.48	0.26
Money	0.26	0.28	1.39	0.27
Standard	0.32	0.35	0.60	0.33
Italy				
All Asset Prices	0.87	0.78	0.96	0.80
BIS Index	1.01	0.85	1.03	1.00
Equity Prices	0.93	0.82	1.01	0.93
FCI	1.00	0.87	3.97	0.93
Housing Prices	1.03	0.88	1.00	0.98
RER	1.03	0.87	1.02	0.95
Money	0.98	0.87	4.10	0.94
Standard	1.04	0.90	1.03	1.01
Euro Area				
All Asset Prices	n.a.	0.16	n.a.	n.a.
BIS Index	0.23	0.21	n.a.	0.24
Equity Prices	0.15	0.30	n.a.	0.21
Wealth	0.24	0.29	n.a.	0.29
Housing Prices	n.a.	n.a.	n.a.	n.a.
RER	0.24	0.24	n.a.	0.23
Money	0.21	0.66	n.a.	0.32
Standard	0.38	0.33	n.a.	0.37

Table 5 (Continued): Root Mean Squared Errors in Forecast-Based Taylor Rules

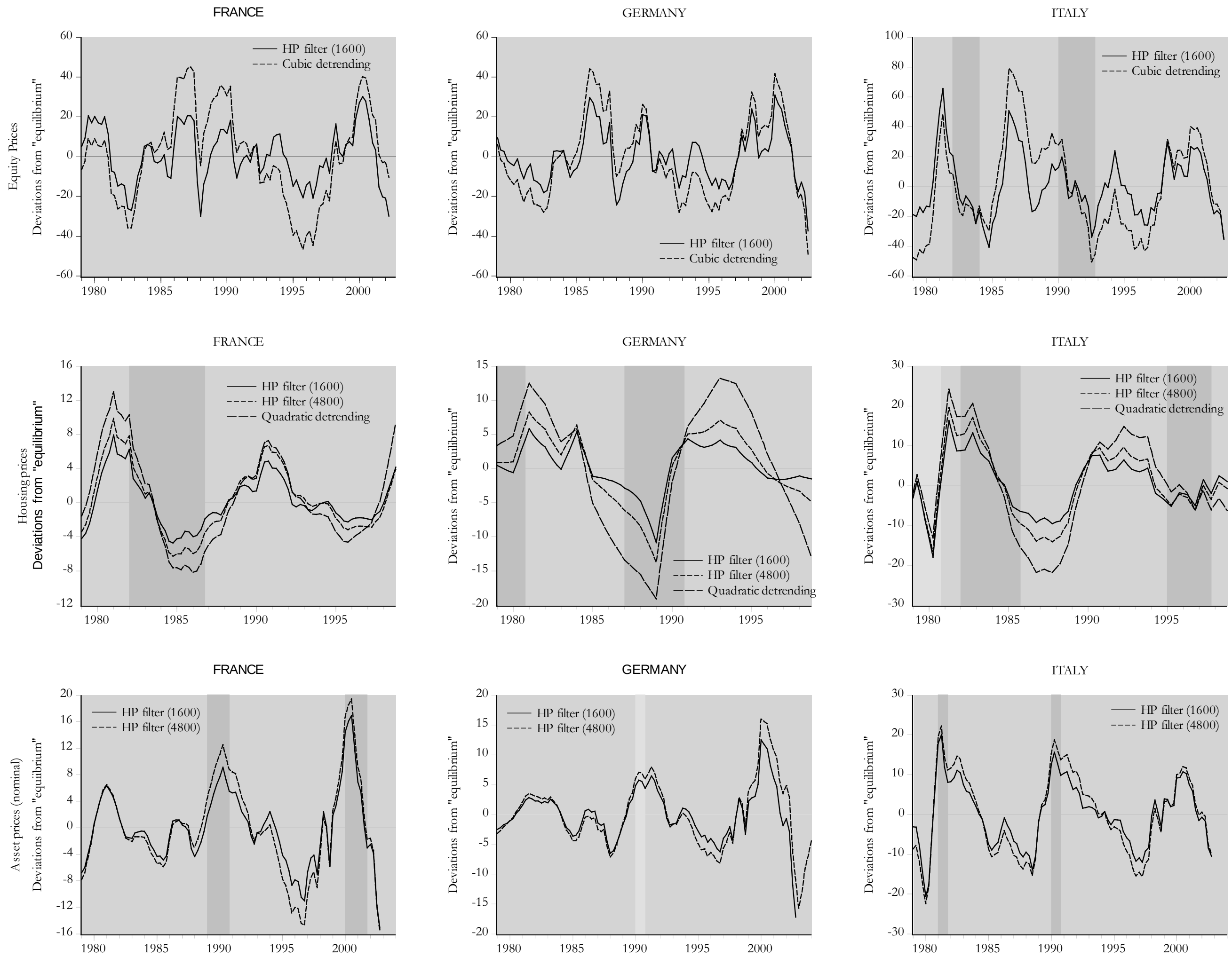
Note: The RMSE is based on equation (1b). Asset price variables enter in levels. OECD is the one year-ahead forecasts of inflation and the output gap from OECD Economic Outlook (insufficient data were available for the euro area). Economist is the one year-ahead forecast of inflation and real GDP growth from The Economist. n.a. means insufficient or no data available. Also, see the Note to Table 2.

Table 6: Encompassing Tests

Country, Sample	Type of Taylor Rule	Test Statistic
France, 1991 - 1999	forecast-based forward-looking	0.85 (0.07)** 0.17 (0.08)*
Germany, 1991 - 1999	forecast-based forward-looking	0.98 (0.03)** 0.02 (0.03)
Italy, 1991 - 1999	forecast-based forward-looking	0.92 (0.08)** 0.09 (0.08)
Euro Area, 1996 - 2002	forecast-based forward-looking	0.97 (0.03)** 0.04 (0.03)

Note: The test statistic is derived from estimates of the specification $i_t = \lambda_0 i_t^f + \lambda_1 i_t^e + \chi_t$ where i_t^f is the implied interest rate estimated from a forecast-based Taylor rule and i_t^e is the implied interest rate obtained from a forward-looking Taylor rule. The chosen forecast-based Taylor rules are France, German, Italy (money) and the euro area (all asset prices). The chosen forward-looking Taylor rules are France, Germany, Italy, and the euro area (all asset prices). The last two columns give the coefficient values and the standard error for the null $\lambda_0 = 0$, $\lambda_1 = 0$ in the first row and $\lambda_0 = 1$, $\lambda_1 = 0$ in the second row. ** (*) indicates whether the relevant null is rejected at the 1% (5%) level.

Figure 1: Gaps in Asset Prices in Three Euro Area Countries



Note: Gaps are log levels of the time series shown less the "equilibrium" proxy, estimated either via an HP filter with the smoothing parameter shown in the Figures or quadratic detrending. The shaded areas are boom and bust cycles, as reported in Bordo and Jeanne (2004), and Detken and Smets (2004). No cycles in equity prices for France and Germany were reported in either study.