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by

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Keywords: Forecasting, core money growth, stability, filter

JEL classification: E47, E58

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Abstract

In this paper, it is analyzed whether core money growth helps to predict future inflation in a useful and reliable way. Using an out-of-sample forecasting exercise and a stability analysis, it is shown that core money growth carries important information not contained in the inflation history, that its inclusion in a forecasting model can increase the forecasting accuracy, and that it has had a strong and stable long-run link to inflation over the last decades. A particularly promising forecasting model at all horizons is the one proposed by Gerlach (2004) that includes the inflation gap, the difference between core money growth and core inflation, and the output gap. This model has a very good track record and exhibits stable parameters over both the pre-EMU and the EMU era. What makes it appealing from a more theoretical perspective is that it relies on the stable long-run relationship between money growth and inflation.

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1 Introduction

Ever since the formulation of the two-pillar strategy of the European Central Bank (ECB), there has been a controversial debate whether the distinction be-

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tween a monetary pillar and an economic pillar makes sense.[1] One of the main arguments of the ECB in favor of the monetary pillar is the supposed medium-term orientation of a monetary signal as opposed to the more short-term orientation of other economic signals like, e.g., the output gap. This claim is based both on the Monetarist dictum that ‘inflation is always and everywhere a monetary phenomenon’ and on the available empirical evidence for the euro area that attests money a very good forecasting ability for inflation at horizons between one and three years (Nicoletti-Altimari, 2001) and even suggests a one-to-one relationship between low-frequency movements in inflation and (lagged) money growth (Neumann and Greiber, 2004).

A first look at the data seems to support this position. In fact, Figure 1 suggests that the one-to-one relationship holds surprisingly well, especially when one compares core money growth and core inflation, both of which are constructed using a Baxter-King filter that excludes frequencies of eight years and less. Moreover, core money growth appears to lead inflation, albeit with varying leads. However, at the sample end, the relationship is anything but close. Core money growth has accelerated since 1996 while core inflation increased only very modestly between 1998 and 2002 and has decreased since then. The missing increase in core inflation is striking, even if the well-known sample-end problem of the Baxter-King (and any other) filter is taken into account. Hence, the important question emerging from this descriptive analysis is whether the close relationship between core money growth and inflation has broken down in the recent years or whether a rise in inflation is soon to come.

From a more theoretical perspective, the relevance of core money growth is formalized by Gerlach (2004) as the so-called two-pillar Phillips (TPPC) curve, where he proxies inflation expectations with core money growth that is then

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[1] See, e.g., Masuch et al. (2003) and Gali et al. (2004). For recent discussion, see Woodford (2006) and the other papers presented at the 4th ECB Central Banking Conference in Frankfurt (http://www.ecb.int/events/conferences/html/cbc4.en.html).

added to an otherwise standard Phillips curve. Estimating this Phillips curve, he obtains plausible and, in the period from 1991 to 2003, stable parameters. Moreover, he shows that money carries information that is not already contained in past inflation and output gaps. In a similar model, Neumann and Greiber (2004) generally do not even find a significant output gap coefficient but a strong effect of core money growth. They also show that high-frequency movements of money growth have no explanatory power for inflation. This issue is analyzed in more detail by Assenmacher-Wesche and Gerlach (2006a, b). They show that there is a strong low-frequency relationship between money growth and inflation, while the relationship of the output gap with inflation relates to the high to medium frequencies.

This paper adds to the literature in several respects. First, it presents an out-of-sample forecasting exercise to assess the relevance of various measures of core money growth for future inflation in the euro area from 1999Q1 to 2006Q4. Thereby, it obviously extends early euro area studies like the one by Nicoletti-Altimari (2001) but it also adds to the two most recent out-of-sample forecasting experiments of Fischer et al. (2006) and Hofmann (2006). Fischer et al. (2006) examine the track record of the internal ECB forecasting models, one of which is based on M3 growth rates. They conclude that M3 growth rates add significant information to the macroeconomic forecast prepared by the ECB staff. However, they have to rely on the relatively short sample of 18 forecasts for the period 2002Q1 to 2006Q2. Moreover, they only consider six-quarter ahead forecasts which may understate the relevance of money that is typically assumed to have mainly medium to long term forecasting power for inflation. Hofmann (2006) conducts an extensive out-of-sample forecasting exercise with a focus on the question whether various monetary measures have better forecasting ability than a huge set of alternative indicators. As one of these measures, he considers Hodrick-Prescott filtered core money growth. However, he does not analyze the performance of competing filters or of core money growth adjusted for core output growth or core inflation as suggested, e.g., by Assenmacher-Wesche and Gerlach (2006b).

Second, this paper also considers models that are more ‘structural’ than the distributed lag models typically employed in the forecasting literature. Among these models the TPPC of Gerlach (2004) receives particular attention because it is both simple and theoretically appealing. Thereby, it may help to communicate the two-pillar strategy to the public. However, the TPPC has so far only be analyzed in-sample. But as it is sometimes difficult to exploit in-sample relationships for out-of-sample forecasting, this does not say much about the practical relevance of the TPPC for inflation forecasting. Moreover, the TPPC is typically specified with the right-hand side variables lagged only by one period. However, it remains an open question whether a highly significant influence of, say, the core money growth in the current quarter on the inflation rate in the next quarter also transmits in a significant influence on the inflation rate in two to four years, which is the typical horizon where money is assumed to matter.

Finally, this paper performs a detailed stability analysis both of the long-run relationship between money growth and inflation, and of the forecasting models. While there appears to be a general long-run link between money growth and inflation (McCandless and Weber, 1995, Lucas, 1996, Haug and Dewald, 2004), it has been argued that this only holds in a high inflation environment (de Grauwe and Polan, 2004). This would suggest that the link is easy to establish in the 70s and perhaps 80s but not in the 90s and in the EMU period. The argument of the vanishing relevance of money growth seems to be strengthened by the visual inspection of Figure 1 and the related evidence of Greiber and Lemke (2005) and Carstensen (2006) that indicates a breakdown of the EMU money demand function and, thereby, of the long-run relationship between money growth and inflation. To analyze this, this paper compares forecasting results for the last eight years of pre-EMU data with those for the first eight years of EMU data, which should be sufficient to get a good impression of the changing (ir)relevance of core money growth for inflation. In addition, a formal stability analysis is provided both for the long-run and low-frequency relationships between money growth and inflation and for the models actually used to forecast inflation. This is important because any forecasting model should be stable over time to be useful for future application.

This paper is structured as follows. The forecasting ability of core money growth for future inflation is analyzed by means of an out-of-sample forecasting experiment in Section 2. The stability of the most promising forecasting models and of the underlying low-frequency relationship between money growth and inflation is examined in Section 3. A summary and a conclusion are given in Section 4.

2 Is money growth a good predictor of future inflation?

In this section, the out-of-sample forecasting performance for inflation of various economic indicators is assessed with a particular emphasis on measures of core money growth. As a comparison, indicators like the output gap, core inflation, the interest rate spread, the real interest rate, and survey measures of inflation expectations are also considered. After a brief outline of the forecasting models and data used in this paper, the forecast results are presented. Since forecasting performance has at least two dimensions—forecast accuracy and information content—, the results of tests for forecast accuracy and forecast encompassing are reported.

2.1 Forecasting models

A large number of different models and variables has been used to forecast inflation. In this paper, only single-equation models are considered, among which models of a general Phillips curve type appear to be particularly promising. In these models, future inflation depends on current and possibly past realizations of inflation and one or more indicators. Depending on whether and how lags are chosen, the models can be roughly divided into two groups: time series models and (semi-)structural models.

The time series models are characterized by a flexible lag length of the explanatory variables that is typically determined by model selection criteria or significance considerations. In this paper, a stepwise procedure is used that allows lagged values to enter the model only if they are significant at the pre-specified level SL. Following the approach of Stock and Watson (1999), the model used in this paper is

$$\pi^h_{t+h} - \pi^1_t = \mu + \alpha(L)\Delta\pi^1_t + \gamma(L)x_t + \varepsilon_{t+h}, \tag{1}$$

where $\pi^h_t = (4/h)\ln(P_t/P_{t-h})$ is the annualized h-period inflation rate in the harmonized index of consumer prices (HICP), x_t is an indicator variable, and $\alpha(L)$ and $\gamma(L)$ are lag polynomials of maximum order q.

The following single indicators x_t are considered: core money growth $\Delta\bar{m}_t$, inflation-adjusted core money growth $\Delta\bar{m}_t - \bar{\pi}_t$, output-adjusted core money growth $\Delta\bar{m}_t - \Delta\bar{y}_t$, core inflation $\bar{\pi}_t$, inflation gap $\pi_t - \bar{\pi}_t$, the output gap $y_t - \bar{y}_t$, the spread s_t between a 10-year interest rate r^l_t and a 3-month interest rate r^s_t, the ex post 3-month real interest rate $rr^s_t = r^s_t - \pi^1_t$, survey-based consumer price expectations Epc_t and survey-based manufacturing price expectations Epm_t. These indicators are regularly used in studies on inflation forecasting. Of course, there are many more candidates than considered in this paper. However, here they only serve as a benchmark against which the core money growth measures can be evaluated. These core measures are used in several studies: core money growth and inflation-adjusted core money growth are used by Gerlach (2004), output-adjusted core money growth is used by Gerlach (2003) and Neumann and Greiber

(2004)[2], and core inflation and the inflation gap by Gerlach (2003) and Cogley (2002).

In addition, all the single indicators are considered together with the output gap. This gives rise to forecasting models in the spirit of the two-pillar Phillips curve (TPPC) proposed by Gerlach (2004) and discussed in more detail below. To assess whether the inclusion of the output gap is important, a two-indicator model with core money growth and core inflation is also included. Finally, two three-indicator models are considered as they are discussed in the recent literature: a model with core money growth, core output growth, and the output gap as suggested by Neumann and Greiber (2004), and a model with the inflation gap, the inflation-adjusted core money growth, and the output gap as suggested by the Cogley-Gerlach model discussed below. In order to include only stationary variables in the time series models, core money growth and core inflation are used in first differences.

The semi-structural models are slightly more directly related to economic reasoning, even though they are not structural in the strict sense of being derived from an economic model. Instead, they mainly abstain from adding lagged indicators chosen by statistical criteria, which typically worsens their in-sample fit but may improve their out-of-sample forecasting performance, especially at long forecast horizons h. The semi-structural models used in this paper are discussed in the following.

Cogley (2002) finds that the very parsimonious model

$$\pi^1_{t+h} - \pi^1_t = \mu + \gamma_1(\bar{\pi}_t - \pi^1_t) + \varepsilon_{t+h}, \tag{2}$$

has considerable forecasting power for the US. In addition, if $\bar{\pi}_t$ is a proxy for

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[2] Note that Neumann and Greiber (2004) use $\Delta\bar{m}_t - \beta\Delta\bar{y}_t$ with β estimated, but here the restriction $\beta = 1$ is imposed to reduce estimation uncertainty. This can be justified by the observation that β can be interpreted as the long-run output elasticity of EMU money demand, which is typically estimated to be only slightly above 1 (Bruggeman et al., 2003, Carstensen, 2006).

expected inflation, the restrictions $\mu = 0$ and $\gamma = 1$ should hold. Therefore, the model is used both under these restrictions and in an unrestricted form. However, for comparability the left-hand side of (2) is replaced with the average change in the inflation rate over the forecast horizon, $\pi_{t+h}^{h} - \pi_t^1$.

Gerlach (2004) extends the Cogley (2002) model to

$$\pi_{t+h}^{1} - \pi_t^1 = \mu + \gamma_1(\bar{\pi}_t - \pi_t^1) + \gamma_2\tilde{y}_t + \gamma_3(\Delta\bar{m}_t - \bar{\pi}_t) + \varepsilon_{t+h} \tag{3}$$

and estimates it with euro area data. He always obtains significant parameter estimates for the inflation gap, while the significance of the output gap and the inflation-adjusted core money growth depend both on the horizon h and the sample. Overall, his results suggest that the output gap has become more important recently, whereas the relevance of the core money growth-core inflation spread has diminished. Like above, the left-hand side of the Cogley-Gerlach model (3) is replaced with $\pi_{t+h}^{h} - \pi_t^1$.

Neumann and Greiber (2004) analyze the equation

$$\pi_{t+h}^{h} = \mu + \alpha(L)\Delta\pi_t^1 + \gamma_1\Delta\bar{m}_t + \gamma_2\Delta\bar{y}_t + \gamma_3\pi_t^{oil} + \varepsilon_{t+h} \tag{4}$$

for $h = 1$, where $\bar{y}_t$ denotes trend output growth and π_t^{oil} denotes oil price inflation. Only the lag order of $\alpha(L)$ is chosen by statistical criteria. Therefore, to distinguish it from the pure time series model 1, it is also classified as being semi-structural. Note that the model does not include the output gap because Neumann and Greiber find it to be not significant.

Finally, as a structural model, the TPPC of Gerlach (2004) is considered. This is a conventional expectational Phillips curve

$$\pi_{t+h}^{h} = \alpha_f E[\pi_{t+h+1}^{h}] + \alpha_b\pi_t^1 + \alpha_y\tilde{y}_t + \varepsilon_{t+h} \tag{5}$$

with $h = 1$, where $E[\pi_{t+h+1}^{h}]$ is expected future inflation. Assuming that, according to the monetary pillar of the ECB, core money growth determines inflation expectations, at least beyond the very short run, he substitutes $\Delta\bar{m}_t$ for $E[\pi^h_{t+h+1}]$ and obtains the TPPC

$$\pi^h_{t+h} = \alpha_f \Delta\bar{m}_t + \alpha_b \pi^1_t + \alpha_y \tilde{y}_t + \varepsilon_{t+h}. \tag{6}$$

While he further transforms the TPPC by assuming that core money growth should be measured with the help of an exponential filter, in this paper various measures of core money growth are directly used as explanatory variables. Of course, core money growth need not be the best indicator for expected future inflation. Therefore, the following indicators are also examined: core inflation, inflation gap, output gap, interest rate spread, real interest rate, survey-based consumer price expectations and survey-based manufacturing price expectations. As a result, the TTPC models resemble the two-indicator time series models with the only difference that the TPPC models are static in the sense that only current observations are included but no lags. While Gerlach (2004) reports that the theoretical restriction $\alpha_f + \alpha_b = 1$ cannot be rejected, it is not imposed in the following because some initial results indicated that this deteriorates the forecasting performance considerably.

As benchmark models, the purely autoregressive (AR) model

$$\pi^h_{t+h} = \mu + \alpha(L)\Delta\pi^1_t + \varepsilon_{t+h} \tag{7}$$

and an ARIMA(q,2,1) model for p_t is used.

2.2 Data

The data set comprises quarterly observations from 1970Q1 to 2006Q4 for M3 money balances, real GDP, the HICP, a 3-month money market rate and a 10-year government bond rate. They are taken from the updated area-wide model data set provided by Euro Area Business Cycle Network (EABCN) and chained up with the official data taken from the ECB internet site. All data except for the interest rates are seasonally adjusted. The survey measures of inflation expectations are taken from the Eurostat internet site. They only date back to 1985Q1 and are thus not included in the forecasting models for the pre-EMU sample.

To extract the core movements from money growth ($\Delta\bar{m}_t$), inflation ($\bar{\pi}_t$), and output ($\bar{y}_t$), four different filters are used: the Hodrick-Prescott filter with smoothing parameter 1600, the Baxter-King filter that excludes all frequencies higher than eight years, the Christiano-Fitzgerald filter that excludes all frequencies higher than eight years, and the exponential filter with smoothing parameter 0.075 as suggested by Gerlach (2004). To mitigate the well-known end-point problem of the first three filters, the original variables are extrapolated with an ARIMA model for four quarters before the filters are applied. As the properties of the forecasting models that include core variables may depend on the filter, any such model is implemented four times, once for each filter. Note that in the forecasting experiment the filters are only applied to the span of data available at each date, thereby mimicking a real-time forecasting situation, but the data themselves are not real-time but revised. However, this should not be a major drawback because of the data used only GDP is heavily revised over time. Hence, if anything, the real-time relevance of the output gap may be overstated in this paper, not the relevance of money. In addition, it is shown by Orphanides and van Norden (2002) that the end-point problem of the filters is much more important than the data revisions.

2.3 Forecasting results

The forecasting exercise is conducted for two different forecasting samples, 1991Q1 to 1998Q4 and 1999Q1 to 2006Q4. Of course, the second sample is of particular interest because it coincides with the EMU period. The first sample is of the same length and serves for comparison. The forecasting samples comprise 32 observations each and are thus large enough to allow a meaningful analysis of the results.

The forecasts are computed as recursive out-of-sample forecasts. For an h-quarter forecast, the first estimation sample is 1970Q1 to 1991Q1-h and the first forecast is with respect to the average inflation rate during the period 1991Q1$-h+$1 to 1991Q1; the second estimation sample is 1970Q1 to 1991Q2-h and the first forecast is with respect to the average inflation rate during the period 1991Q2$-h+$1 to 1991Q2; and so on. By this method, there are always 32 forecasts per forecast sample, regardless of the forecast horizon h. The obvious drawback is that only the endpoints of the forecast periods lie within the forecast sample. For example, consider 12-quarter forecasts for the EMU forecast sample. The first forecast is with respect to the average inflation rate during the period 1996Q2 to 1999Q1, the second with respect to 1996Q3 to 1999Q2 and so on. Hence, the first forecast period that is completely within the EMU sample is the one with respect to 1999Q1 to 2001Q4. Starting with this forecast period would leave only 21 forecasts and, thereby, reduce the basis for statistical forecast evaluation.

For the time series models, the maximum lag order q and the significance level SL necessary for a lagged variable to be included appear to be important parameters because they help determine the in-sample fit. If the fit is bad, forecasts may be poor, while overfitting might be even more detrimental. However, some initial experiments with $q = 2, 3, 4$ and $SL = 0.1, 0.05, 0.01$ revealed that the results are not strongly affected by their choices. Perhaps the most pronounced effect is that a high maximum lag order can lead to worse forecasts at longer horizons. Therefore, the subsequent results are based on $q = 2$ and $SL = 0.05$.

The relative root mean-squared forecasting error (RMSFE) of the forecasting models relative to the benchmark AR model are reported in Tables 1 (1991Q1 to 1998Q4) and 2 (1999Q1 to 2006Q4) together with the results of Diebold-Mariano tests for forecast accuracy (Diebold and Mariano, 1995) and modified Diebold-Mariano tests for forecast encompassing (Harvey et al., 1998). For both tests, the null hypothesis is that the forecasting models have nothing to add to the benchmark AR model.[3] The results differ considerably between the two forecast samples. This may reflect the fact that, even though inflation rates were relatively low in both samples, the first sample is a disinflation period, while the second sample is characterized by relatively stable inflation. Perhaps for this reason, it is difficult in the first sample to outpredict the AR model in terms of forecast accuracy, particularly not at longer horizons. For horizons between 1 and 4 quarters, models including core inflation and the inflation gap can significantly improve upon the AR model. For the 8-quarter horizon, this is only achieved by the time series model with Baxter-King filtered core inflation and core money growth, which performs also favorably at shorter horizons (Table 1, row 66). For horizons beyond 8 quarters, no significant improvement over the AR model is observed.

This changes dramatically for the EMU sample, where various models outpredict the AR model. At horizons between 1 and 4 quarters, again models including core inflation and the inflation gap perform particularly well, but also those that include the term spread and the real interest rate. However, the Cogley-Gerlach model (both the time series and the semi-structural variant) appear to perform best (Table 2, rows 73-76 and 85-88). At horizons between 8 and 12 quarters, models that include money become more dominant. The time series variant of the Cogley-Gerlach model exhibits the smallest forecast error, closely followed by time series models that include core money growth and output-adjusted core money growth. In all these cases, the use of the Christiano-Fitzgerald filter seems necessary to achieve such a good performance. Surprisingly, at the very long horizon of 16 quarters, significant improvements over the AR model are only achieved by models that include the inflation gap and the real interest rate.

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[3] It must be noted that these tests are designed for non-nested forecasts while for some models and quarters, the AR benchmark model may be nested in the competing model. However, since this may change from quarter to quarter, the non-nested tests are nevertheless applied, even if their results have to be interpreted with some care.

However, the information content of the variables over the inflation history are probably more interesting for policy makers than pure forecast accuracy. Not surprisingly, the simple AR model does not encompass a large fraction of models. For the first sample, it is particularly core money growth and core inflation that add significant information to the AR model. The the output gap alone is not very helpful, while two-indicator models with the output gap and a monetary variable are quite promising. At least three models deserve special attention: First, the time series model with core money growth, core output growth, and the output gap in the spirit of Neumann and Greiber (2004); second, the semi-structural Cogley-Gerlach model with the inflation gap, inflation-adjusted core money growth, and the output gap as proposed by Gerlach (2004); and, third, the TPPC with core money growth as a measure of inflation expectations introduced by Gerlach (2004). All these models add significant information to the AR model, irrespective of the forecast horizon and the filter used to calculate the core measures. In addition, the semi-structural Cogley-Gerlach model also outperforms the AR model in terms of forecast accuracy. On balance, it is therefore probably the best model for the pre-EMU sample.

For the EMU sample it is more difficult to emphasize the information content of just a few models. Given the focus of this paper, the excellent information content at horizons of 4 quarters and beyond of the time series models with (adjusted and unadjusted) core money growth deserve special attention. Adding the output gap to these models leads to very good models both in terms of forecast accuracy and information content for all horizons. Interestingly, the time series and semi-structural variants of the Cogley-Gerlach model carry again significant additional information over the AR model. Overall, for the EMU sample, the time-series variant of the Cogley-Gerlach model seems to perform best when the Christiano-Fitzgerald filter is used but several others follow at least closely behind.

To summarize the findings of the out-of-sample forecasting experiment, it is fair to say that core money growth is certainly not the only indicator for medium-term inflation with a good track record both in terms of forecast accuracy and information content. However, it seems to be a fundamental ingredient of the most successful models, among which the Cogley-Gerlach model performs outstandingly in both samples. As regards the filters, no general recommendation can be made. However, for the EMU sample, the Christiano-Fitzgerald filter is most recommendable.

3 Is core money growth a stable predictor of future inflation?

In the previous section, it turned out that core money is a promising indicator of future inflation, especially at horizons beyond one year. However, it also turned out that the forecasting performance between the pre-EMU and EMU samples changes. While this does not necessarily indicate that the low-frequency relationship between money growth and inflation has broken down but may be due to high-frequency noise that has been reduced during the EMU sample, it definitely suggests that a closer look is necessary. This is done in the current section. In a first step, the stability of the long-run (cointegration) relationship between money growth and inflation is examined. Since cointegration is a property at the zero frequency, this analysis is complemented with an analysis of the possibly changing link between the low-frequency components of money growth and inflation. Finally, the stability of some of the most promising forecasting models obtained from the previous section is checked.

3.1 The cointegration relationship between money growth and inflation

A cointegration relationship between money growth and inflation means that they are tied together in the "long run" which is, from a statistical perspective, at frequency zero. At first sight, this might not be too helpful for finite forecasting horizons of, say, one or two years. But according to the Granger representation theorem (Engle and Granger, 1987), any two cointegrated variables feature an error-correction mechanism that pulls them together each time they depart from the long-run relationship. Hence, the cointegration property should be exploitable even for short to medium run forecasts.

To test for cointegration, a vector autoregressive (VAR) model is specified with three lags as indicated by the Schwarz and Hannan-Quinn information criteria. The Bartlett-corrected trace test clearly rejects the null hypothesis of no cointegration (test statistic 17.8, p-value 0.02).[4] Imposing cointegration rank 1, the long-run relationship is estimated by full-information maximum likelihood (FIML) as

$$\Delta m_t = \underset{(0.194)}{1.23}\ \pi_t + \hat{e}_t$$

Taking the standard error of 0.194 into account, the parameter estimate $\hat{\beta}$ is not significantly different from one. Consequently, the restriction of a one-to-one long-run relationship cannot be rejected (Bartlett-corrected likelihood ratio statistic 0.92, p-value 0.34). Moreover, the joint restriction of $\beta = 1$ and weak exogeneity of inflation cannot be rejected (Bartlett-corrected likelihood ratio statistic 3.30, p-value 0.19), while the joint restriction of $\beta = 1$ and weak exogeneity of money growth is strongly rejected (Bartlett-corrected likelihood ratio statistic 11.27, p-value 0.004). This implies, first, that there is a one-to-one long-run relationship between money growth and inflation and, second, that money growth represents

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[4] In addition, the test does not reject the null hypothesis of cointegration rank one with test statistic 1.3 and p-value 0.26.

the pushing force while inflation adjusts towards the long-run relationship.

However, the results should be interpreted with care. In particular, since cointegration is a long-run concept, they do not imply that all short and medium run movements in money growth will also transmit one-to-one to inflation. But they do imply that a permanent increase in money growth will entail a one-to-one increase in inflation in the long run.

To check for the robustness and stability of the results, the long-run relationship is also estimated by fully-modified OLS (FM-OLS). This yields an estimate $\hat{\beta} = 0.999$ with standard error 0.135, which clearly supports the FIML result in favor of a one-to-one relationship.

While the results of the cointegration analysis are not particularly new (Kugler and Kaufmann (2005) and Assenmacher-Wesche and Gerlach (2006b) obtain similar results for a shorter sample), they might be driven by past observations and ignore recent structural changes. For this reason, a recursive estimation by FIML and FM-OLS is performed. It does not yield any signs of instability on part of the long-run parameter β, see Figure 2. Several tests for long-run stability as proposed by Hansen and Johansen (1999) for FIML and by Hansen (1992) for FM-OLS round off this picture. The FIML based eigenvalue fluctuation test (test statistic 0.558, p-value 0.915) and the supremum and average Nyblom tests (supremum statistic 0.371, p-value 0.820, average statistic 0.070, p-value 0.724) as well as the FM-OLS based Nyblom-type test (L_c statistic 0.115, 10% critical value 0.361) and the supremum and average F tests (Sup$F$ 3.21, 10% critical value 11.2, Mean$F$ 1.20, 10% critical value 3.73) do not indicate instability either.

The results of the cointegration and stability analysis come a bit unexpected given the supposed disconnection of money growth and inflation in the recent years. Apparently, the current wedge between money growth and inflation is still not "permanent enough" to make the long-run stability tests react. This indicates that there is not enough evidence to reject the null hypothesis of *stability*. Of course, the power of these tests might be low, especially at the sample end.

Hence, someone with a strong prior against the value of money growth does not necessarily have to reject the null hypothesis of *instability.*

As a way to operationalize the instability prior, the long-run relationship is estimated with a moving window of 20 years of observations, see Figure 3. Thereby, observations in the very distant past like the ones from the high money growth-high inflation regime of the 70s do not affect the current estimates. This approach takes the critique of de Grauwe and Polan (2004) into account who argue that a strong link between money growth and inflation can only be found in a high-inflation regime.[5] At the same time, the estimates become more sensitive both to changes in the underlying relationship (which is desired) and to short-run and business cycle fluctuations (which is not desired). Therefore, it is no surprise that the moving window estimates are much more volatile than the recursive estimates. Moreover, as a result of the wedge between money growth and inflation, the estimates decrease over the EMU sample. For example, the FM-OLS estimates go down from around 1.00 for samples ending in the pre-EMU era to below 0.5 for samples ending in 2006, but still remain statistically significant. A similar movement can be observed for the FIML estimates. However, this approach is not a formal statistical test and it is of course well possible that the moving window estimates are too sensitive and simply react to transitory effects.

The conflicting results reflect the difficulty to decide whether the recent wedge between money growth and inflation is transitory or permanent. On the one hand, recursive estimates under the maintained hypothesis of stability suggest that there is by far not enough evidence to term the wedge permanent. On the other hand, moving window estimates seem to indicate that the long-run

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[5] However, Nelson (2003) argues that the results of de Grauwe and Polan (2004) are biased by not considering the dynamics of the relationship between money growth and inflation. The cointegration methods applied in this paper definitely take the dynamics into account and are, therefore, much less prone to the de Grauwe and Polan critique even when the full sample of data is included.

relationship has changed over the last decade or so, but only at the risk of being oversensitive.

3.2 The low-frequency relationship between money growth and inflation

A simple regression of core inflation on lagged core money growth,

$$\bar{\pi}_t = \alpha + \beta \Delta \bar{m}_{t-8} + \varepsilon_t,$$

may help to confirm the previous evidence. The choice of lag eight corresponds to the finding that money helps to predict inflation best at medium term horizons. However, the results are extremely robust to choosing different lags between 4 and 16 quarters. Using the pre-EMU sample from 1970Q1 to 1998Q4, one obtains an $R^2 = 0.92$ and the estimate $\hat{\beta} = 1.05$ (HAC standard error 0.09) that is not significantly different from one (p-value $= 0.60$). For the full sample from 1970Q1 to 2006Q4, the results are almost the same: an $R^2 = 0.92$ and the estimate $\hat{\beta} = 1.03$ (HAC standard error 0.08) that is again not significantly different from one (p-value $= 0.70$).[6]

While this appears to suggest that the relationship between core money growth and core inflation has not deteriorated during the EMU period, a closer analysis using again a moving window of 80 quarterly observations reveals again that there might have been recent changes. Figure 4 shows the R^2 and the estimate of β for the preceding regression with lags 4, 8, 12 and 16, where the first observation corresponds to a window of data from 1970Q1 to 1989Q4. Obviously, the R^2 (left axis) of these regressions decreases towards the sample end, and so do the estimates of β (right axis). Hence, the relationship between core money

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[6] Obviously, the results must be taken with great care because money growth and inflation are integrated variables and so are their core measures. Hence, the regressions may give spurious results and the distribution of the estimator is not normal. Nevertheless, the results are suggestive and, given the cointegration analysis reported above, not surprising.

growth and core inflation has become less close both in terms of the fit and in terms of the parameter estimates that have drifted away from unity. These results closely resemble the findings of the cointegration analysis and thereby confirm that they do not depend on the specific way how the underlying low-frequency relationships are analyzed.

3.3 The stability of the forecasting models

In a final step, the stability of the forecasting models used in the out-of-sample forecasting experiment is examined. For the time series models, it is not obvious how to best accomplish this because the included lags are allowed to change from quarter to quarter. Therefore, these models are excluded from the analysis with the the single exception being the AR benchmark model for which the lag order is now fixed to $q = 1$ even though this inhibits a direct comparison to the out-of-sample forecasting experiment. In addition, five structural models with the Christiano-Fitzgerald filter are considered that performed well in the out-of-sample forecasting experiment, particularly for the EMU sample. The first model is the unrestricted Cogley model (2) and the second one is the Cogley-Gerlach model (3), which both performed very well in both samples. The remaining three models are of the TPPC type (6) with inflation expectations proxied by core money growth, inflation-adjusted core money growth, and the inflation gap. In the EMU sample, core money growth and inflation-adjusted core money growth contain important information for future inflation at the horizons of 4 to 8 and 12 to 16 quarters, respectively, while the inflation gap is important for all horizons.

To assess the stability of these six forecasting models, they are estimated recursively starting from the first sample end in 1990Q1 to the final sample end in 2006Q4. The recursively estimated parameters are displayed in Figures 5 to 9 for forecast horizons $h = 1$ to $h = 16$, respectively. Their 95% confidence intervals are based on autocorrelation consistent estimation of the standard errors.[7]

Overall, the estimates look pretty stable regardless of the horizon h. The results for the unrestricted Cogley model is reported in the first row of each Figure. There is a slight downward trend in the inflation gap parameter, especially for large h, but given the estimation uncertainty this is far from being significant. The following three models each include a measure of core money. The corresponding parameter is reported in the second column of each Figure. It shows a weak sign of a structural change during the 90s but this is neither statistically significant nor quantitatively important. The fifth model is a TPPC with the inflation gap as the proxy for inflation expectations. It seems to exhibit a somewhat more pronounced structural change at the beginning of the 90s but is perfectly stable since the middle of the 90s. Finally, even the simple AR(1) model does not show significant signs of structural change.

To further corroborate this informal analysis, forecast breakdown tests as proposed by Giacomini and Rossi (2005) are conducted for the most interesting EMU forecasting sample from 1999Q1 to 2006Q4. This test is closely related to, but more general than, conventional structural break tests. Specifically, for each model it compares the out-of-sample performance with the average in-sample performance in every forecasting step. A large deterioration in out-of-sample performance compared to the in-sample fit of a forecasting model will indicate a forecast breakdown, while an improvement is of course not harmful. Therefore, this is a one-sided test that rejects the null hypothesis of forecast stability if the test statistic is larger than the corresponding critical value taken from the standard normal distribution.[8] As one may expect from the recursive parameter

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[7] To account for moving average errors of order $h-1$, a nonparametric covariance estimator with Bartlett kernel and lag window of $h-1$ is used.

[8] In this paper, the test is used for a quadratic loss function and under the assumption of covariance stationary losses. The test statistic is adjusted for possible overfitting as suggested by Giacomini and Rossi (2005).

estimates, the test does not reject forecast stability at conventional significance levels for all models (see Table 3). This confirms the overall result that (parameter and forecast) stability cannot be rejected for any of the models, irrespective of whether core money is included or not.

4 Summary and conclusions

In this paper, it has been analyzed whether core money growth helps to predict future inflation in a useful and reliable way. The empirical results confirm an important role for core money growth in several dimensions. First, it carries important additional information beyond that already contained in the inflation history. Second, it has a strong long-run link to inflation that has been stable over the last decades. Third, it can be included in h-step forecasting models without showing a severe sign of instability since the beginning of the 90s.

A particularly promising tool for inflation forecasting is the Cogley-Gerlach model that includes three indicators: the inflation gap $\pi_t - \bar{\pi}_t$, the inflation-adjusted core money growth $\Delta\bar{m}_t - \bar{\pi}_t$, and the output gap $y_t - \bar{y}_t$. While the first two indicators are more strongly related to medium-term inflation, the output gap rather signals short-run inflationary movements. Hence, this combination of indicators makes sure that the model has very good forecasting ability at all horizons, both in the pre-EMU and in the EMU era. In addition, recursive analysis of this model shows quite stable parameters estimates. Moreover, it is also appealing from a "monetarist" perspective because it utilizes the difference between money growth and inflation that, as shown in this paper, constitutes an extremely stable cointegration relationship.

As a grain of salt, estimates with a moving window of 20 years of observations seemed to indicate that the wedge between accelerating money growth and almost constant inflation that the euro area has witnessed in the recent years may have affected the long-run relationship between money growth and inflation, even though formal statistical tests cannot reject the stability hypothesis by a wide margin. From this perspective, the current evidence is not sufficient to dismiss the theoretically appealing claim that money growth and inflation go hand in hand in the long run. However, it suggests that there is good reason for the ECB to maintain its careful analysis of the monetary developments because if money growth remains at the current levels there will be either a structural change in the long-run money growth-inflation relationship or, much worse, a considerable rise in inflation.

As a final remark, it should be stressed that the results do not necessarily support the monetary pillar of the ECB monetary policy strategy for two reasons. First, as far as the monetary pillar serves to structure discussions and facilitate communication both within the ECB and to the outside world, this paper has not much to add. If the the 'structural' two-pillar Phillips curve is taken as a rationale for the two pillars, the results are not overly supportive because other models performed better. Second, whereas core money growth appears to play an important role as an indicator of future inflation, it is clearly not the only important indicator. For example, core inflation and the real interest rate also turned out to be good predictors. Hence, these results do not confirm a 'prominent' role for money. As argued by Svensson (2006), even the stable long-run relationship between money growth and inflation need not imply such a prominent role.

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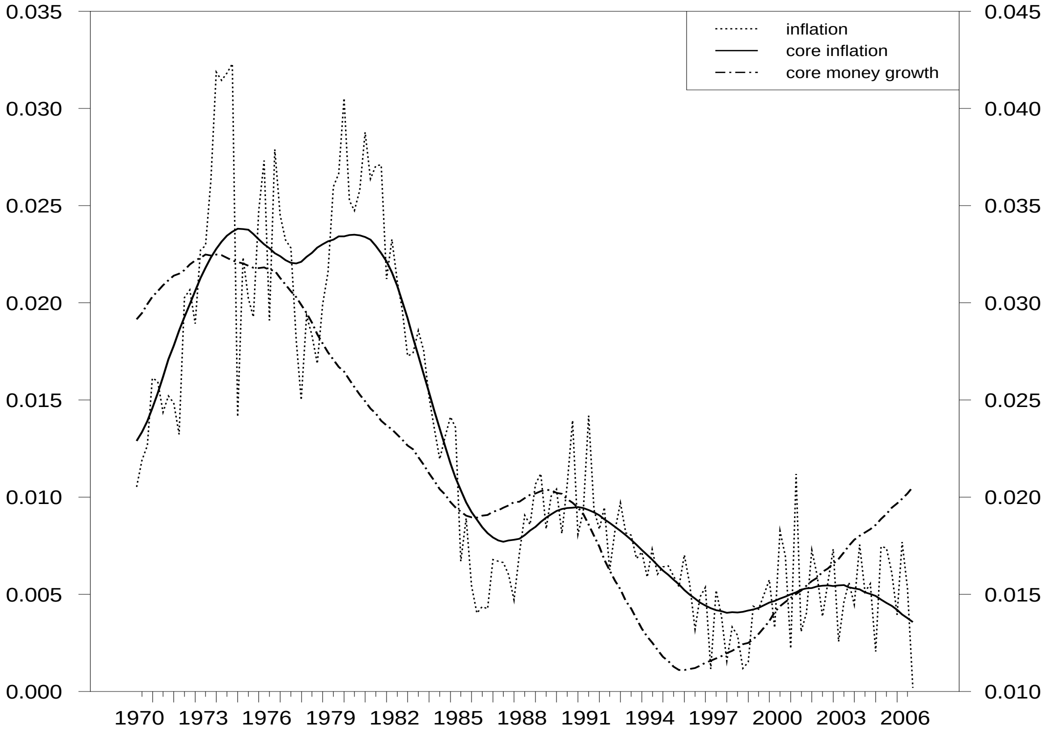


Figure 1: The relationship between core money growth (right axis) and inflation (left axis)

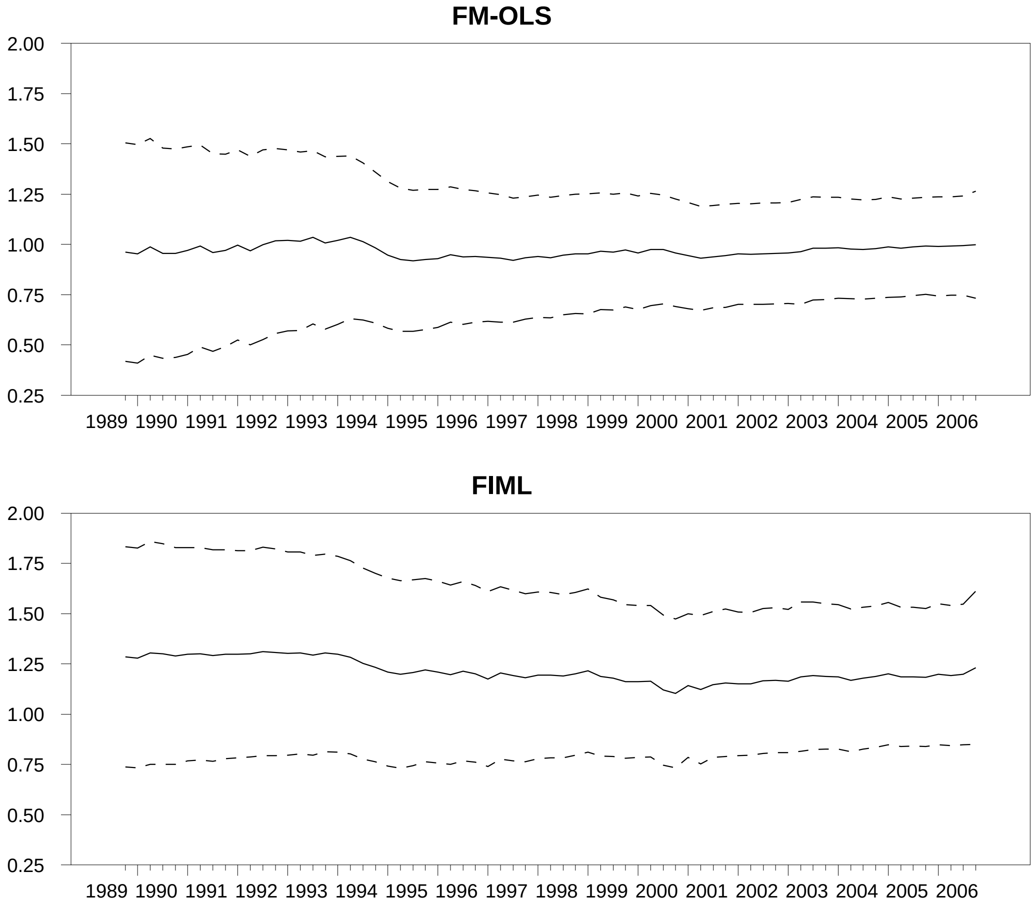


Figure 2: Recursive estimates of the long-run relationship between money growth and inflation

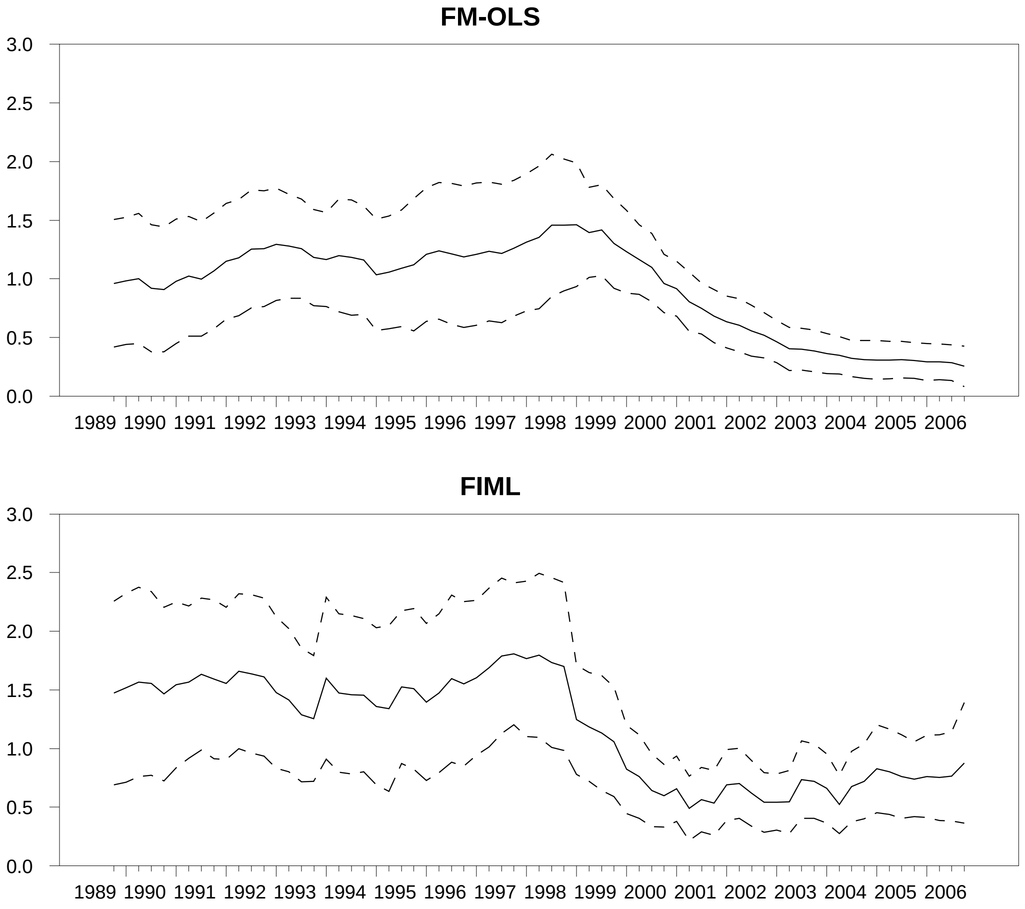


Figure 3: Moving window estimates of the long-run relationship between money growth and inflation

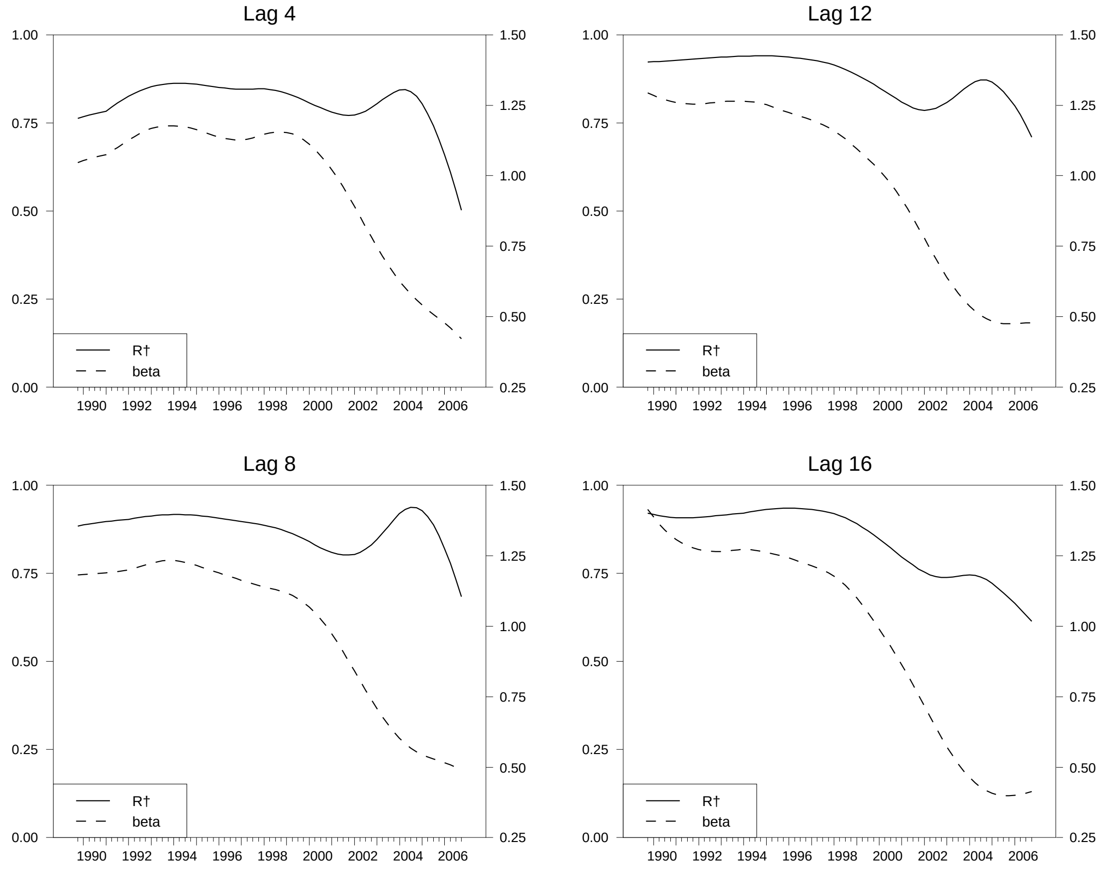


Figure 4: R^2 (left axis) and parameter estimates (right axis) for the rolling regressions of core inflation on core money growth

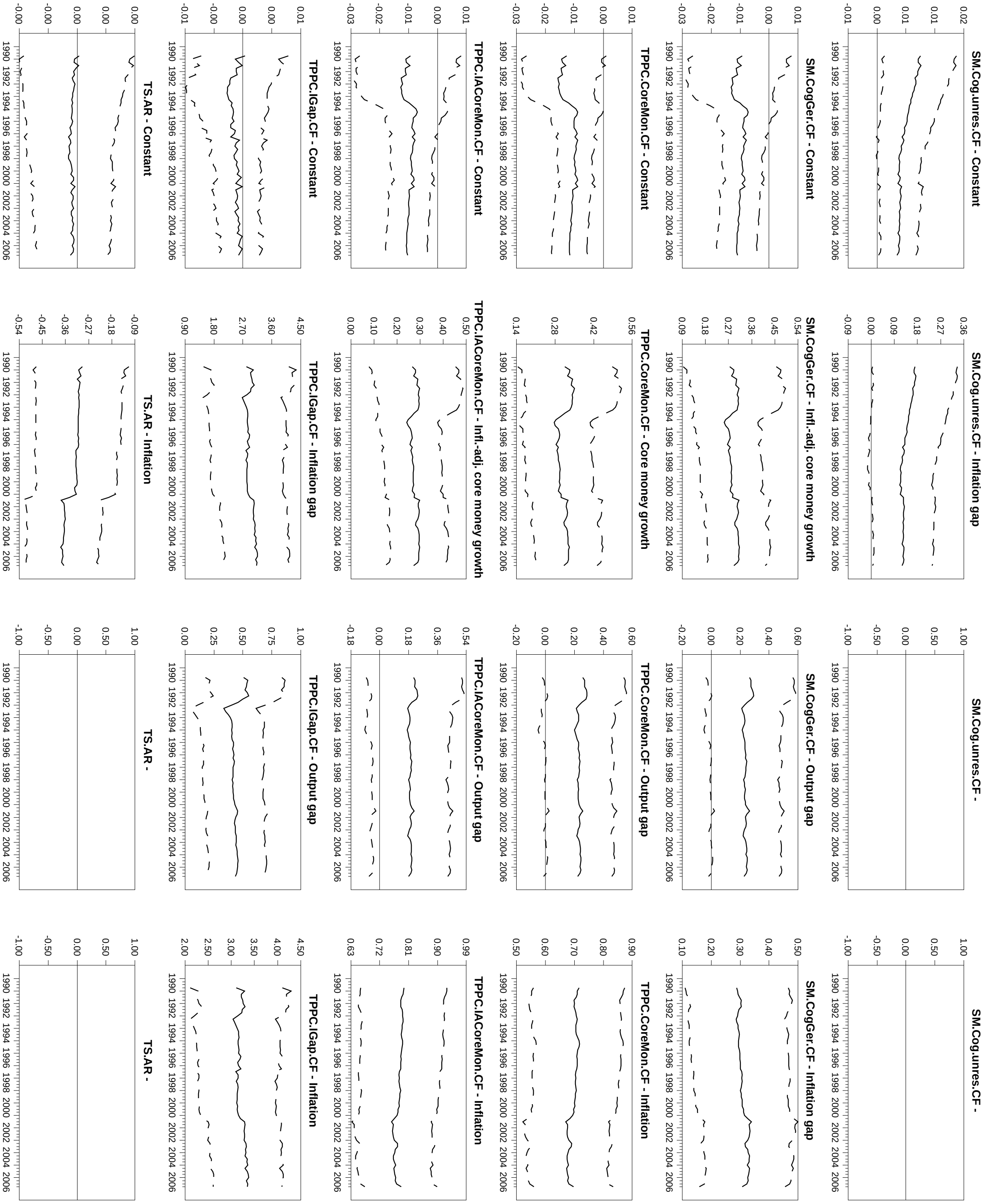
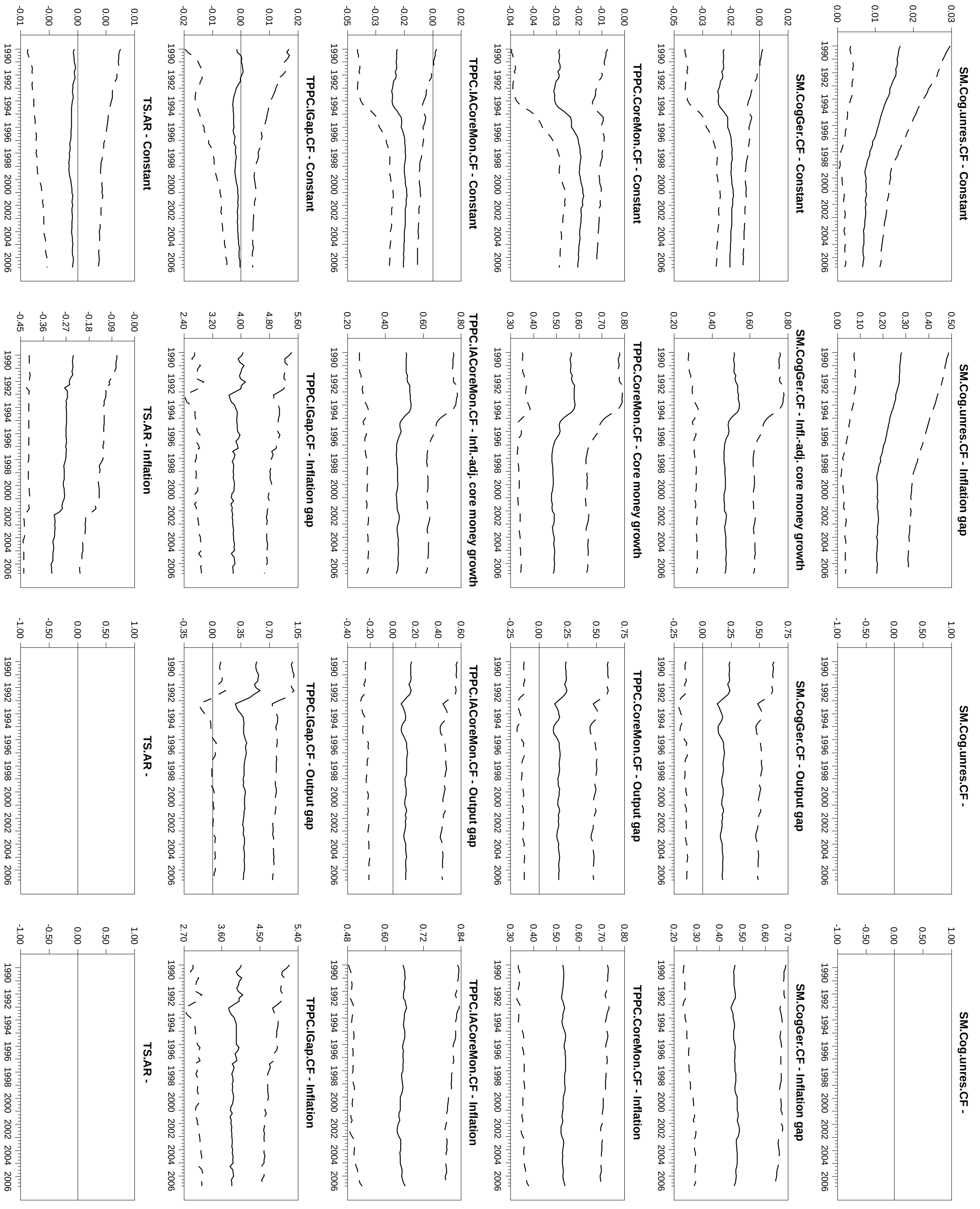


Figure 5: Recursive parameter estimates for $h = 1$ quarter


SM.Cog.unres.CF - Constant

SM.Cog.unres.CF - Inflation gap

SM.Cog.unres.CF -

SM.Cog.unres.CF -

SM.CogGer.CF - Constant

SM.CogGer.CF - Infl.-adj. core money growth

SM.CogGer.CF - Output gap

SM.CogGer.CF - Inflation gap

TPPC.CoreMon.CF - Constant

TPPC.CoreMon.CF - Core money growth

TPPC.CoreMon.CF - Output gap

TPPC.CoreMon.CF - Inflation

TPPC.IACoreMon.CF - Constant

TPPC.IACoreMon.CF - Infl.-adj. core money growth

TPPC.IACoreMon.CF - Output gap

TPPC.IACoreMon.CF - Inflation

TPPC.IGap.CF - Constant

TPPC.IGap.CF - Inflation gap

TPPC.IGap.CF - Output gap

TPPC.IGap.CF - Inflation

TS.AR - Constant

TS.AR - Inflation

TS.AR -

TS.AR -

Figure 6: Recursive parameter estimates for $h = 4$ quarters

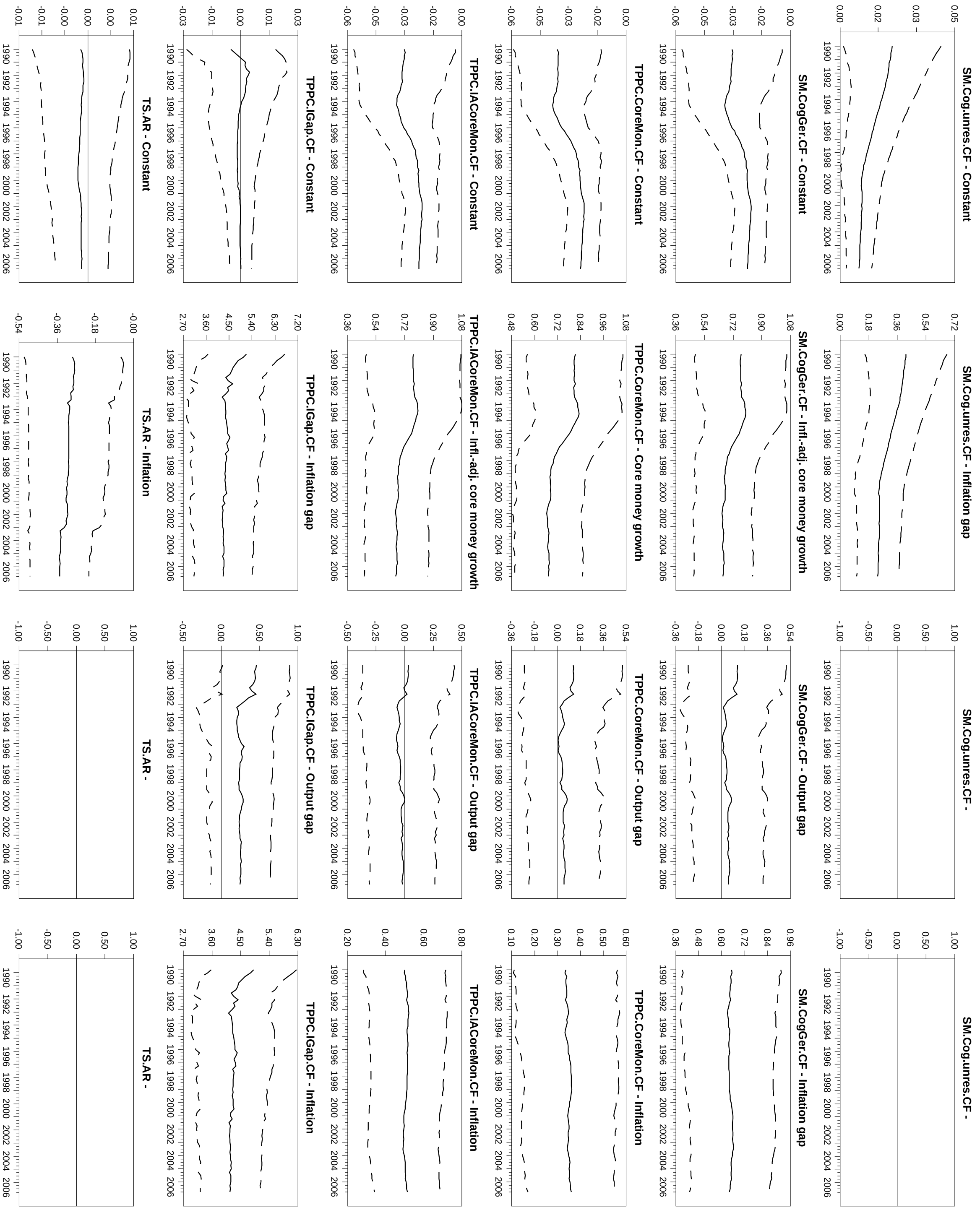


Figure 7: Recursive parameter estimates for $h = 8$ quarters

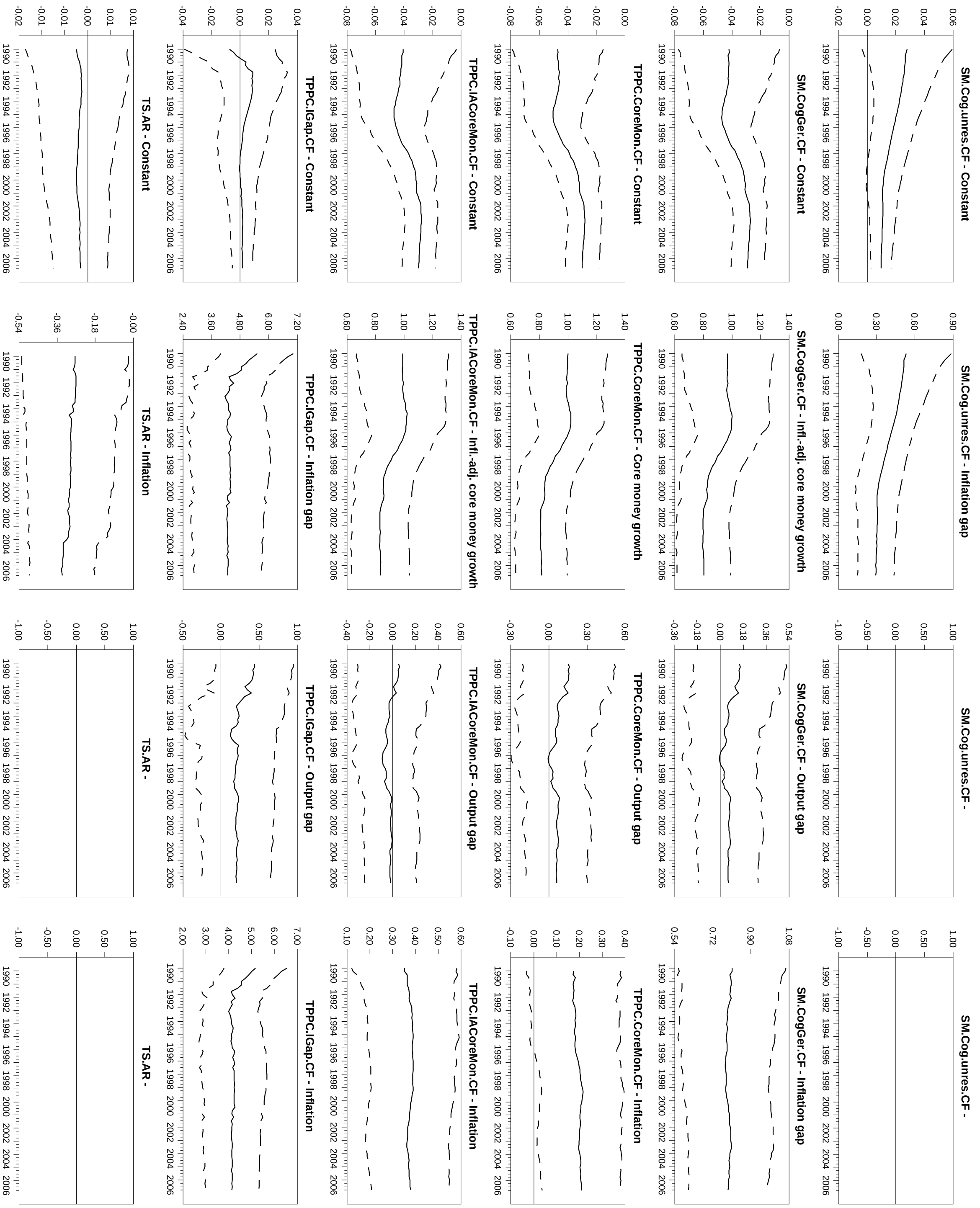


Figure 8: Recursive parameter estimates for $h = 12$ quarters

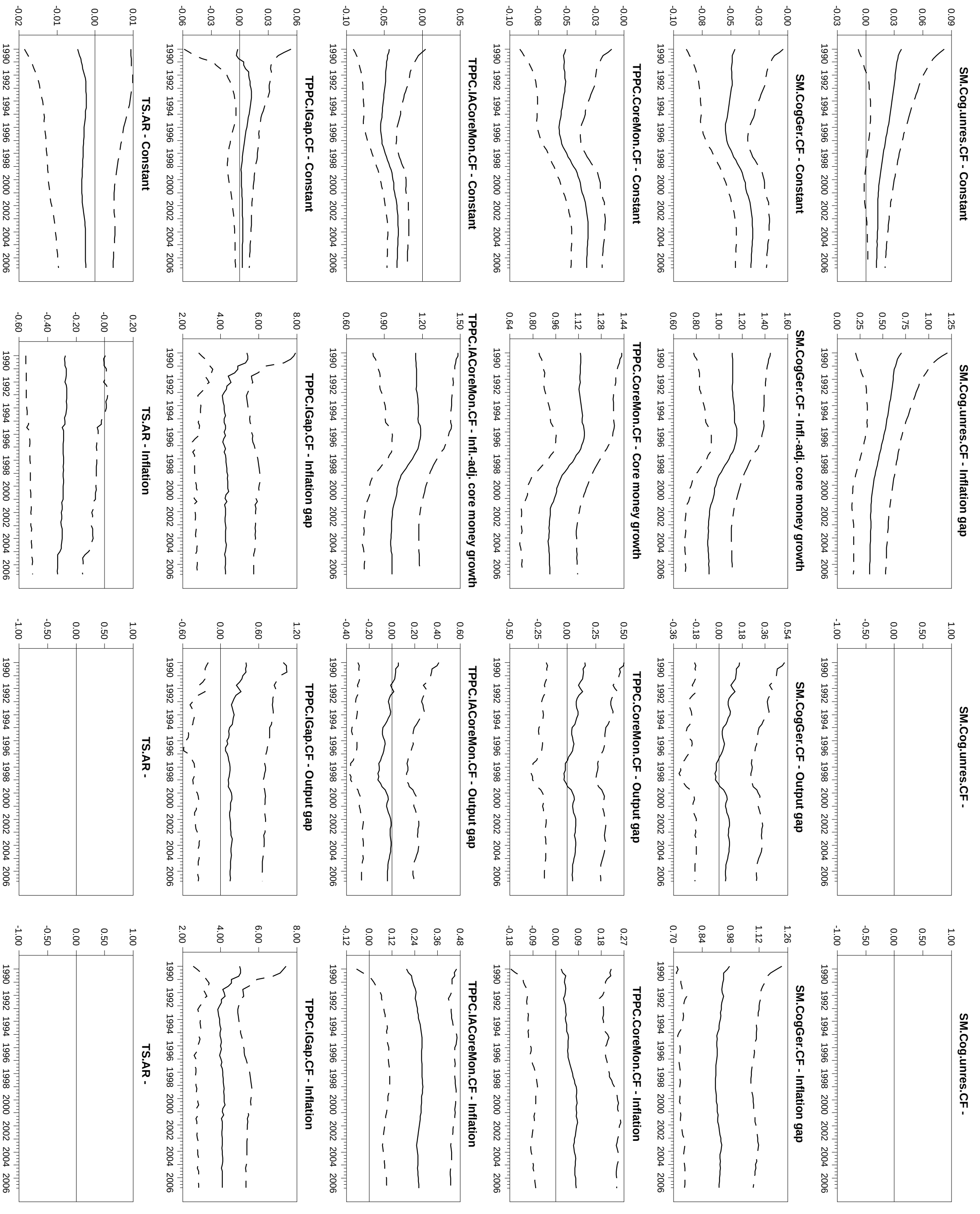


Figure 9: Recursive parameter estimates for $h = 16$ quarters

Table 1: Results of the forecasting experiment for 1991Q1 to 1998Q4

No.	Model	h=1	h=2	h=4	h=8	h=12	h=16
1	**TS.CoreMoney.HP**	1.02 ,	1.02 , *	1.14 , ***	1.57 , **	1.75 ,	1.63 ,
2	**TS.CoreMoney.BK**	0.99 ,	1.01 ,	1.02 ,	1.07 , ***	1.15 , ***	1.18 ,
3	**TS.CoreMoney.CF**	0.99 , **	1.02 , *	1.08 , *	1.33 , ***	1.45 , ***	1.24 , *
4	**TS.CoreMoney.ES**	1.00 ,	1.07 ,	1.18 ,	1.49 ,	1.43 ,	1.34 ,
5	**TS.IACoreMoney.HP**	0.97 , *	1.05 ,	1.11 ,	1.38 ,	1.59 ,	1.99 ,
6	**TS.IACoreMoney.BK**	1.00 ,	1.01 ,	1.03 ,	1.24 ,	1.25 ,	1.24 ,
7	**TS.IACoreMoney.CF**	0.99 ,	1.03 ,	1.08 ,	1.59 , *	1.54 ,	1.60 ,
8	**TS.IACoreMoney.ES**	0.93 , **	1.03 , *	1.13 , **	1.36 , **	1.22 ,	1.17 ,
9	**TS.OACoreMoney.HP**	1.00 ,	1.07 ,	1.23 , *	1.95 ,	2.14 ,	2.24 ,
10	**TS.OACoreMoney.BK**	0.99 ,	1.09 ,	1.27 , *	1.82 ,	1.71 ,	1.72 ,
11	**TS.OACoreMoney.CF**	1.03 ,	1.10 ,	1.30 , **	2.42 , *	2.44 ,	2.51 ,
12	**TS.OACoreMoney.ES**	1.05 ,	1.08 ,	1.16 ,	1.54 ,	1.47 ,	1.38 ,
13	TS.CoreInf.HP	0.96 , **	1.01 ,	1.09 ,	1.46 ,	1.56 ,	1.72 ,
14	TS.CoreInf.BK	0.93 ***, ***	0.98 ,	0.93 * , **	0.92 , ***	1.11 ,	1.32 ,
15	TS.CoreInf.CF	0.97 , **	1.03 ,	1.06 , *	1.45 , *	1.29 ,	1.28 ,
16	TS.CoreInf.ES	0.99 ,	1.00 ,	1.00 ,	1.02 ,	1.00 ,	0.80 ,
17	TS.IGap.HP	0.90 ** , **	0.85 * , **	0.90 , **	1.24 , *	1.74 ,	2.29 ,
18	TS.IGap.BK	0.89 ***, ***	0.82 ** , **	0.79 ** , **	0.95 , *	1.19 ,	1.45 ,
19	TS.IGap.CF	0.94 , **	0.93 , **	1.08 , **	1.53 ,	1.73 ,	2.21 ,
20	TS.IGap.ES	0.99 ,	1.00 ,	1.00 ,	1.02 ,	1.00 ,	0.80 ,
21	TS.OGap.HP	1.04 ,	1.10 ,	1.20 ,	1.13 ,	1.09 ,	1.14 ,
22	TS.OGap.BK	1.04 ,	1.09 ,	1.17 ,	1.06 ,	1.00 ,	1.03 ,
23	TS.OGap.CF	1.04 ,	1.07 ,	1.12 ,	1.04 ,	1.05 ,	1.18 ,
24	TS.OGap.ES	1.10 ,	1.20 ,	1.48 ,	1.46 , *	1.21 , ***	1.10 , **
25	TS.Spread	1.01 ,	1.13 ,	1.43 ,	1.97 ,	1.46 ,	1.50 ,
26	TS.RealInterest	1.01 ,	1.01 ,	1.04 ,	1.34 ,	1.88 ,	2.52 ,
27	TS.Epc						
28	TS.Epm						
29	**TS.CoreMon.OGap.HP**	1.05 ,	1.10 ,	1.24 , *	1.34 , ***	1.59 ,	1.59 ,
30	**TS.CoreMon.OGap.BK**	1.04 , *	1.11 ,	1.18 ,	1.03 , ***	1.10 , ***	1.12 , *
31	**TS.CoreMon.OGap.CF**	1.03 , *	1.09 ,	1.17 , *	1.25 , ***	1.42 , **	1.42 ,
32	**TS.CoreMon.OGap.ES**	1.09 , **	1.29 ,	1.81 , *	2.57 , **	2.27 , ***	2.05 , ***
33	**TS.IACoreMon.OGap.HP**	1.04 , *	1.14 ,	1.34 , *	1.77 ,	2.04 ,	3.11 ,
34	**TS.IACoreMon.OGap.BK**	1.00 , *	1.08 ,	1.17 ,	1.44 ,	1.30 ,	1.37 ,
35	**TS.IACoreMon.OGap.CF**	1.01 , *	1.08 , *	1.16 , **	1.66 ,	1.56 ,	1.79 ,
36	**TS.IACoreMon.OGap.ES**	0.85 ** , ***	0.98 , *	0.94 , ***	1.33 , ***	1.14 , **	1.00 , ***
37	**TS.OACoreMon.OGap.HP**	1.05 ,	1.12 , *	1.30 , **	1.82 , **	2.12 ,	2.33 ,
38	**TS.OACoreMon.OGap.BK**	1.04 ,	1.13 ,	1.30 , *	1.58 , ***	1.78 ,	2.07 ,
39	**TS.OACoreMon.OGap.CF**	0.96 , **	1.12 , *	1.36 , ***	2.33 , *	2.47 ,	3.14 ,
40	**TS.OACoreMon.OGap.ES**	1.11 ,	1.22 ,	1.82 ,	2.53 , *	2.50 , *	2.06 , *
41	TS.CoreInf.OGap.HP	0.96 , **	1.09 ,	1.16 , **	1.41 , *	1.54 ,	1.78 ,
42	TS.CoreInf.OGap.BK	0.97 , **	1.07 ,	1.16 , **	1.10 , ***	1.15 ,	1.43 ,
43	TS.CoreInf.OGap.CF	0.97 , **	1.10 ,	1.15 , **	1.48 , **	1.31 , *	1.40 , *
44	TS.CoreInf.OGap.ES	1.12 ,	1.18 ,	1.28 ,	1.41 , *	1.10 , **	1.51 ,
45	TS.IGap.OGap.HP	0.90 , **	0.85 , **	0.92 , **	1.20 , **	1.69 ,	2.26 ,
46	TS.IGap.OGap.BK	0.89 , **	0.88 , **	0.90 , **	0.97 , *	1.18 ,	1.44 ,
47	TS.IGap.OGap.CF	0.89 * , **	0.89 , **	1.06 , **	1.50 , *	1.72 ,	2.19 ,
48	TS.IGap.OGap.ES	1.12 ,	1.18 ,	1.28 ,	1.41 , *	1.10 , **	1.51 ,
49	TS.Spread.OGap.HP	1.17 ,	1.58 ,	2.34 ,	3.08 ,	2.35 ,	2.13 , **
50	TS.Spread.OGap.BK	1.10 ,	1.39 ,	1.92 ,	2.64 ,	2.15 ,	2.11 , *
51	TS.Spread.OGap.CF	1.07 ,	1.23 ,	1.69 ,	2.37 ,	1.89 ,	1.91 , *
52	TS.Spread.OGap.ES	1.07 ,	1.34 ,	2.10 ,	3.22 ,	2.76 , **	2.65 , **
53	TS.RIR.OGap.HP	1.07 ,	1.17 ,	1.35 ,	1.68 ,	2.07 ,	2.66 ,
54	TS.RIR.OGap.BK	1.06 ,	1.14 ,	1.31 ,	1.66 ,	2.05 ,	2.62 ,
55	TS.RIR.OGap.CF	1.04 ,	1.12 ,	1.23 ,	1.44 ,	2.00 ,	2.66 ,
56	TS.RIR.OGap.ES	1.14 , *	1.34 ,	2.07 ,	3.31 ,	3.45 ,	3.64 ,
57	TS.Epc.OGap.HP						
58	TS.Epc.OGap.BK						
59	TS.Epc.OGap.CF						
60	TS.Epc.OGap.ES						
61	TS.Epm.OGap.HP						
62	TS.Epm.OGap.BK						
63	TS.Epm.OGap.CF						
64	TS.Epm.OGap.ES						
65	**TS.CoreMon.CoreInf.HP**	0.95 , **	1.04 ,	1.19 ,	1.76 ,	1.78 ,	1.63 ,
66	**TS.CoreMon.CoreInf.BK**	0.95 ** , ***	0.98 , *	0.93 * , ***	0.90 ** , ***	1.08 , *	1.30 ,
67	**TS.CoreMon.CoreInf.CF**	0.97 , **	1.03 ,	1.08 , **	1.69 ,	1.33 ,	1.53 ,
68	**TS.CoreMon.CoreInf.ES**	1.02 ,	1.15 ,	1.29 ,	1.44 , ***	1.28 , **	1.03 , **
69	**TS.NeuGrei.HP**	1.03 , **	1.17 , *	1.25 , ***	2.24 ,	2.48 ,	2.82 ,
70	**TS.NeuGrei.BK**	1.04 , *	1.10 , *	1.42 , ***	2.61 , *	2.66 , *	2.72 ,
71	**TS.NeuGrei.CF**	1.04 , *	1.13 , *	1.51 , ***	2.55 , ***	2.32 , **	2.72 , **
72	**TS.NeuGrei.ES**	1.04 , **	1.23 ,	1.65 , **	2.43 , ***	2.30 , ***	2.07 , ***
73	**TS.CogGer.HP**	0.89 , **	1.22 , **	1.54 , **	1.48 , **	1.69 ,	1.72 ,
74	**TS.CogGer.BK**	0.89 , **	1.24 , *	1.39 ,	1.11 ,	1.06 ,	0.97 ,
75	**TS.CogGer.CF**	0.87 * , **	0.89 , **	1.05 , **	1.52 , **	1.64 ,	1.79 ,
76	**TS.CogGer.ES**	0.93 ** , ***	0.92 * , ***	1.02 , **	1.59 ,	1.43 ,	1.53 ,
77	SM.Cog.restr.HP	0.97 , *	1.07 ,	1.05 ,	1.14 , **	1.05 ,	1.03 ,

Table 1 continued

78	SM.Cog.restr.BK	0.98 ,	1.08 ,	1.06 ,	1.14 , **	1.03 ,	1.01 ,
79	SM.Cog.restr.CF	0.99 ,	1.09 ,	1.07 ,	1.17 , **	1.10 ,	1.10 ,
80	SM.Cog.restr.ES	1.04 ,	1.19 , **	1.19 , *	1.28 , *	1.03 ,	0.95 ,
81	SM.Cog.unres.HP	0.88 ***, ***	0.87 * , **	0.91 , *	1.26 ,	1.41 ,	1.38 ,
82	SM.Cog.unres.BK	0.89 ***, ***	0.88 * , **	0.89 , *	1.13 ,	1.19 ,	1.10 ,
83	SM.Cog.unres.CF	0.91 * , **	0.92 , **	1.04 , **	1.52 ,	1.71 ,	1.72 ,
84	SM.Cog.unres.ES	1.07 ,	1.21 , **	1.16 , **	1.19 , ***	1.00 ,	0.82 ,
85	**SM.CogGer.HP**	0.88 * , **	0.84 , **	0.86 , **	0.84 , **	0.87 , **	0.84 ,
86	**SM.CogGer.BK**	0.89 * , **	0.87 , **	0.96 , **	0.96 , **	0.95 , **	0.91 ,
87	**SM.CogGer.CF**	0.86 ** , ***	0.84 , **	0.98 , **	1.29 , **	1.18 , **	1.00 ,
88	**SM.CogGer.ES**	1.03 ,	1.14 ,	1.19 ,	1.74 ,	1.54 ,	1.67 ,
89	**SM.NeuGrei.HP**	1.19 ,	1.47 ,	1.79 , *	2.81 ,	2.34 ,	1.24 , *
90	**SM.NeuGrei.BK**	1.24 ,	1.56 ,	1.91 , **	2.39 , *	2.07 ,	0.97 , *
91	**SM.NeuGrei.CF**	1.23 ,	1.56 ,	1.94 , ***	2.56 , *	2.22 ,	1.02 ,
92	**SM.NeuGrei.ES**	1.21 , *	1.58 , **	2.21 , ***	3.49 , ***	2.82 , **	2.61 ,
93	**TPPC.CoreMon.HP**	1.00 , **	1.08 , **	1.16 , ***	1.67 , ***	1.54 , ***	0.98 ,
94	**TPPC.CoreMon.BK**	0.99 , *	1.07 , **	1.12 , ***	1.58 , ***	1.51 , ***	0.94 ,
95	**TPPC.CoreMon.CF**	0.99 , **	1.10 , **	1.25 , ***	1.87 , ***	1.59 , **	1.26 ,
96	**TPPC.CoreMon.ES**	1.10 , *	1.35 , *	1.74 , **	2.51 , ***	2.13 , ***	2.07 , *
97	**TPPC.IACoreMon.HP**	1.19 ,	1.38 , **	1.46 , *	1.88 ,	2.01 ,	3.13 ,
98	**TPPC.IACoreMon.BK**	1.20 ,	1.40 , **	1.48 , *	1.79 ,	1.84 ,	2.95 ,
99	**TPPC.IACoreMon.CF**	1.19 ,	1.38 , **	1.43 , *	1.75 ,	1.89 ,	3.27 ,
100	**TPPC.IACoreMon.ES**	1.20 ,	1.44 , *	1.79 ,	3.03 ,	3.00 ,	3.45 ,
101	**TPPC.OACoreMon.HP**	1.04 , **	1.28 , **	1.75 , **	2.64 , *	2.58 ,	2.01 ,
102	**TPPC.OACoreMon.BK**	1.11 , **	1.43 , **	1.98 , **	2.87 ,	2.72 ,	2.17 ,
103	**TPPC.OACoreMon.CF**	1.15 , **	1.51 , **	2.12 , **	3.03 ,	2.94 ,	2.40 ,
104	**TPPC.OACoreMon.ES**	1.15 ,	1.33 , **	1.43 ,	1.63 ,	1.69 ,	3.17 ,
105	TPPC.CoreInf.HP	0.87 * , **	0.85 , **	0.99 , **	1.49 ,	1.42 ,	1.77 ,
106	TPPC.CoreInf.BK	0.85 ** , **	0.81 * , **	0.94 , **	1.38 ,	1.32 ,	1.99 ,
107	TPPC.CoreInf.CF	0.86 ** , **	0.85 , **	1.07 , **	1.85 ,	2.10 ,	2.20 ,
108	TPPC.CoreInf.ES	1.17 ,	1.42 , **	1.80 , *	3.32 ,	3.86 ,	5.03 ,
109	TPPC.IGap.HP	0.87 * , **	0.85 , **	0.99 , **	1.49 ,	1.42 ,	1.77 ,
110	TPPC.IGap.BK	0.85 ** , **	0.81 * , **	0.94 , **	1.38 ,	1.32 ,	1.99 ,
111	TPPC.IGap.CF	0.86 ** , **	0.85 , **	1.07 , **	1.85 ,	2.10 ,	2.20 ,
112	TPPC.IGap.ES	1.17 ,	1.42 , **	1.80 , *	3.32 ,	3.86 ,	5.03 ,
113	TPPC.Spread.HP	1.26 ,	1.59 , **	2.09 ,	2.82 ,	2.19 ,	3.03 ,
114	TPPC.Spread.BK	1.24 ,	1.55 , **	2.00 ,	2.72 ,	2.13 ,	3.02 ,
115	TPPC.Spread.CF	1.22 ,	1.48 , ***	1.79 , **	2.36 ,	1.80 ,	2.90 ,
116	TPPC.Spread.ES	1.21 ,	1.44 , **	1.75 ,	2.60 ,	1.96 ,	2.55 ,
117	TPPC.RIR.HP	1.28 ,	1.67 , ***	2.24 , **	2.90 ,	2.20 ,	2.70 ,
118	TPPC.RIR.BK	1.27 ,	1.64 , ***	2.18 , **	2.85 ,	2.17 ,	2.68 ,
119	TPPC.RIR.CF	1.25 ,	1.61 , ***	2.11 , ***	2.76 , *	2.03 ,	2.56 ,
120	TPPC.RIR.ES	1.22 ,	1.54 , ***	2.02 , **	2.65 ,	1.86 ,	2.25 ,
121	TPPC.Epc.HP						
122	TPPC.Epc.BK						
123	TPPC.Epc.CF						
124	TPPC.Epc.ES						
125	TPPC.Epm.HP						
126	TPPC.Epm.BK						
127	TPPC.Epm.CF						
128	TPPC.Epm.ES						
129	TS.ARIMA	0.96 ,	1.01 ,	0.95 ,	1.01 ,	0.99 ,	1.05 ,
130	TS.AR	0.85 ,	0.67 ,	0.60 ,	0.60 ,	0.83 ,	0.99 ,

Note: The Table reports the RMSFE relative to the benchmark AR model (for which the absolute RMSFE is reported). Models that include core money growth are printed in bold. Behind each RMSFE there are two columns with stars separated by a comma. The first one denotes significance of the Diebold-Mariano test for forecast accuracy and the second one denotes significance of the modified Diebold-Mariano test for forecast encompassing. In both cases, the tests are against the simple AR model. Significance at the 10%, 5%, 1% level is denoted by *, **, ***, respectively. The identification codes of the forecasting models consist of three parts that are separated by a point. The first part indicates whether the model is of the time series type (TS), the semi-structural model type (SM) or the TPPC type (TPPC). The second part identifies the indicator variables used, where "CoreMoney" is core money growth, "IACoreMoney" is inflation-adjusted core money growth, "IOCoreMoney" is output-adjusted core money growth, "CoreInf" is core inflation, "IGap" is the inflation gap, "OGap" is the output gap, "NeuGrei" is the set of variables used by Neumann and Greiber (2004), and "CogGer" is the set of variables used by Gerlach (2004) for the extended Cogley (2002) model. The two-indicator models have two such identifiers separated by a point. The Cogley model is used both in restricted ("Cog.restr") and unrestricted ("Cog.unres") form. If applicable, the last part identifies the filter used, where "HP" is Hodrey-Prescott, "BK" is Baxter-King, "CF" is Christiano-Fitzgerald, and "ES" is exponential smoothing.

Table 2: Results of the forecasting experiment for 1999Q1 to 2006Q4

No.	Model	h=1	h=2	h=4	h=8	h=12	h=16
1	**TS.CoreMoney.HP**	0.99 ,	0.99 ,	0.97 , **	1.07 , **	1.22 , ***	1.58 , ***
2	**TS.CoreMoney.BK**	0.98 ,	0.98 , *	0.97 , *	0.96 , ***	0.98 , **	1.16 , ***
3	**TS.CoreMoney.CF**	0.97 , *	0.97 , **	0.89 ** , ***	0.77 * , **	0.67 * , **	0.95 , ***
4	**TS.CoreMoney.ES**	1.00 ,	1.04 ,	1.02 , *	1.10 , ***	1.11 , **	1.16 ,
5	**TS.IACoreMoney.HP**	0.97 ,	1.03 ,	1.08 ,	1.30 ,	1.39 ,	1.50 ,
6	**TS.IACoreMoney.BK**	0.98 ,	1.01 ,	0.96 , *	1.10 ,	1.23 ,	1.44 ,
7	**TS.IACoreMoney.CF**	0.97 , *	1.00 ,	0.92 , **	0.98 , **	1.08 ,	1.27 ,
8	**TS.IACoreMoney.ES**	0.97 ,	1.02 ,	0.96 , **	1.13 , ***	1.22 , *	1.36 ,
9	**TS.OACoreMoney.HP**	1.00 ,	0.99 , *	0.99 , ***	1.15 , ***	1.30 , ***	1.37 , ***
10	**TS.OACoreMoney.BK**	0.97 , **	0.99 ,	1.00 , **	1.09 , ***	0.96 , ***	0.91 , ***
11	**TS.OACoreMoney.CF**	0.95 ** , **	0.96 , **	0.83 ** , ***	0.76 , **	0.70 * , **	0.87 , **
12	**TS.OACoreMoney.ES**	0.99 ,	0.99 ,	0.98 ,	0.95 ,	0.90 ,	0.82 ,
13	TS.CoreInf.HP	0.96 , *	0.97 , *	0.94 , *	1.09 ,	1.15 ,	1.15 ,
14	TS.CoreInf.BK	0.97 , *	0.98 ,	0.94 , *	1.02 ,	1.03 ,	1.04 ,
15	TS.CoreInf.CF	0.95 * , **	0.96 * , **	0.85 ***, ***	0.86 * , ***	0.97 , **	0.96 , *
16	TS.CoreInf.ES	1.01 ,	0.99 ***, ***	0.97 ***, ***	0.96 * , *	0.96 * ,	0.94 ,
17	TS.IGap.HP	0.97 ,	0.85 ** , ***	0.91 , *	1.15 ,	1.25 ,	1.29 ,
18	TS.IGap.BK	0.97 ,	0.84 ***, ***	0.84 * , **	0.99 ,	1.03 ,	1.06 ,
19	TS.IGap.CF	0.95 , *	0.79 ***, ***	0.74 ***, ***	0.83 ** , ***	0.82 ***, ***	0.87 ***, ***
20	TS.IGap.ES	1.01 ,	0.99 ***, ***	0.97 ***, ***	0.96 * , *	0.96 * ,	0.94 ,
21	TS.OGap.HP	0.91 ** , **	0.95 , *	0.95 , *	0.99 ,	1.02 ,	1.05 ,
22	TS.OGap.BK	0.90 ** , ***	0.95 , *	0.94 , *	0.97 , *	0.98 ,	0.99 ,
23	TS.OGap.CF	0.92 ** , **	0.95 , *	0.95 , *	0.97 ,	0.99 ,	1.02 ,
24	TS.OGap.ES	1.00 ,	1.04 ,	1.04 ,	1.17 ,	1.18 ,	1.05 ,
25	TS.Spread	0.99 ,	1.00 ,	0.96 , *	1.02 ,	1.13 ,	1.31 ,
26	TS.RealInterest	0.96 , *	0.98 ,	1.00 ,	0.97 , *	0.93 ** , **	0.90 ***, ***
27	TS.Epc	0.93 , **	0.93 , **	0.94 , ***	1.08 , *	1.09 ,	1.04 ,
28	TS.Epm	0.94 , **	0.91 * , **	1.02 ,	1.10 ,	1.02 ,	1.11 ,
29	**TS.CoreMon.OGap.HP**	0.91 ** , **	0.93 , **	0.82 ** , ***	0.97 , ***	1.12 , ***	1.43 , ***
30	**TS.CoreMon.OGap.BK**	0.90 ** , ***	0.92 * , **	0.89 ** , **	0.92 , ***	0.92 , **	1.10 , ***
31	**TS.CoreMon.OGap.CF**	0.91 ** , **	0.92 * , **	0.81 ***, ***	0.76 * , **	0.71 * , **	1.08 , ***
32	**TS.CoreMon.OGap.ES**	0.98 ,	1.05 ,	0.90 , **	0.99 , **	0.90 , **	0.93 , **
33	**TS.IACoreMon.OGap.HP**	0.92 * , **	0.99 ,	1.13 ,	1.55 ,	1.62 ,	1.70 ,
34	**TS.IACoreMon.OGap.BK**	0.92 * , **	0.99 ,	0.97 , *	1.23 ,	1.31 ,	1.43 ,
35	**TS.IACoreMon.OGap.CF**	0.92 * , **	0.96 , *	0.87 * , **	0.98 , *	1.13 ,	1.41 ,
36	**TS.IACoreMon.OGap.ES**	0.98 ,	0.96 , **	0.86 * , ***	0.86 ** , ***	0.88 * , ***	1.04 , ***
37	**TS.OACoreMon.OGap.HP**	0.91 ** , **	0.93 , **	0.84 * , ***	1.21 , ***	1.45 , **	1.64 , ***
38	**TS.OACoreMon.OGap.BK**	0.90 ***, ***	0.94 , **	0.93 , **	1.11 , ***	0.98 , ***	1.07 , ***
39	**TS.OACoreMon.OGap.CF**	0.88 ***, ***	0.91 * , **	0.73 ***, ***	0.73 * , *	0.80 , **	1.05 , **
40	**TS.OACoreMon.OGap.ES**	1.01 ,	1.06 ,	0.88 , ***	1.22 ,	0.99 ,	0.95 , *
41	TS.CoreInf.OGap.HP	0.89 ** , **	0.90 * , **	0.85 * , **	1.06 ,	1.17 ,	1.19 ,
42	TS.CoreInf.OGap.BK	0.90 ** , **	0.91 * , **	0.87 * , **	1.01 ,	1.04 ,	1.06 ,
43	TS.CoreInf.OGap.CF	0.89 ** , **	0.89 * , **	0.78 ***, ***	0.83 ** , ***	0.91 , ***	0.91 , *
44	TS.CoreInf.OGap.ES	0.98 ,	1.06 ,	1.03 ,	1.17 ,	1.19 ,	0.91 ,
45	TS.IGap.OGap.HP	0.89 * , **	0.75 ***, ***	0.81 * , **	1.11 ,	1.23 ,	1.28 ,
46	TS.IGap.OGap.BK	0.88 ** , **	0.76 ***, ***	0.79 ** , **	0.98 , *	1.03 ,	1.05 ,
47	TS.IGap.OGap.CF	0.91 , **	0.75 ***, ***	0.75 ** , ***	0.86 * , ***	0.85 ** , ***	0.88 ** , ***
48	TS.IGap.OGap.ES	0.98 ,	1.06 ,	1.03 ,	1.17 ,	1.19 ,	0.91 ,
49	TS.Spread.OGap.HP	0.91 ** , **	0.95 , *	0.91 * , **	1.05 , *	1.28 ,	1.59 ,
50	TS.Spread.OGap.BK	0.90 ** , ***	0.94 , **	0.92 * , **	1.02 , *	1.25 ,	1.48 ,
51	TS.Spread.OGap.CF	0.92 ** , **	0.95 , *	0.93 * , **	1.00 , *	1.20 ,	1.42 ,
52	TS.Spread.OGap.ES	1.00 ,	1.04 ,	0.98 , *	1.10 ,	1.34 ,	1.46 ,
53	TS.RIR.OGap.HP	0.92 ** , **	0.95 , *	0.90 ** , **	0.95 , **	0.94 * , **	0.94 ***, ***
54	TS.RIR.OGap.BK	0.92 ** , **	0.95 , *	0.92 * , **	0.94 , **	0.91 ** , **	0.88 ***, ***
55	TS.RIR.OGap.CF	0.92 ** , **	0.96 , *	0.95 , *	0.95 , **	0.93 ** , **	0.94 ** , **
56	TS.RIR.OGap.ES	0.96 , *	1.04 ,	0.98 , **	1.02 ,	1.04 ,	0.88 ,
57	TS.Epc.OGap.HP	0.93 , **	0.94 , **	0.97 , ***	1.16 , *	1.23 ,	1.21 ,
58	TS.Epc.OGap.BK	0.94 , **	0.94 , **	0.98 , ***	1.13 , *	1.20 ,	1.18 ,
59	TS.Epc.OGap.CF	0.94 , **	0.87 ** , ***	0.91 , ***	0.97 , **	1.02 , *	0.92 ,
60	TS.Epc.OGap.ES	0.95 , **	0.91 , ***	0.95 , ***	1.13 , **	1.10 , *	1.08 ,
61	TS.Epm.OGap.HP	0.95 , **	0.93 , *	1.02 ,	1.16 ,	1.15 ,	1.28 ,
62	TS.Epm.OGap.BK	0.95 , *	0.93 , **	1.02 ,	1.16 ,	1.14 ,	1.30 ,
63	TS.Epm.OGap.CF	0.95 , **	0.90 , **	1.02 ,	1.22 ,	1.16 ,	1.20 ,
64	TS.Epm.OGap.ES	0.94 * , **	0.94 , *	1.05 ,	1.45 ,	1.95 ,	2.17 ,
65	**TS.CoreMon.CoreInf.HP**	0.96 ,	1.00 ,	1.12 ,	1.42 ,	1.45 ,	1.42 ,
66	**TS.CoreMon.CoreInf.BK**	0.97 , *	0.97 , *	0.93 , *	1.00 ,	0.98 ,	0.91 * , *
67	**TS.CoreMon.CoreInf.CF**	0.95 ** , **	0.95 ** , **	0.81 ***, ***	1.05 , *	1.41 ,	1.12 , *
68	**TS.CoreMon.CoreInf.ES**	1.00 ,	1.03 ,	1.00 , **	1.11 , **	1.10 , **	1.13 , **
69	**TS.NeuGrei.HP**	0.94 , **	1.01 ,	1.19 ,	2.08 ,	2.88 ,	3.05 ,
70	**TS.NeuGrei.BK**	0.92 ** , **	0.97 ,	1.13 ,	1.71 ,	2.23 ,	2.18 ,
71	**TS.NeuGrei.CF**	0.92 ** , **	0.95 , *	0.85 , ***	1.00 , *	0.95 ,	1.22 ,
72	**TS.NeuGrei.ES**	0.93 * , **	0.97 , *	0.86 , **	0.96 , **	0.92 , *	0.83 , **
73	**TS.CogGer.HP**	0.91 * , **	0.83 * , **	0.98 , **	1.18 ,	1.12 ,	1.18 ,
74	**TS.CogGer.BK**	0.88 ** , **	0.82 ** , **	0.97 , **	1.10 ,	0.98 , *	1.00 , *
75	**TS.CogGer.CF**	0.92 , *	0.76 ***, ***	0.74 ***, ***	0.66 ***, ***	0.58 ***, ***	0.98 , ***

Table 2 continued

76	**TS.CogGer.ES**	0.96 ,	0.92 , **	0.78 ***, ***	0.80 ***, ***	0.90 , ***	1.16 , **
77	SM.Cog.restr.HP	1.08 ,	1.12 ,	1.02 ,	1.01 ,	0.95 ,	0.91 ,
78	SM.Cog.restr.BK	1.08 ,	1.13 ,	1.04 ,	1.02 ,	0.96 ,	0.91 ,
79	SM.Cog.restr.CF	1.07 ,	1.11 ,	1.01 ,	0.99 ,	0.92 ,	0.88 ,
80	SM.Cog.restr.ES	1.08 ,	1.14 ,	1.02 ,	1.00 ,	0.95 ,	0.92 ,
81	SM.Cog.unres.HP	0.96 , *	0.87 ***, ***	0.82 * , **	0.97 , *	1.03 , **	1.09 , *
82	SM.Cog.unres.BK	0.96 , *	0.86 ***, ***	0.80 ** , **	0.92 , **	0.96 , ***	1.00 , **
83	SM.Cog.unres.CF	0.94 ** , **	0.81 ***, ***	0.74 ***, ***	0.83 ** , **	0.86 ***, ***	0.90 ** , ***
84	SM.Cog.unres.ES	1.14 , *	1.23 ,	1.14 ,	1.12 ,	1.06 ,	1.00 ,
85	**SM.CogGer.HP**	0.89 ** , **	0.74 ***, ***	0.69 ***, ***	0.80 ***, ***	0.90 * , ***	1.14 , **
86	**SM.CogGer.BK**	0.88 ** , **	0.75 ***, ***	0.74 ***, ***	0.85 ** , ***	0.93 , ***	1.17 , **
87	**SM.CogGer.CF**	0.89 ** , **	0.74 ***, ***	0.65 ***, ***	0.75 ***, ***	0.94 , ***	1.25 , **
88	**SM.CogGer.ES**	1.11 ,	1.14 ,	0.97 , ***	0.93 , ***	0.96 , ***	1.15 , *
89	**SM.NeuGrei.HP**	1.33 ,	1.48 ,	1.70 ,	1.97 ,	2.07 ,	2.52 ,
90	**SM.NeuGrei.BK**	1.28 ,	1.42 ,	1.59 ,	1.72 ,	1.83 ,	2.49 ,
91	**SM.NeuGrei.CF**	1.19 ,	1.25 ,	1.31 , *	1.62 , *	1.96 ,	2.42 ,
92	**SM.NeuGrei.ES**	1.10 ,	1.12 ,	1.09 ,	1.45 ,	2.37 ,	3.16 ,
93	**TPPC.CoreMon.HP**	1.11 ,	1.13 ,	0.98 , ***	1.16 , ***	1.53 ,	2.24 ,
94	**TPPC.CoreMon.BK**	1.10 ,	1.11 ,	0.99 , ***	1.19 , **	1.56 ,	2.29 ,
95	**TPPC.CoreMon.CF**	1.12 ,	1.13 ,	0.99 , ***	1.17 , ***	1.59 ,	2.27 ,
96	**TPPC.CoreMon.ES**	1.13 ,	1.22 ,	1.33 ,	1.80 ,	2.07 ,	2.50 ,
97	**TPPC.IACoreMon.HP**	1.20 , *	1.33 ,	1.26 ,	1.32 ,	1.33 , *	1.26 , **
98	**TPPC.IACoreMon.BK**	1.19 ,	1.31 ,	1.24 ,	1.26 ,	1.26 , *	1.23 , **
99	**TPPC.IACoreMon.CF**	1.20 , *	1.33 ,	1.27 ,	1.32 ,	1.30 , *	1.22 , **
100	**TPPC.IACoreMon.ES**	1.22 , *	1.33 ,	1.21 ,	1.10 ,	0.95 , *	0.94 ,
101	**TPPC.OACoreMon.HP**	1.24 ,	1.41 ,	1.67 , *	2.30 ,	2.66 ,	3.12 ,
102	**TPPC.OACoreMon.BK**	1.20 ,	1.37 ,	1.67 , *	2.34 ,	2.73 ,	3.22 ,
103	**TPPC.OACoreMon.CF**	1.21 ,	1.37 ,	1.64 , *	2.34 ,	2.70 ,	2.92 ,
104	**TPPC.OACoreMon.ES**	1.21 , *	1.29 , *	1.21 ,	1.31 ,	1.49 ,	1.53 ,
105	TPPC.CoreInf.HP	0.90 * , **	0.79 ***, ***	0.88 , **	1.11 , *	1.11 , ***	1.09 , *
106	TPPC.CoreInf.BK	0.90 * , **	0.82 ** , ***	0.97 , **	1.17 , *	1.11 , **	1.06 , *
107	TPPC.CoreInf.CF	0.89 * , **	0.76 ***, ***	0.78 ** , ***	0.84 ** , ***	0.78 ***, ***	0.79 , *
108	TPPC.CoreInf.ES	1.16 , *	1.25 ,	1.17 ,	1.43 ,	1.78 ,	2.23 ,
109	TPPC.IGap.HP	0.90 * , **	0.79 ***, ***	0.88 , **	1.11 , *	1.11 , ***	1.09 , *
110	TPPC.IGap.BK	0.90 * , **	0.82 ** , ***	0.97 , **	1.17 , *	1.11 , **	1.06 , *
111	TPPC.IGap.CF	0.89 * , **	0.76 ***, ***	0.78 ** , ***	0.84 ** , ***	0.78 ***, ***	0.79 , *
112	TPPC.IGap.ES	1.16 , *	1.25 ,	1.17 ,	1.43 ,	1.78 ,	2.23 ,
113	TPPC.Spread.HP	1.20 ,	1.31 ,	1.26 ,	1.54 ,	2.03 ,	2.37 ,
114	TPPC.Spread.BK	1.19 ,	1.30 ,	1.24 ,	1.48 ,	1.98 ,	2.35 ,
115	TPPC.Spread.CF	1.19 , *	1.30 ,	1.23 ,	1.38 ,	1.77 ,	2.05 ,
116	TPPC.Spread.ES	1.20 , *	1.31 ,	1.22 ,	1.48 ,	1.89 ,	2.15 ,
117	TPPC.RIR.HP	1.20 ,	1.36 ,	1.56 ,	2.54 ,	3.39 ,	3.94 ,
118	TPPC.RIR.BK	1.19 ,	1.35 ,	1.52 ,	2.43 ,	3.26 ,	3.84 ,
119	TPPC.RIR.CF	1.19 , *	1.34 ,	1.47 ,	2.31 ,	3.10 ,	3.66 ,
120	TPPC.RIR.ES	1.20 , *	1.33 ,	1.41 ,	2.35 ,	3.15 ,	3.72 ,
121	TPPC.Epc.HP	1.02 , *	0.97 , **	0.89 , ***	1.23 , *	1.57 ,	1.67 ,
122	TPPC.Epc.BK	1.03 , *	0.97 , **	0.86 , ***	1.11 , *	1.46 ,	1.58 ,
123	TPPC.Epc.CF	1.03 ,	1.01 , **	0.94 , ***	1.01 , *	1.27 ,	1.40 ,
124	TPPC.Epc.ES	1.01 , *	0.98 , **	0.99 , ***	1.26 ,	1.49 ,	1.59 ,
125	TPPC.Epm.HP	0.99 ,	0.92 , ***	0.83 , ***	1.10 , *	1.13 , *	1.25 ,
126	TPPC.Epm.BK	0.98 ,	0.91 , ***	0.78 * , ***	1.01 , *	1.07 , *	1.23 ,
127	TPPC.Epm.CF	1.02 ,	0.94 , **	0.81 ** , ***	0.92 , *	0.93 , *	1.13 ,
128	TPPC.Epm.ES	1.00 ,	0.92 , **	0.79 ** , ***	1.12 , **	1.34 ,	1.59 ,
129	TS.ARIMA	1.15 ,	1.19 ,	1.14 ,	1.15 ,	1.16 ,	1.26 ,
130	TS.AR	1.14 ,	0.85 ,	0.72 ,	0.73 ,	0.83 ,	0.90 ,

Table 3: Tests of forecast breakdown for selected models

	Forecast horizon					
Model	$h = 1$	$h = 2$	$h = 4$	$h = 8$	$h = 12$	$h = 16$
SM.Cog.unres.CF	0.01 (0.50)	−0.23 (0.59)	−1.05 (0.85)	−1.40 (0.92)	−1.07 (0.86)	−0.66 (0.74)
SM.CogGER.CF	0.01 (0.49)	−0.26 (0.60)	−1.36 (0.91)	−1.29 (0.90)	0.10 (0.46)	0.41 (0.34)
TPPC.CoreMon.CF	0.02 (0.49)	−0.26 (0.60)	−1.30 (0.90)	−0.90 (0.82)	0.18 (0.43)	0.43 (0.33)
TPPC.IACoreMon.CF	0.03 (0.49)	−0.20 (0.58)	−1.13 (0.87)	−1.16 (0.88)	0.03 (0.49)	0.36 (0.36)
TPPC.IGap.CF	−0.13 (0.55)	−1.48 (0.93)	−1.44 (0.93)	−1.38 (0.92)	−2.77 (1.00)	−3.48 (1.00)
TS.AR	−0.06 (0.52)	−0.99 (0.84)	−2.24 (0.99)	−2.64 (0.99)	−2.91 (1.00)	−3.18 (1.00)

Notes: p-values are reported below the test statistics. See Table 1 for explanation of the identification codes.