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Does Money Help Predict Inflation? An Empirical Assessment for Central Europe

Roman Horváth, Luboš Komárek and Filip Rozsypal*

Abstract

This paper investigates the predictive ability of money for future inflation in the Czech Republic, Hungary, Poland, and Slovakia. We construct monetary indicators similar to those the ECB regularly uses for monetary analysis. We find some in-sample evidence that money matters for future inflation at the policy horizons that central banks typically focus on, but our pseudo out-of-sample forecasting exercise shows that money does not in general improve the inflation forecasts vis-à-vis some benchmark models, such as the autoregressive process. Since at least some models containing money improve the inflation forecasts in certain periods, we argue that money still serves as a useful cross-check for monetary policy analysis.

JEL Codes: E41, E47, E52.

Keywords: Central Europe, forecasting, inflation, money.

* Roman Horváth – corresponding author: Institute of Economic Studies, Charles University, Prague. Contact: roman.horvath@gmail.com.
Luboš Komárek: Czech National Bank and University of Economics, Prague. Contact: lubos.komarek@cnb.cz.
Filip Rozsypal: University of Cambridge. Contact: fr282@cam.ac.uk.
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Nontechnical Summary

In this paper, we study the role of money and various monetary indicators in inflation forecasting in four Central European countries (the Czech Republic, Hungary, Poland, and Slovakia) in 1998–2008. Our aim is to contribute empirically to the literature dealing with the role of money in monetary policy. The extent to which money should influence monetary policy discussions has come under scrutiny in recent years. Many commentators put forward that money does not carry any additional information and thus, from a monetary policy perspective, there is little need to care about it. On the other hand, others have emphasized that money serves as a useful cross-check for monetary policy analysis and remains an important vehicle of long-term inflation.

We examine the performance of money growth as well as three other commonly-used monetary indicators (monetary overhang, the nominal money gap, and the real money gap) for inflation forecasting vis-à-vis some other standard econometric models for inflation forecasting, such as the autoregressive process (inflation depending on its own past values) and with the output gap as the forcing variable. We carry out a comprehensive forecasting exercise and compare the accuracy of the aforementioned models in our sample countries. We forecast inflation up to a horizon of two years, i.e., a period that largely coincides with the monetary policy horizons in countries that practice inflation targeting.

Our results suggest that although money growth as well as all the monetary indicators provide useful information for future inflation, they do not improve the accuracy of inflation predictions. More specifically, some money indicators in some countries improve the accuracy of inflation predictions, but other indicators in other countries do not. All in all, the performance of the examined forecasting models containing money is found to be quite heterogeneous. Since at least some models contribute positively to the precision of inflation forecasts, we argue that money should not be ignored in monetary policy analysis.

1. Introduction

The role of money in monetary policy conduct has been greatly disputed in recent years. While some see little point in analyzing money developments (Woodford, 2008), others claim that money provides useful information for monetary policy (Nelson, 2008). We want to tackle this issue empirically using data from Central Europe.

Numerous research articles examine whether money matters for inflation (Assenmacher-Wesche et al., 2008, and Fourcans and Vranceanu, 2008, among others). Nevertheless, from the policy perspective the attendant question is not so much whether money matters, but rather *to what extent* it matters. Clearly, money may be found significant in many inflation forecast equations, but an important issue is here whether inflation forecasts become more accurate with money, as compared to other standard models. If they do, then there is a strong argument for monitoring money developments. Even if the forecasting accuracy remains largely the same, it might still be useful to monitor money developments, as there is, of course, uncertainty about how forecasting exercises carried out on past data remain informative for the future.

Therefore, in this paper, we want to contribute with empirical evidence on four Central European economies (the Czech Republic, Hungary, Poland, and Slovakia) and evaluate whether money improves the forecasting accuracy of inflation. For this reason, we construct several standard money indicators, such as monetary overhang and the nominal and real money gap, and investigate their predictive ability via a comprehensive set of forecasting methods. Overall, our results show that money matters, although it does not improve the predictability of inflation. In other words, forecasting models to a large extent deliver comparable forecasting accuracy of inflation with or without money.

The paper is organized as follows. We briefly discuss the related literature in section 2. Section 3 describes our empirical methodology. A data description is provided in section 4. Section 5 presents the results. First, we report the money demand estimates and next, we investigate the predictive ability of monetary indicators. Concluding remarks are available in section 6. An appendix with additional results follows.

2. Related Literature

The theoretical debate on the role of money in monetary policy is far from reaching a consensus. Modern macroeconomics, especially models based on the New Keynesian framework[1], suggests that central banks should set interest rates without focusing on monetary aggregates (see, for example, Woodford, 2003). On the other hand, the fact that a model can be written without any direct reference to monetary aggregates does not mean that money should be left out of the central bank decision-making process. As, for example, McCallum (2001) argues, money should play a role as a structural or informative factor for inflation. Christiano et al. (2007) point out that money and credit may provide a useful role for anchoring private inflation expectations as well as contributing to lower fluctuations of real and financial variables. Berger, Harjes, and Stavrev

[1] A more detailed discussion about the role of monetary aggregates, covering both general and partial equilibrium models, is available in Berger, Harjes, and Stavrev (2008).

(2008) discuss in a detail the arguments that money is a source of real-time information and a forward-looking indicator of economic activity.

Empirically, there has been a lot of effort to understand the role of money from the policy perspective in the European context (especially by researchers affiliated with the European Central Bank). Brand and Cassola (2000), Coenen and Vega (1999), and Masuch, Pill, and Willeke (2001) estimate various cointegration models of demand for money in the euro area and derive various measures, such as money overhang or the money gap, to assess the role of money in future inflation. They argue that adopting a variety of approaches to explaining monetary (and credit) developments is helpful in achieving a well-founded and detailed picture of the monetary situation in the euro area. Gerlach and Svensson (2000) and Trecoci and Vega (2000) investigate the predictive performance of monetary aggregates by means of the real money gap obtained from a P-Star model of inflation. Both studies broadly support the idea that money (M3) has a significant predictive content for future price developments in the euro area. Less optimistic results are found in the study of Gottschalk et al. (2000) based on vector autoregression analysis. Their results suggest a minor role for money.

There is also a number of empirical papers applied to the United States. Their findings vary, too. On the one hand, Bachmeier and Swanson (2005) find that inflation forecasts can be marginally improved by including money, compared to simple AR models, for horizons exceeding one year. Berger and Österholm (2011), using Bayesian VARs, show that models including money consistently produce better inflation forecasts than models excluding money. On the other hand, Hale and Jordà (2007) report that money has no predictive power for U.S. inflation at any horizon. Similarly, a recent study of Binner et al. (2009) examines whether or not monetary aggregates are relevant for forecasting U.S. inflation using non-linear techniques during the new millennium. They conclude that monetary aggregates do not improve the inflation forecast.

As regards empirical evidence for new Member States of the European Union (NMSs), Dreger, Reimers, and Roffia (2007) examine money demand in the NMSs using panel cointegration methods. Similarly, Fidrmuc (2009) estimates money demand with panel cointegration methods for six NMSs (the Czech Republic, Hungary, Poland, Romania, Slovakia, and Slovenia) over the recent disinflation period. He finds that demand for money is significantly determined by euro area interest rates and the exchange rate against the euro, which may indicate some instability of money demand functions in the Central and Eastern European Countries (CEECs).

3. Empirical Methodology

In this section, we first explain which money indicators we construct for the evaluation of the contribution of money to inflation forecasting. Second, we provide a description of the forecasting models we use, and third, we deal with the issue of how we evaluate forecasting accuracy.

3.1 Money Indicators

Monetary Overhang

Monetary overhang is constructed as the deviation of money from its equilibrium inferred from money demand, which is estimated within some vector error correction model (VECM). The VECM form can be written as

$$\Delta X_t = \mu + \Pi X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \varepsilon_t , \qquad (1)$$

where $\Pi = -\left(I - \sum_{i=1}^{k} \Pi_i \right) = \alpha\beta'$. β' consists of cointegration vectors and α scales the effect of disequilibrium in cointegrating vectors. Γ_i captures the short-run dynamics of the system. X_t are assumed to be I(1) individually, but their linear combination is I(0) if they are cointegrated. For a comprehensive treatment of VECM models, see Juselius (2006). As an alternative to this well-established econometric technique, we re-estimate the money demand equations by additional cointegration methods – fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) – to shed light on the robustness of the estimates.

We employ the following standard vector specification for a small open economy (see Leventakis, 1993, for a balance portfolio model of money demand in a small open economy), X_t: $X_t = \left((m-p)_t, y_t, i_t, s_t \right)'$, where *m* is the logarithm of the nominal money stock (more specifically, monetary aggregate M2), *p* denotes the logarithm of the price index (the GDP deflator) – in consequence, *m-p* is the real money stock, *y* stands for the GDP level, *i* represents the interest rate (due to data availability, we must employ the short-term interest rate), and *s* denotes the effective exchange rate. The (normalized) cointegrating vector is thus defined in our case as follows: $0 = m_t - p_t + \alpha + \beta * y_t + \delta * i_t + \eta * s_t$. *m* is interpreted as being at the equilibrium level in this equation, and after simple algebraic manipulation we can calculate the "equilibrium money stock" as

$$m_t^{eq} = p_t + \alpha + \beta * y_t + \delta * i_t + \eta * s_t . \qquad . \qquad (2)$$

The monetary overhang, $overhang_t$, is then obtained as:

$$overhang_t = m_t - m_t^{eq} . \qquad (3)$$

Positive values of $overhang_t$ indicate inflationary pressures over the medium-term horizon. The stability of money demand is investigated in the results section.

As we evaluate the forecasting ability of money for four countries in this paper, we have also tried to estimate money demand within a panel cointegration setting employing a mean group estimator (Pesaran and Smith, 1995). Nevertheless, our results show that we cannot impose common parameters across the countries, as they differ significantly from each other (see Appendix 2 for the corresponding estimates).

Nominal Money Gap

The nominal money gap is calculated as follows. First, we calculate the reference value of M2 $m^{ref\,val}$. This is understood to be the level of M2 (m) that would obtain if it were growing at its reference rate. The reference rate of money growth, $\Delta m^{ref\,val}$, is obtained as $\Delta m^{ref\,val} = \pi^* + \beta * \Delta y^{potential}$, where π^* denotes the inflation target and $\Delta y^{potential}$ represents the potential non-inflation product growth rate (y-o-y). The above equation for $\Delta m^{ref\,val}$ is obtained by differencing the standard money demand equation, $m_t - p_t = \alpha + \beta * y_t + \delta * i_t$, and assuming that the equilibrium change of i_t, and s_t is zero (thus, these two terms vanish when differenced). Further, it is assumed that $\Delta p_t = \pi^*$ in the long run. Consequently, the differenced equation is $\Delta m_t - \Delta p_t = \beta * \Delta y_t$ (see also Masuch, Pill, and Willeke, 2001). Finally, the nominal money gap, nmg_t, is obtained by comparing the actual M2 level (seasonally adjusted) with the M2 reference value:

$$nmg_t = m_t - m_t^{ref\,val}. \tag{4}$$

Real Money Gap

The real money gap, rmg_t, is the nominal money gap adjusted for the difference between actual inflation and the inflation target. It is calculated as follows:

$$rmg_t = m_t / p_t^{CPI} - m_t^{refval} / p_{t+4}^*, \tag{5}$$

where p_t^{CPI} denotes the CPI price index and p_t^* is calculated assuming that p_t^{CPI} would always grow according to the inflation target.[2] The lead of p_t^* by four periods is used (e.g. p_{t+4}^*) in order to account for the monetary policy horizon of the Czech National Bank, which is between 12 and 18 months. Consumer prices are employed for this exercise as the inflation target is defined in terms of consumer prices, too. Clearly, the real money gap might be a preferable indicator in an environment of less stable inflation.

3.2 Forecasting Models

We use eight competing models for inflation forecasting. Two of these models do not include any money indicator, while the remaining models include either one money indicator or a combination of money indicators. As benchmarks, the random walk and simple autoregressive models are used ($\phi(L)$ denotes the lag polynomial):

$$\pi_{t+1|t}^{rw} = \pi_t, \tag{6}$$

$$\pi_{t+1|t}^{aw} = \alpha_{ar} + \beta_{ar}(L)\pi_t. \tag{7}$$

The three aforementioned money indicators are evaluated separately one after the other:

$$\pi_{t+1|t}^{over} = \alpha_{over} + \beta_{over}(L)over_t, \tag{8}$$

$$\pi_{t+1|t}^{nmg} = \alpha_{nmg} + \beta_{nmg}(L)nmg_t, \tag{9}$$

[2] See Masuch et al. (2001) on the link between the real money gap and the P-star model.

$$\pi_{t+1|t}^{rmg} = \alpha_{rmg} + \beta_{rmg}(L)rmg_t . \tag{10}$$

The next two forecasting models are more comprehensive and include all three money indicators together. The latter model also controls for lagged inflation:

$$\pi_{t+1|t}^{cmb1} = \alpha_{cmb1} + \beta_{cmb1}(L)nmg_t + \gamma_{cmb1}(L)over_t + \delta_{cmb1}(L)rmg_t , \tag{11}$$

$$\pi_{t+1|t}^{cmb2} = \alpha_{cmb2} + \omega_{cmb2}(L)\pi_t + \beta_{cmb2}(L)nmg_t + \gamma_{cmb2}(L)over_t + \delta_{cmb2}(L)rmg_t . \tag{12}$$

Finally, the last forecasting model uses lagged values of inflation as well as yearly money growth:

$$\pi_{t+1|t}^{lm} = \alpha_{lm} + \omega_{lm}(L)\pi_t + \beta_{lm}(L)\Delta m_t . \tag{13}$$

The choice of lag polynomials for the forecasting equations is the following. The original intention was to select the order using the Schwarz Bayesian Information Criterion (SBIC) and Akaike's information criterion (AIC). Nevertheless, we find that the results are very stable over the choice of lag structure in the forecasting equations and the corresponding differences in the forecasting exercises are rather negligible. In the end, a specification including one and four lags of inflation was selected uniformly for all the non-benchmark forecasting methods using lagged inflation. This lag structure captures both the immediate persistence of the series and the base shift (inflation is constructed on a year-on-year basis).

3.3 Forecasting Accuracy

In general, the error of forecasting method *Q* at horizon *h* given a forecasting exercise at date *t* is given by

$$\varepsilon_{t,h}^{Q} = \pi_{t+h|t}^{Q} - \pi_{t+h} . \tag{14}$$

Three standard measures are calculated to evaluate forecasting accuracy: mean error, mean absolute error, and mean squared error. These three measures can be calculated either from the perspective of the date of the forecasting exercise or from the perspective of the forecasting horizon. If the forecasting horizon is *M*, then at each date, each forecasting method gives *h = 1,…, M* forecasting errors at different (sub)horizons. The forecasting date is denoted by *t = 1,…, N*.

Forecast Error at Given (Forecasting) Date

For each forecasting model, the three aforementioned measures can be constructed by averaging the forecast errors over the forecasting horizon. The resulting estimates characterize the performance of the particular model at a given forecasting date *t = 1,…, N*, i.e.:

$$me_t^Q = \frac{\sum_{h=1}^{M} \varepsilon_{t,h}^{Q}}{M}, \qquad mabse_t^Q = \frac{\sum_{h=1}^{M} \left|\varepsilon_{t,h}^{Q}\right|}{M}, \quad mse_t^Q = \frac{\sum_{h=1}^{M} \left(\varepsilon_{t,h}^{Q}\right)^2}{M}, \tag{15}$$

where *me* denotes mean error, *mabse* mean absolute error, and *mse* mean square error.

Forecast Error at Given (Forecasting) Horizon

The errors at a given (sub)horizon for each method can also be averaged over all forecasting dates. Using this approach, the performance over different horizons can be examined. For horizons $h = 1,\ldots, M$, we can rewrite me, $mabse$, and mse in the following form:

$$me_h^Q = \frac{\sum_{t=1}^{N} \varepsilon_{t,h}^Q}{N}, \qquad mabse_h^Q = \frac{\sum_{t=1}^{N} \left|\varepsilon_{t,h}^Q\right|}{N}, \qquad mse_h^Q = \frac{\sum_{t=1}^{N} \left(\varepsilon_{t,h}^Q\right)^2}{N}. \tag{16}$$

In consequence, averaging across different horizons or dates makes the resulting measures less vulnerable to one-off shocks.

Naturally, more variable inflation may lead to higher errors in forecasting. To allow for international comparison, we compute the Granger and Newbold (1986) (GN) measure, which adjusts the squared errors by the corresponding inflation variability. The GN is constructed only for evaluation of forecasts along the different horizons. Let us define

$$GN_h^Q = 1 - \frac{\mathrm{var}_t\left(\varepsilon_{t,h}^X\right)}{\mathrm{var}(\pi)} = 1 - \frac{mse_h^Q}{\mathrm{var}(\pi)}, \tag{17}$$

where $\mathrm{var}(\pi)$ denotes the variance of inflation over the whole sample. The second equality holds if it is assumed that the forecasts are unbiased. To sum up, the forecasting model follows a recursive algorithm:

1. Estimate vector error correction model (VECM) and obtain forecasts of differences of real variables in model over whole forecasting period;

2. Estimate inflation forecasting equations on all past data;

3. Forecast inflation using money indicator; repeat steps (a)–(d) until the whole path of forecasted inflation is constructed:

    a. Construct one-period-ahead forecast of inflation using estimated relation;

    b. Using real money from VECM, construct next-period nominal money forecast by adjusting real money by inflation obtained in 3a;

    c. Construct next-period reference levels of money;

    d. Construct next-period value of indicator;

4. Evaluate forecast errors;

5. Move forecasting date one period and go to 1.

Two sources of error can be distinguished. Apart from the error in the forecast due to the stochastic nature of the monetary variables themselves, our forecasting mechanism uses real variables to construct the forecasts. Hence, any deviation in the forecast of the real variables adds to the final error. In order to assess the magnitude of this second type of error, we performed the

same forecasting exercise using the true realized values of the real variables. The compared results showed that only a small part of the error is caused by misforecasted real variables, possibly due to the strong persistence in GDP.

4. Data

Data are acquired from the Thomson Datastream database (Datastream) and the International Monetary Fund International Financial Statistics database (IFS). The sample period is set to 1998Q3–2008Q3. Some basic statistical properties of the key time series are provided in Appendix 1.

Price developments are represented by the GDP deflator. The deflator is a natural choice for money demand estimation since it captures movements in the prices of produced output, whereas consumer price indices focus only on the consumption basket of a typical household. The estimates using the CPI proved to be much less stable than the ones using the deflator. For a comparison, see Figures 1 and A3.11. The differences in the CPI and deflator series are not negligible (see Figure A3.10), so it is no surprise that the results differ.

GDP data in the national currencies at 1995 prices (2005 for Hungary) were acquired from the IFS database. Money is represented by the M2 aggregate. Monetary data were obtained from Datastream. Data for GDP, prices, and M2 were seasonally adjusted using the widely applied X12 procedure.

Interest rates are short 3M rates acquired from Datastream. Long-run interest rates (Brand and Cassola, 2000) or the spread between long and short-run rates (Coenen and Vega, 1999) are sometimes used in the literature. The choice of short 3M rates is motivated mainly by data unavailability of long rates for Hungary, especially at the beginning of the sample period.

Data on inflation targets were obtained from the national central banks' websites. At the beginning of inflation targeting in these countries, targets were sometimes set in such a way that they became binding only at the end of the year. For such periods, the time series on inflation targets are linearly interpolated in the periods between the explicit targets (see Horváth, 2008, for the underlying reasoning). In Slovakia and Hungary, inflation targeting was adopted after 1998, i.e., the beginning of our sample period. In this case, we calculate the implicit inflation target as the value of filtered inflation, adjusted so that it is smoothly linked to the first explicit target. We acknowledge that this is arbitrary and nominal and that the real money gap estimates reflect our method of imputing inflation targets.[3] Therefore, when evaluating the issue of whether money is informative for future inflation, we put an emphasis on monetary overhang, i.e., the money indicator that is not affected by this issue.

The equilibrium values (potential level) of output and interest rates are obtained by filtering the series using the Hodrick-Prescott (HP) filter with a smoothing parameter of 1,600 (see also Altimari, 2001).

[3] Since the largest error is introduced for the first forecasts (because of the relatively higher weight on the beginning of the data), if this is an issue, the *nmg* and *rmg* based forecasts should, *ceteris paribus*, improve over time. As this is not happening, it can be assumed that the error introduced is probably not large.

The recursive algorithm is set up in the following fashion. The data period available for the first estimation is 1998Q3–2004Q2. Then, with each forecast exercise the data window is extended by one period so there are ten forecasts generated, each eight periods long. Hence the last forecast is evaluated in 2006Q3 and the period forecasted is 2006Q4–2008Q3.

5. Results

This section first provides the estimates of money demand. Second, the question of whether money matters, i.e., whether money indicators are found to be significant in the inflation forecasting equations, is evaluated. Third, we investigate whether our money indicators improve the accuracy of the inflation forecasts.

5.1 Money Demand Estimation

First, we followed the literature (e.g. Fidrmuc, 2009) and estimated money demand for all sample countries jointly within a panel cointegration framework. Nevertheless, in contrast to this literature we find that the money demand coefficients differ across countries (see Appendix 2) and we therefore opted for single-country cointegration analysis as proposed by Johansen and Juselius (1990) and proceeded with general-to-specific modeling. The fact that the money demand estimates differ significantly from country to country should not come as a surprise, as the degree of dollarization/euroization differs greatly across the transition countries (see Luca and Petrova, 2008, and Rosenberg and Tirpak, 2009). In some cases, we included the foreign interest rate as an exogenous variable. As Abeysinghe and Boon (1999) and Phillips (1994) put forward that the small sample properties of the Johansen and Juselius (1990) method can be poor, we complement the Johansen and Juselius cointegration technique estimates with estimates based on cointegration techniques that are more suited to small samples – 1) fully modified OLS (Phillips and Hansen, 1990) and 2) dynamic OLS (Stock and Watson, 1993).

The single country estimates are available in Table 1. Although there is some variation across the countries, the results indicate that the GDP elasticity is greater than one and the interest rate semi-elasticity is rather low. In general, this broadly corresponds with evidence on previous money demand estimates in Central Europe (Komárek and Melecký, 2003, Dreger et al., 2007, and Fidrmuc, 2009). In the case of Hungary, we find that exchange rate movements influence real money demand (exchange rate appreciation is associated with higher money demand). This is in line with Luca and Petrova (2008), who report much higher deposit and credit dollarization in Hungary as compared to the Czech Republic, Poland, and Slovakia.

Table 1: Money Demand Estimates in Central Europe

		GDP	*i*	*s*
Czech Republic	Johansen-Juselius VECM	1.10***	-0.005***	---
		(0.04)	(0.001)	---
	FMOLS	1.03***	-0.005***	---
		(0.04)	(0.001)	---
	DOLS	1.06***	-0.005***	---
		(0.05)	(0.001)	---
Hungary	Johansen-Juselius VECM	2.77***	-0.019**	-1.27***
		(0.27)	(0.10)	(0.35)
	FMOLS	2.46***	-0.007	-1.47***
		(0.29)	(0.01)	(0.49)
	DOLS	1.91***	-0.018*	-1.28***
		(0.30)	(0.01)	(0.48)
Poland	Johansen-Juselius VECM	0.56***	-0.011***	---
		(0.04)	(0.002)	---
	FMOLS	0.89***	-0.006*	---
		(0.06)	(0.003)	---
	DOLS	0.99***	-0.011***	---
		(0.07)	(0.003)	---
Slovakia	Johansen-Juselius VECM	1.12***	-0.010***	---
		(0.22)	(0.01)	---
	FMOLS	0.85***	-0.003***	---
		(0.06)	(0.001)	---
	DOLS	0.79***	-0.003*	---
		(0.10)	(0.002)	---

Note: ***, **, and * denote significance at the 1 percent, 5 percent, and 10 percent level, respectively. Standard errors in brackets.

An important precondition for the forecasting exercise is to assess the stability of the estimated money demand equations. For this reason, we examine whether the recursive eigenvalues are stable (Hansen and Johansen, 1999). Note that Chow tests, which are typically employed for stability analysis, compare the variances for different time periods to assess coefficient constancy. As such, Chow tests may reject parameter constancy even if the parameters are stable, if there is volatility clustering and this ARCH structure of residuals is not accounted for (Lutkepohl and Kratzig, 2004). The results are reported in Figure A.1 in the Appendix and indicate that the estimated money demand is stable for all countries.

5.2 Does Money Matter?

In Table 2, we analyze whether monetary overhang matters for future inflation up to a 2-year forecasting horizon. We choose this horizon as it largely coincides with the monetary policy horizon (i.e., the horizon that forward-looking monetary policy focuses on in order to minimize the volatility of inflation and output). Following broadly the framework of Fourcans and Vranceanu (2008), we examine whether monetary overhang still matters for future inflation after controlling for the output gap (the HP filter with a smoothing parameter of 1,600 was used to estimate the gap). The results show that monetary overhang is informative for future inflation at most forecasting horizons even after controlling for lagged inflation and the output gap.

Table 2: Does Monetary Overhang Matter for Future Inflation? In-Sample Evaluation, Controlling for Lagged Inflation and Output Gap

$$Inflation_{t+i} = a_0 + a_1 * inflation_t + a_2 * overhang_t + a_3 * outputgap_t + e_{1+i}$$

i	a_0	a_1	a_2	a_3	Adj. R^2
Czech Republic					
1	0.98***	0.82***	0.28***	0.28***	0.87
2	1.81***	0.64***	0.37***	0.39***	0.66
3	2.82***	0.41***	0.47***	0.54***	0.46
4	3.39***	0.24*	0.43***	0.54***	0.26
5	3.38***	0.20	0.29*	0.46**	0.14
6	3.14***	0.22	0.16	0.34	0.08
7	2.67***	0.25*	-0.03	0.15	0.05
8	2.45***	0.26*	-0.06	0.23	0.02
Hungary					
1	1.57***	0.81***	0.05**	0.12*	0.97
2	3.07***	0.63***	0.09**	0.21*	0.91
3	4.22***	0.48***	0.11***	0.29**	0.85
4	4.94***	0.38***	0.12***	0.31***	0.79
5	4.71***	0.31***	0.10**	0.25**	0.72
6	4.50***	0.36***	0.07	0.19	0.65
7	4.63***	0.32**	0.07	0.19	0.60
8	4.92***	0.27*	0.06	0.14	0.56
Poland					
1	-4.53*	0.92***	0.10**	0.38	0.97
2	-9.04***	0.83***	0.21***	0.08	0.92
3	-13.64***	0.72***	0.32***	0.13*	0.87
4	-16.86***	0.62***	0.40***	0.16**	0.83
5	-17.15***	0.55***	0.41***	0.12	0.77
6	-14.49***	0.51***	0.35***	0.09	0.70
7	-10.18	0.46***	0.25*	0.06	0.61
8	-4.15	0.43***	0.12	0.01	0.51
Slovakia					
1	1.29**	0.79***	0.01*	0.17	0.70
2	2.87***	0.53***	0.03**	0.31	0.45
3	4.82***	0.22*	0.05**	0.40	0.29
4	6.56***	-0.05	0.06***	0.67**	0.34
5	7.01***	-0.12	0.06***	1.01***	0.44
6	7.44***	-0.16	0.05***	1.41***	0.58
7	7.71***	-0.20*	0.06***	1.58***	0.68
8	7.89***	-0.24***	0.06***	1.35***	0.59

Note: ***, **, and * denote significance at 1 percent, 5 percent, and 10 percent level, respectively.

5.3 Does Money Improve the Accuracy of Inflation Forecasts?

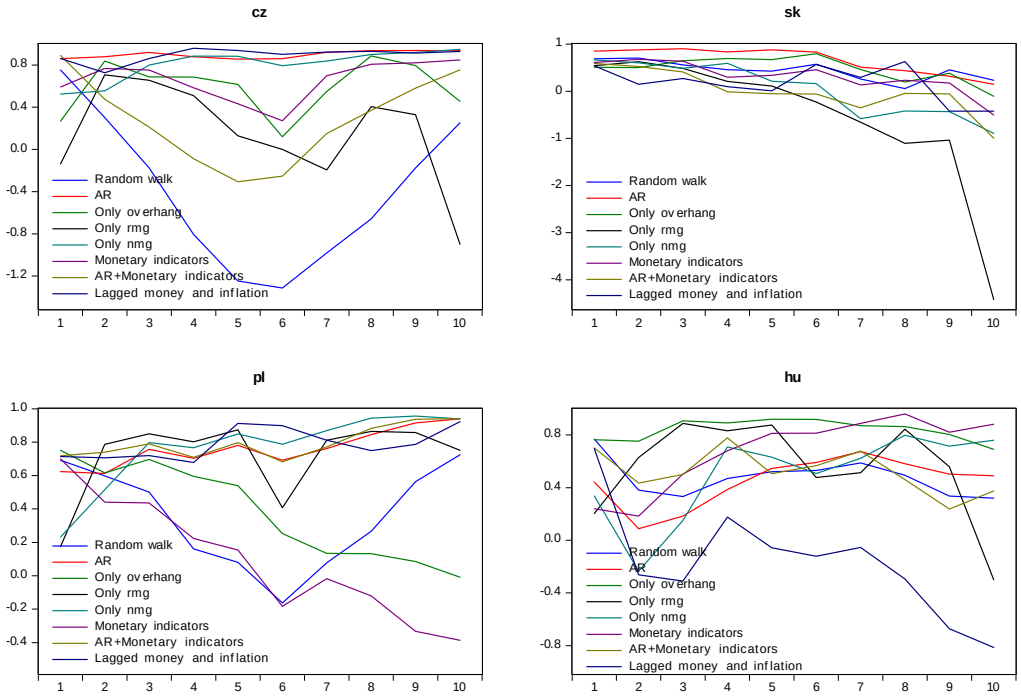
This section contains the results on whether *nmg*, *rmg*, and *overhang* improve the accuracy of inflation forecasts. As mentioned in the empirical methodology section, we carry out substantial sensitivity analysis to shed light on the forecasting ability of money.

The results suggest that the performance of the examined forecasting models containing money is quite heterogeneous and, in general, not better in comparison with the autoregressive and random walk benchmarks. This is not fully surprising, as Stock and Watson (2007) and Hale and Jordà (2007) document this empirical result for U.S. data. The potential explanation is that, as inflation becomes more stable in these countries, more information is already incorporated into the lagged values of inflation itself and thus it is harder to beat simple autoregressive forecasts.

Nevertheless, the results indicate that in the case of Hungary and especially of Poland, some money indicators improve the inflation forecast and beat the benchmark models. However, no monetary indicator systematically beats the benchmark. In terms of the comparison of forecasting precision across the countries, there is no clear ranking according to the Granger-Newbold forecast evaluation criterion.

Fisher et al. (2007) note that the ECB uses the LM (money growth) method for forecasting inflation and that other methods were tested but their use has been discontinued. Our results, however, do not point to better performance of this method for Central European countries. The detailed results on the forecasting errors as assessed by *me*, *mabse*, and *mse* for each country are available in Appendix 3.

Figure 1: Does Money Improve the Forecasts of Inflation? Granger-Newbold Forecast Evaluation Criterion



Note: Horizontal axes depict the forecasting horizon and vertical axes the values of the Granger-Newbold criterion. A higher GN criterion means better predictability of inflation.

6. Concluding Remarks

Does money matter for inflation? To what extent does it matter? We deal with this issue empirically using the data of four Central European countries in 1998–2008. We construct measures of money indicators, i.e., monetary overhang, the nominal money gap, and the real money gap and we investigate their role, together with that of money growth, in future inflation over a period of up to two years.

Monetary overhang is found to be informative for future inflation even after controlling for lagged inflation and the output gap at most of the forecasting horizons we evaluate. This suggests that money matters for future inflation. Next, we carry out a comprehensive pseudo out-of-sample forecasting exercise, where we compare how monetary overhang, the nominal money gap, the real money gap, and money growth help in improving the accuracy of inflation forecasts. Compared to our benchmark models (the autoregressive model and the random walk model for inflation), our results do not show that money-related forecasts outperform our benchmarks systematically and, indeed, the performance of the examined forecasting models containing money is found to be quite heterogeneous. As a result, this finding suggests that money matters for future inflation to the same degree as lagged inflation.

In terms of future research, we believe it would be worthwhile to evaluate the predictive ability of money in Central Europe at different frequencies and within a more structural framework. Similarly, it would be also interesting to investigate whether and how money matters for the future degree of economic activity.

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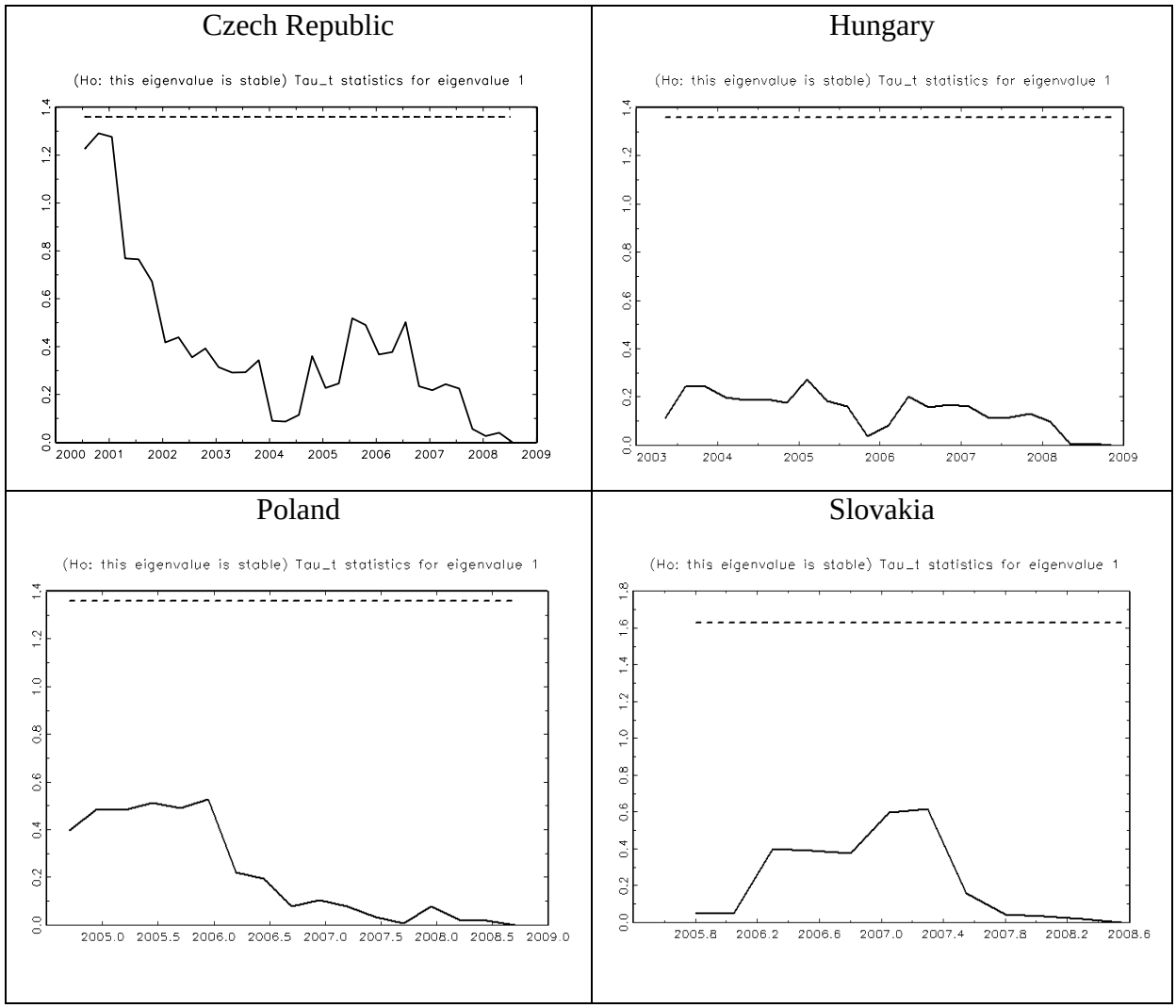
Appendix

Appendix 1

Table A.1: Stability Analysis of Money Demand Equations



Note: The figures present the tests of stability of the recursive eigenvalue (Hansen and Johansen, 1999). H0: eigenvalue is stable; resulting Tau statistic with limiting distribution that depends on Brownian bridge.

Appendix 2

We estimate the real money demand function (*m/p*), where M denotes monetary aggregate M2 and *p* the price level, in a panel of our sample countries via the mean group estimator. In this case, we have opted for the open economy version of money demand and include the effective exchange rate in the vector of variables. Nevertheless, we do not find the exchange rate to be significant. The estimates of money demand are the following (standard errors in brackets):

$$m/p = -5.49 + 1.52*gdp - 0.004*i - 0.63*s$$
$$(4.00) \quad (0.83) \quad (0.003) \quad (0.54)$$

The estimated coefficients have the expected signs, although interest rates and the exchange rate are not statistically significant. We hypothesize that this reflects the fact that the mean group estimator is designed for "large *N* and large *T*" panels. We find that the GDP elasticity is greater than one, which is in line with Fidrmuc (2009). The semi-elasticity of interest rates is rather low, but this accords with previous evidence on Central European countries (Komárek and Melecký, 2003; Dreger et al., 2007).

Next, we present the test of coefficient equality (i.e., whether the estimated parameters in money demand are sufficiently similar across countries) in Table A2.1. Our results suggest that the estimated coefficients differ from country to country even in the long run, supporting the notion that it is important to account for between-country heterogeneity in a full manner. In consequence, imposing common slope parameters would yield inconsistent estimates.

Table A2.1: Test for Coefficient Equality, Money Demand in Central Europe

$$\Delta(M/P)_{i,t} = \alpha_{0,i}\Delta GDP_{i,t} + \alpha_{1,i}\Delta i_{i,t} + \alpha_{2,i}\Delta s_{i,t} -$$
$$\beta_{0,i}((M/P)_{i,t-1} - \beta_{1,i}GDP_{i,t-1} - \beta_{2,i}i_{i,t-1} - \beta_{3,i}s_{i,t-1} - \mu_i) + \varepsilon_{it}$$

$\alpha_{0,i}$	$\alpha_{1,i}$	$\alpha_{2,i}$
10.33**	1.03	7.69**
0.02	0.79	0.05
$\beta_{0,i}$	$\beta_{1,i}$	$\beta_{2,i}$
5.88	0.23	7.15*
0.11	0.97	0.07

Note: ***, **, and * denote significance at 1 percent, 5 percent, and 10 percent level, respectively. The null hypothesis is that all coefficients across countries are equal. The test statistic is distributed as chi-square with *n-1* degrees of freedom.

Appendix 3

Figure A3.1: Inflation Forecasts, Czech Republic

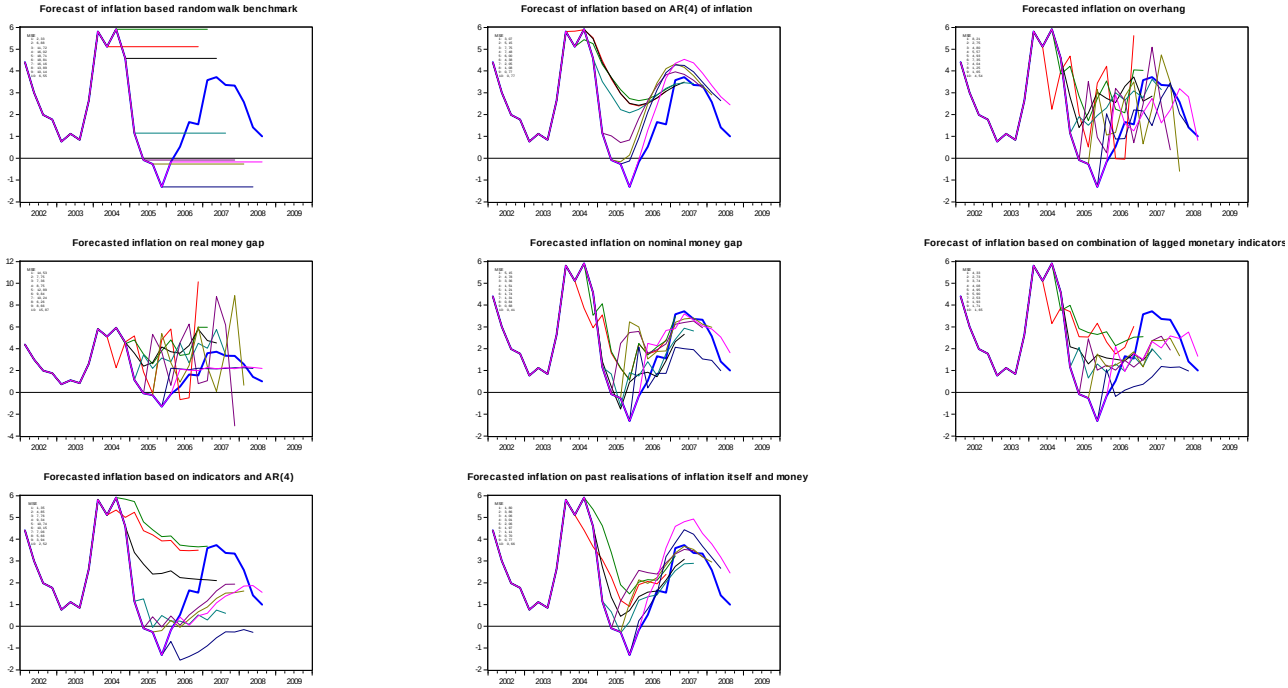


Figure A3.2: Inflation Forecast Evaluation, Czech Republic

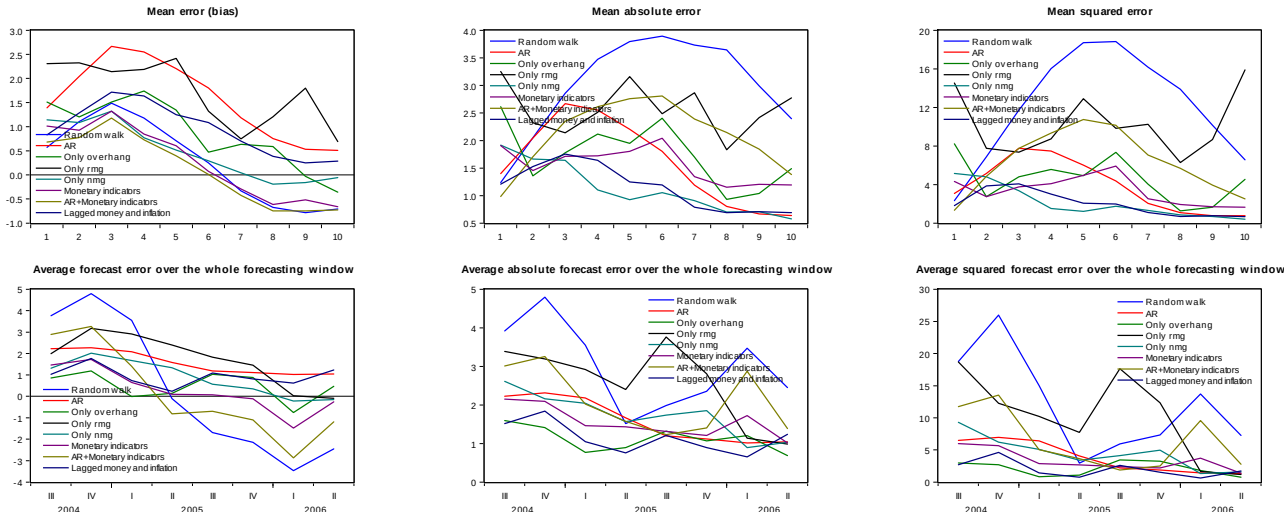


Figure A3.3: Inflation Forecasts, Poland

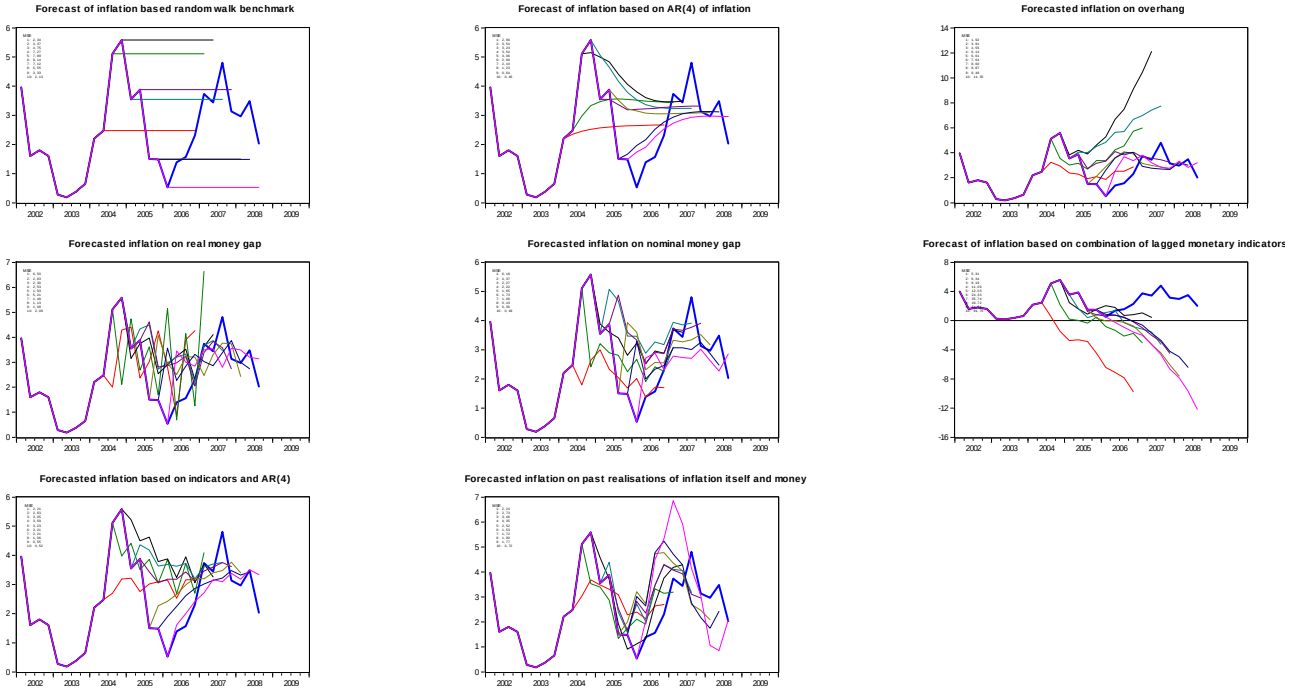


Figure A3.4: Inflation Forecast Evaluation, Poland

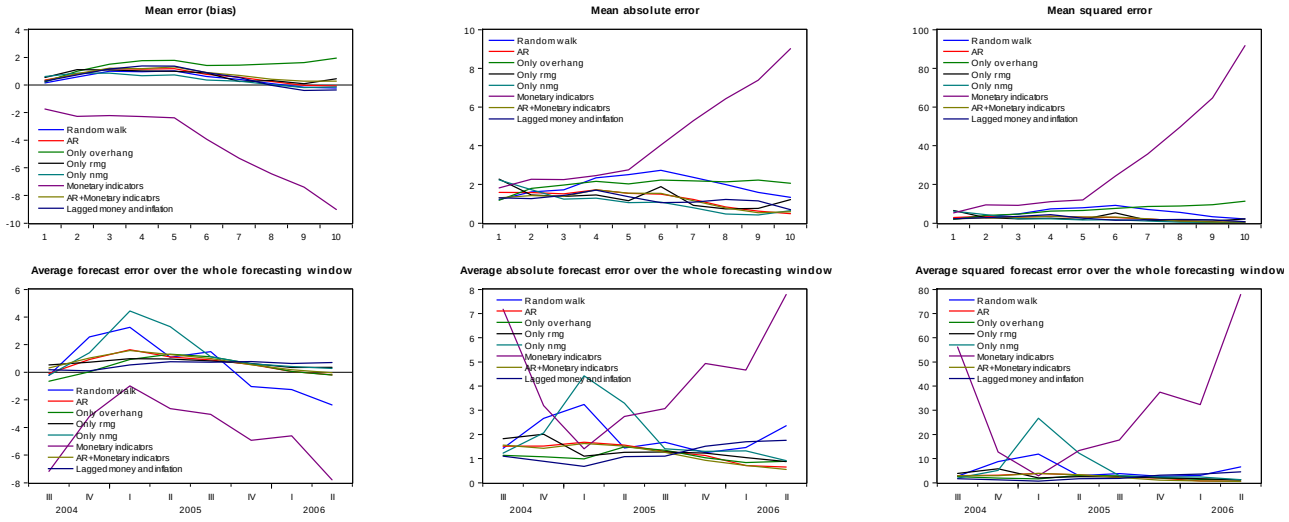


Figure A3.5: Inflation Forecasts, Slovakia

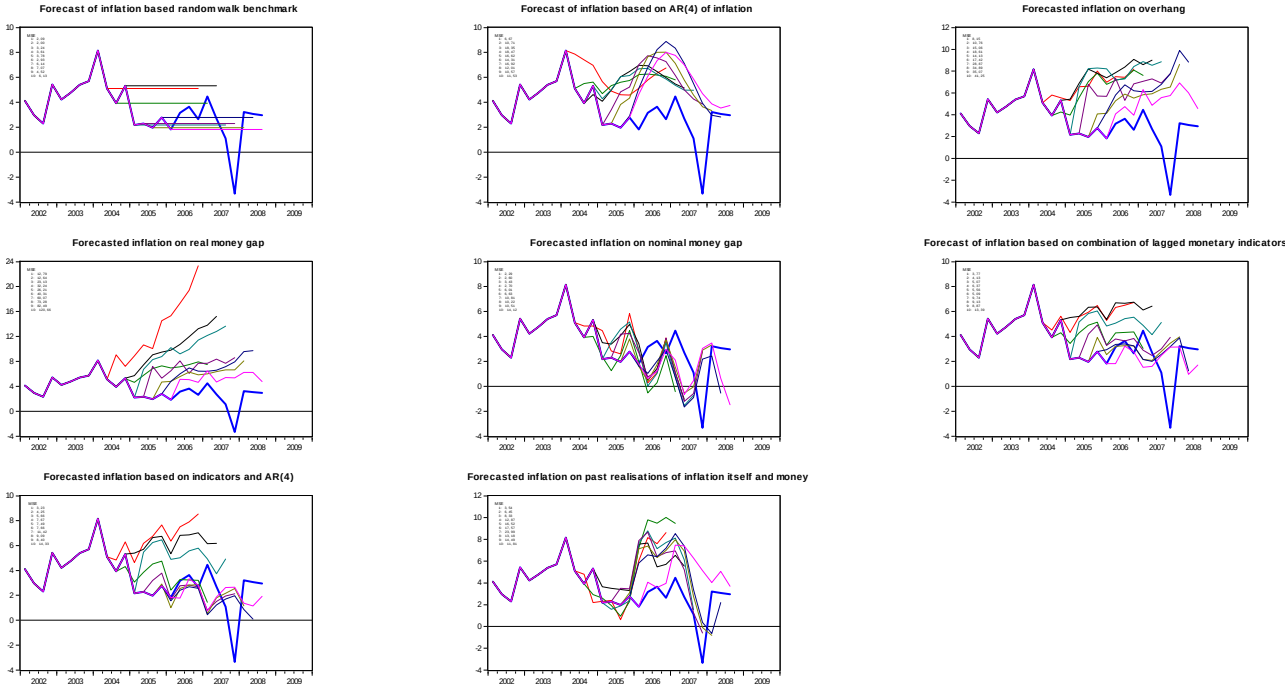


Figure A3.6: Inflation Forecast Evaluation, Slovakia

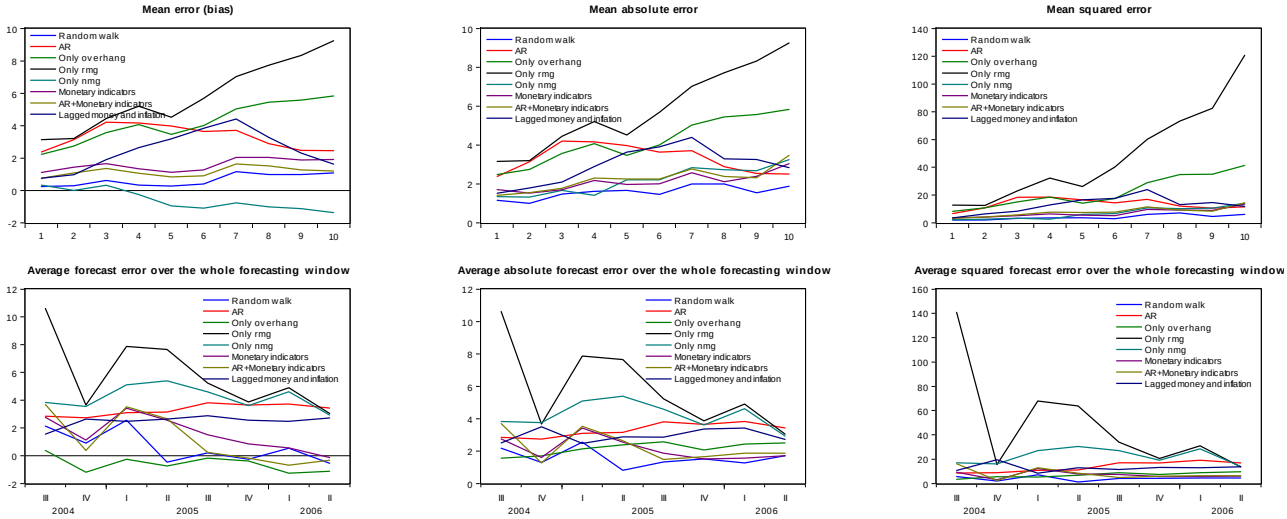


Figure A3.7: Inflation Forecasts, Hungary

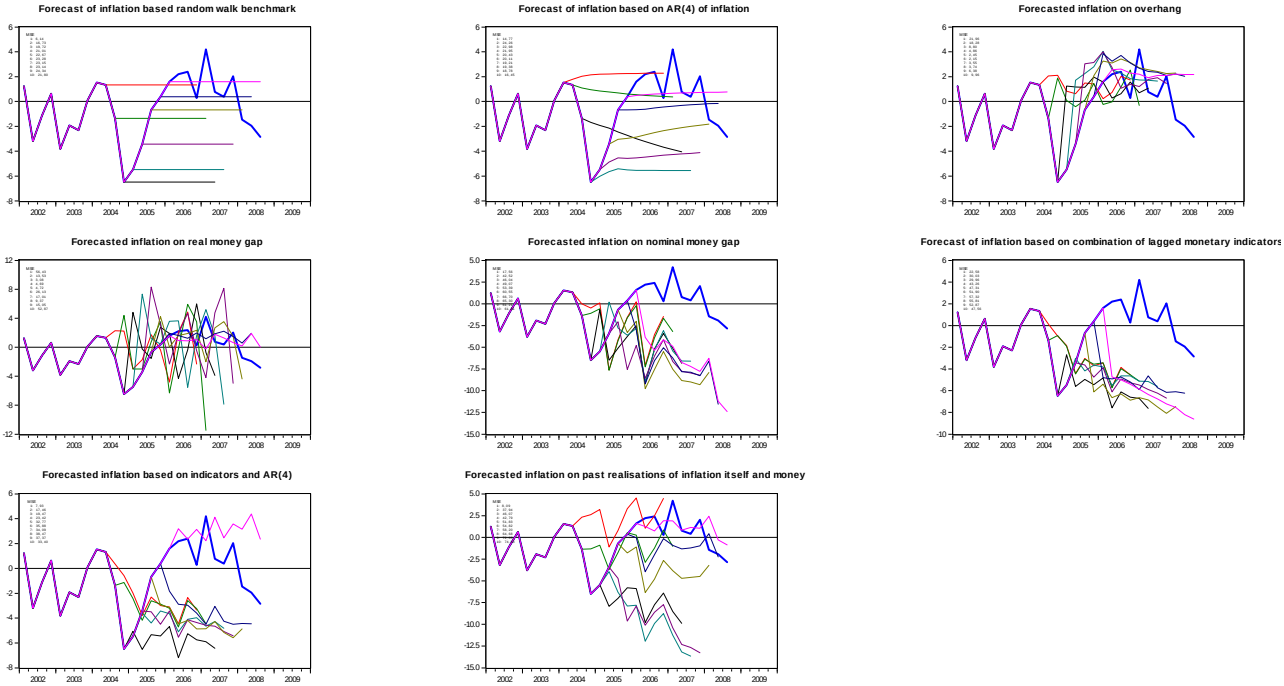


Figure A3.8: Inflation Forecast Evaluation, Hungary

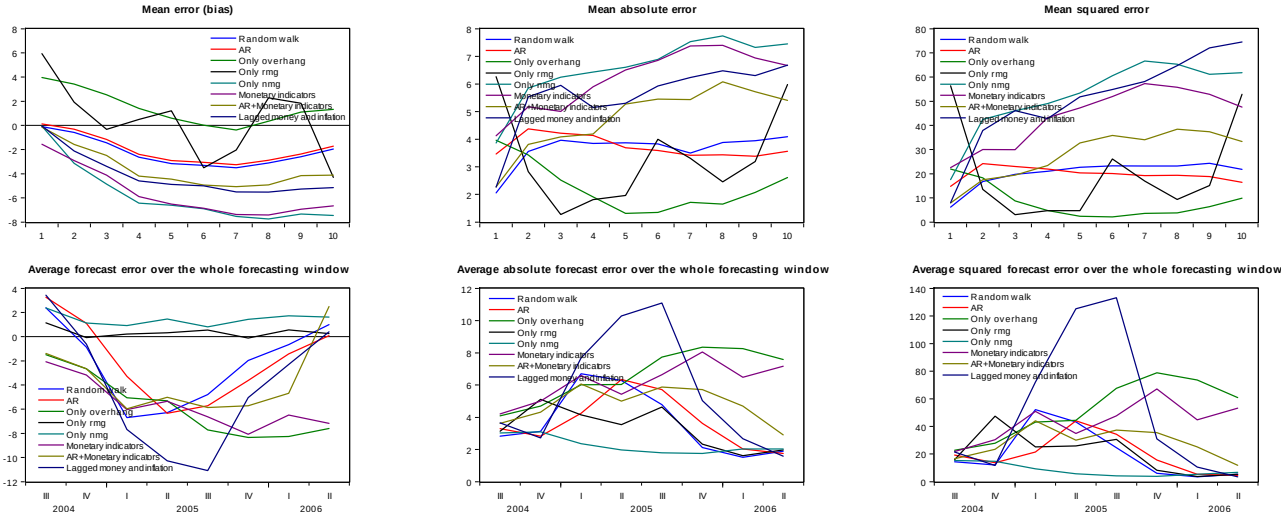


Figure A3.9: Real Money Forecasts

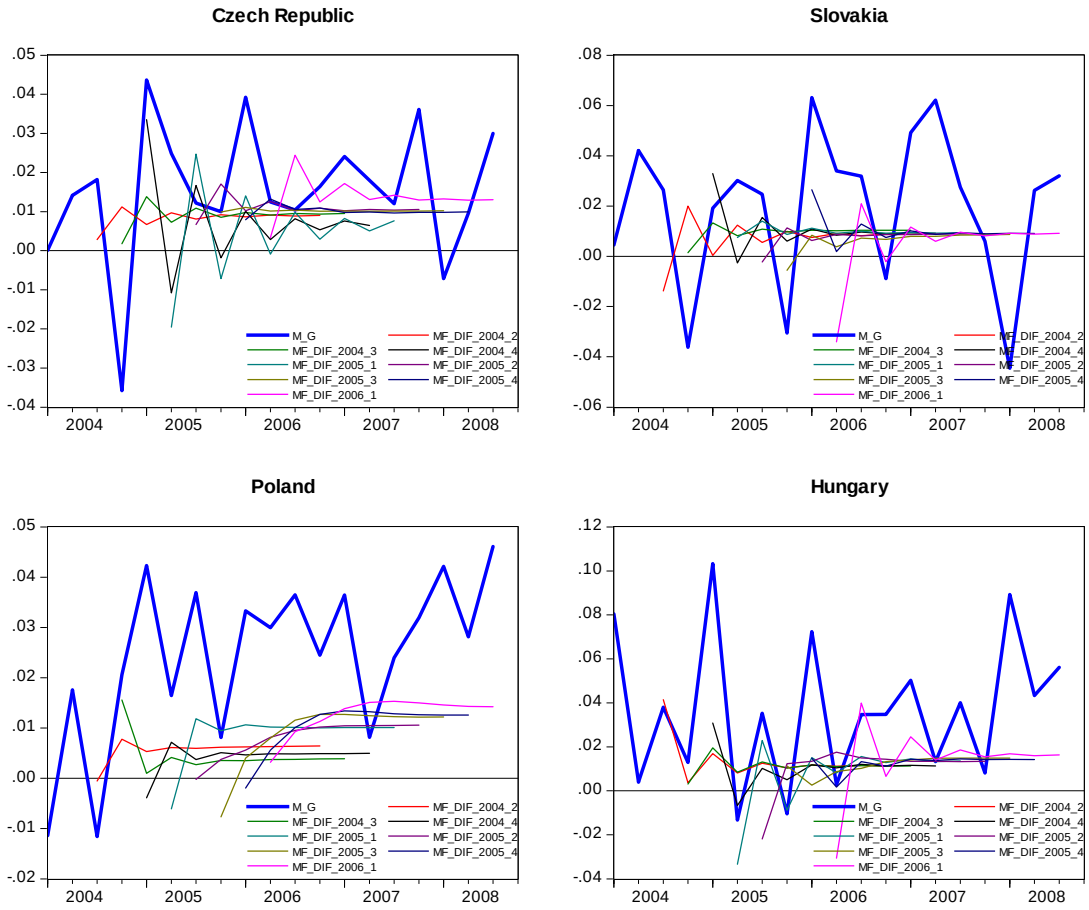


Figure A3.10: Inflation Forecasts

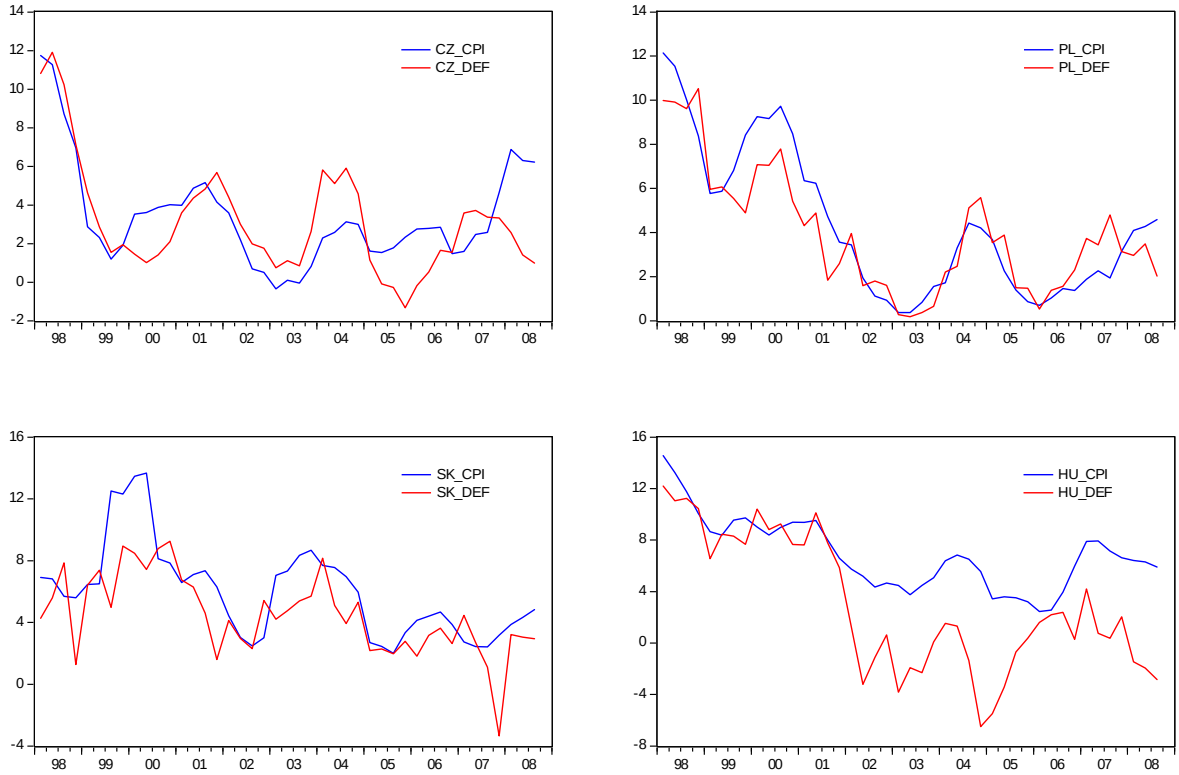
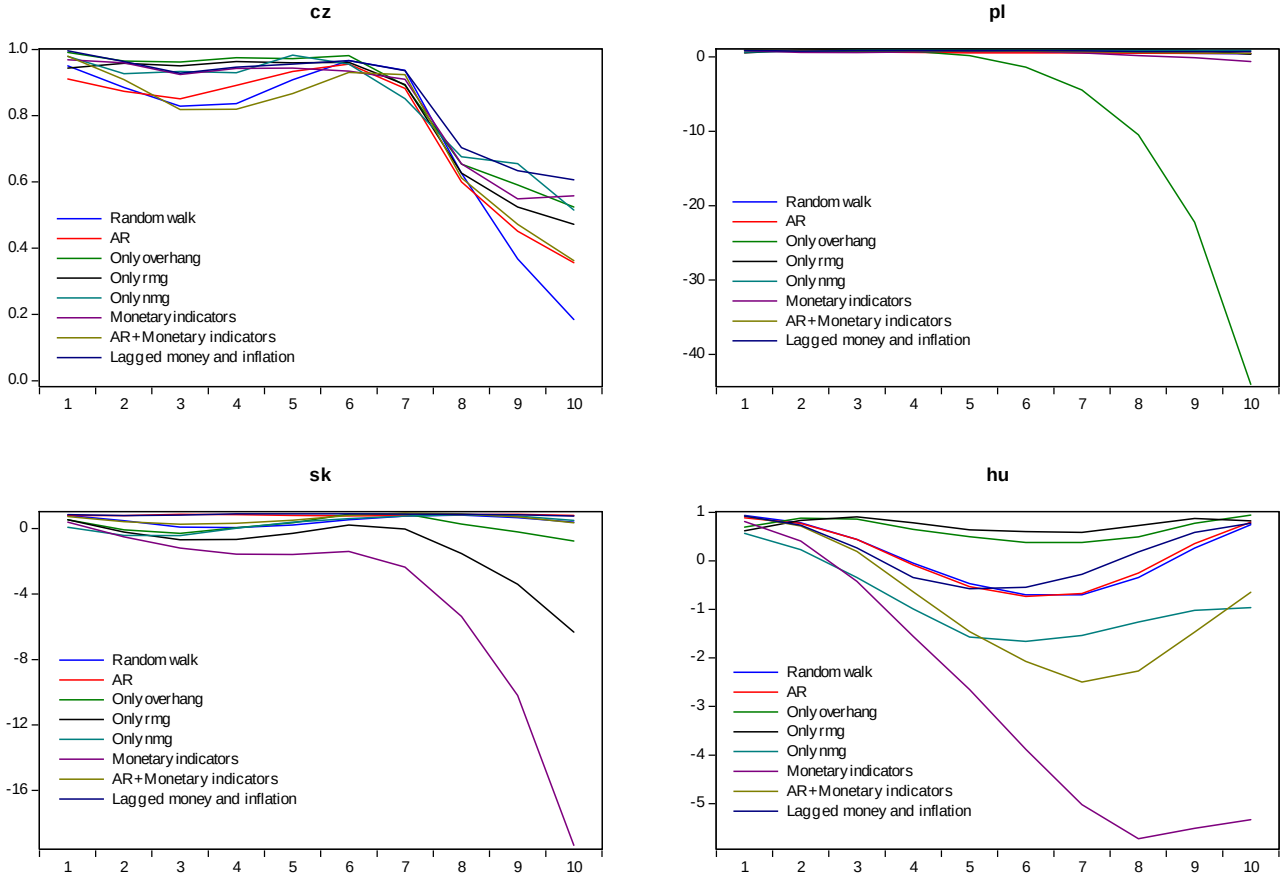


Figure A3.11: Granger-Newbold Forecast Evaluation Criterion with CPI



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Czech National Bank
Economic Research Department
Na Příkopě 28, 115 03 Praha 1
Czech Republic
phone: +420 2 244 12 321
fax: +420 2 244 14 278
http://www.cnb.cz
e-mail: research@cnb.cz
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