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Does money help predict inflation? An empirical assessment for Central Europe

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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 European Central Bank regularly uses for monetary analysis. We find 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.

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; Fourcans and Vranceanu, 2008; among others). Nevertheless, from the policy perspective,

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the attendant question is not so much whether money matters, but rather *to what extent* it matters. Clearly, money may be found to be significant in many inflation forecast equations, but an important issue here is whether inflation forecasts become more accurate with money, as compared to other standard models. If they do, there is a strong argument to monitor money developments. Even if the forecasting accuracy remains largely the same, it might still be useful for monitoring 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 provides a brief introduction to actual policy making in the sample countries. Section 4 describes our empirical methodology. A data description is provided in Section 5. Section 6 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 7. 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 et al. (2008) discuss in 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 et al. (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 by Gottschalk et al. (2000) based on vector autoregression analysis. Their results suggest a minor role for money. Stracca (2004) takes a somewhat different approach and examines the forecasting properties on Divisia monetary aggregate for the euro area.

There is also a number of empirical papers applied to the United States. Their findings vary, too. On the one hand, Bachmaier 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 et al. (2008), using Bayesian VARs, show that models including money consistently produce better inflation

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

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 by 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 et al. (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). Vizek and Broz (2009) examine the effect of excess money growth on inflation in Croatia.

3. Monetary policy in the Czech Republic, Hungary, Poland and Slovakia

This section discusses the actual monetary policy making in the Czech Republic, Hungary, Poland and Slovakia. These countries suffered from double-digit inflation in the first half of the 1990s and the main objective of central banks was to achieve price stability. Since all countries exhibited real exchange rate appreciation due to the catching-up process to Western Europe, the fixed exchange rate regimes were sooner or later replaced by a more flexible regime – inflation targeting (Egert and Komarek, 2006). The Czech Republic and Poland adopted inflation targeting in 1998, Slovakia followed in 1999, and Hungary in 2001. In these countries, the inflation targeting regime was adopted as a disinflation strategy. See Barlow (2010) for an empirical examination on which structural and macroeconomic factors mattered for inflation in transition countries.

Nevertheless, the exchange rate continued to play an important role under the new policy as well. Especially in the first years of inflation targeting, the countries intervened on the foreign exchange market in order to depreciate the value of – otherwise highly appreciating – domestic currency (see Gersl and Holub, 2006). Hungary even formalized the corridor for exchange rate fluctuations and experienced a currency attack in 2003 (Siklos, 2006). This issue has been related to large capital inflows to the countries (see Hegerty, 2009; Cardarelli et al., 2010). Over the course of several years, inflation rates stabilized at levels similar to developed countries and inflation targets were subsequently set to values considered in line with price stability (for example, the current inflation target is 2% in the Czech Republic).

Inflation targeting in these countries was characterized by an increased degree of transparency. The central banks started publishing inflation reports, minutes as well as attributed voting records of monetary policy meetings, detailed forecasts including the description of main forecasting models as well as the forecasting process. Dincer and Eichengreen (2009) rank the countries in terms of their central bank transparency and include Central European countries among the top group of most transparent central banks. The Czech Republic ranks 4th, but the degree of transparency increased further after the data collection by Dincer and Eichengreen (2009). The Czech central bank now publishes the density forecasts of inflation, output, interest rate as well as exchange rate. See also Siklos (2010) on the improvements in central bank transparency in Central Europe.

Slovakia fulfilled the Maastricht criteria and adopted the euro in 2009. Euro adoption in the other countries does not seem to be on the agenda these days, either because of the financial crisis associated with the intensified need for fiscal consolidation or the belief that the benefits of euro adoption are in general not high.

The current challenges to central bank monetary policies are determined by the ongoing global financial crisis that has raised several issues for actual policy making. The first issue is related to how to conduct monetary policy with a highly uncertain future outlook. The second issue is linked to zero bound on interest rates. During the crisis, interest rates in many central banks around the world were driven to historical lows and many banks introduced a number of unconventional policy measures. In this respect, unconventional polices are highly discretional and exit strategies are not well specified. The third issue is related to how to operationalize financial stability concerns and to what extent financial stability should play a role in inflation targeting. Nevertheless, it has to be stressed that the global financial crisis hit the Visegrad countries mainly via a drop in the demand for exports and their financial systems remained largely stable.

4. 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.

4.1. Money indicators

4.1.1. 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

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

where $\Pi = \lambda\eta'$. η' consists of cointegration vectors and λ 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 specification for a small open economy (see Leventakis, 1993, for a balance portfolio model of money demand in a small open economy) of vector $X_t : X_t = ((m-p)_t, y_t, i_t, s_t)'$, where m is the logarithm of the nominal money stock (more specifically, monetary aggregate M2) and 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. Foreign variables are not introduced directly into the money demand function, but it should be noted that the effect of these variables is present indirectly, as they are likely to have a strong influence on domestic variables.

The (normalized) cointegrating vector in our case is thus defined 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

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

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

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

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 B for the corresponding estimates).

4.1.2. 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 be obtained if it were growing at its reference rate. The reference rate of money growth, Δm^{refval}, is obtained as $\Delta m^{refval} = \pi^* + \beta^* \Delta y^{potential}$, 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 Δm^{refval} 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 et al., 2001). Finally, the nominal money gap, nmg_t, is obtained by comparing the actual M2 level (seasonally adjusted) with the M2 reference value:

$$nmg_t = m_t - m_t^{refval}. \tag{4}$$

4.1.3. Real money gap

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

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

where p_t^{CPI} denotes the CPI price index and p_t^* is calculated assuming that p_t^{CPI} always grows 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 typical monetary policy horizon such as that 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.

4.2. 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 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 effect of three aforementioned money indicators is evaluated separately one after the other:

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

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

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

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 the lagged values of inflation as well as yearly money growth:

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

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

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 first and fourth 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).

4.3. Forecasting accuracy

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

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

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 $h = 1,\ldots,M$ forecasting errors at different (sub)horizons. The forecasting date is denoted by $t = 1,\ldots,N$.

4.3.1. 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 $t = 1,\ldots,N$, i.e.:

$$me^{Q}_{t} = \frac{\sum_{h=1}^{M} \varepsilon^{Q}_{t,h}}{M}, \quad mabse^{Q}_{t} = \frac{\sum_{h=1}^{M} |\varepsilon^{Q}_{t,h}|}{M}, \quad mse^{Q}_{t} = \frac{\sum_{h=1}^{M} (\varepsilon^{Q}_{t,h})^2}{M}, \tag{15}$$

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

4.3.2. 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:

$$me^{Q}_{h} = \frac{\sum_{t=1}^{N} \varepsilon^{Q}_{t,h}}{N}, \quad mabse^{Q}_{h} = \frac{\sum_{t=1}^{N} |\varepsilon^{Q}_{t,h}|}{N}, \quad mse^{Q}_{h} = \frac{\sum_{t=1}^{N} (\varepsilon^{Q}_{t,h})^2}{N}. \tag{16}$$

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) measure (GN), which adjusts the squared errors by the corresponding inflation variability. The GN is constructed only for the evaluation of forecasts along the different horizons. Let us define

$$GN^{Q}_{h} = 1 - \frac{\mathrm{var}_t(\varepsilon^{X}_{t,h})}{\mathrm{var}(\pi)} = 1 - \frac{mse^{Q}_{h}}{\mathrm{var}(\pi)}, \tag{17}$$

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 forecast of inflation one period ahead 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.

5. 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 A.

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. The differences in CPI and deflator series are not negligible, so it is no surprise that the results differ.

GDP data in 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 3 M 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 3 M rates is mainly motivated 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 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 1600 (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.

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. Standard errors in brackets.
*** Significance at 1% level.
** Significance at 5% level.
* Significance at 10% level.

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 that ten forecasts are generated, each eight periods long. Hence the last forecast is evaluated in 2006Q3 and the period forecasted is 2006Q4–2008Q3.[4]

6. Results

This section first provides the estimates of money demand. Second, the question 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.

6.1. 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 B) and 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; Rosenberg and Tirpak, 2009). In some

[4] As an alternative, we investigated the forecasts up to four quarters only in order to increase the number of observations. The forecasts do not deliver substantially different results. The results are available upon request.

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; 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 2
Does monetary overhang matter for future inflation? In-sample evaluation, controlling for lagged inflation and output gap $Inflation_{t+i} = a_0 + a_1 \times inflation_t + a_2 \times overhang_t + a_3 \times outputgap_t + e_{1+i}$..

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	0.21*	0.92***	0.10**	0.38	0.97
2	0.51*	0.83***	0.21***	0.08	0.92
3	0.87*	0.72***	0.32***	0.13*	0.87
4	1.14*	0.62***	0.40***	0.16**	0.83
5	1.28*	0.55***	0.41***	0.12	0.77
6	1.33*	0.51***	0.35***	0.09	0.70
7	1.40*	0.46***	0.25*	0.06	0.61
8	1.50*	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. Robust standard errors.
*** Significance at 1% level.
** Significance at 5% level.
* Significance at 10% level.

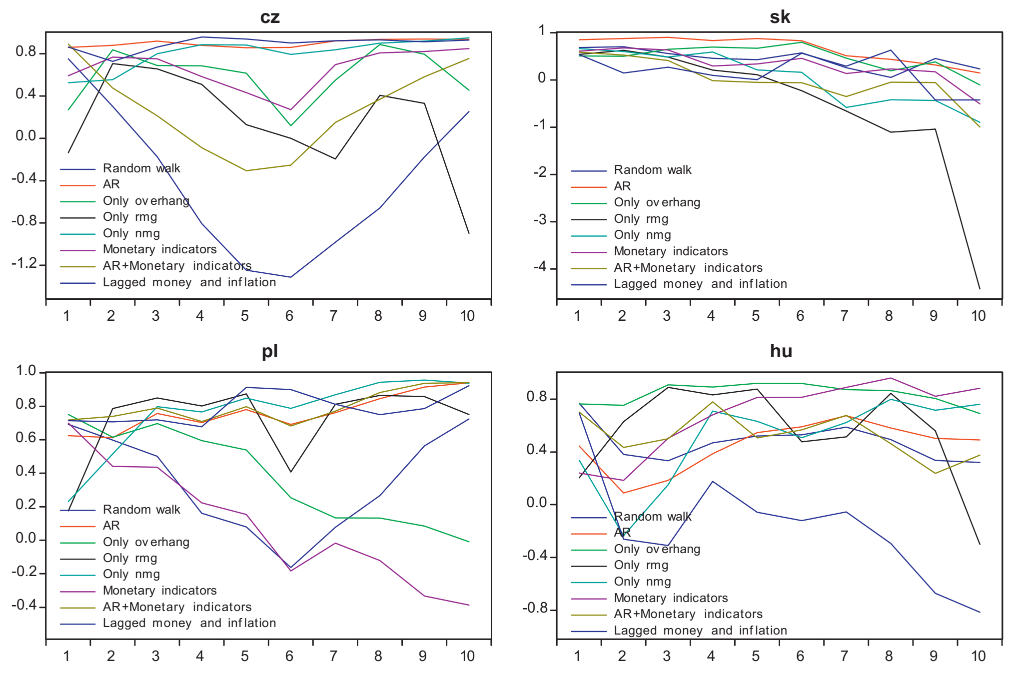
An important precondition for the forecasting exercise is to assess the stability of the estimated money demand equations. For this reason, we examine whether the recursive eigenvalues are stable (Hansen and Johansen, 1999). Note that Chow tests, which are typically employed for stability analysis, compare 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 Fig. A.1 in the Appendix and indicate that the estimated money demand is stable for all countries.

6.2. 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). Broadly following 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 smoothing parameter of 1600 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.

6.3. 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 analyses to shed light on the forecasting ability of money.



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

Fig. 1. Does money improve the forecasts of inflation? Granger–Newbold forecast evaluation criterion.

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 even though the inflation persistence is not high in these countries according to Franta et al. (2007). Nevertheless, many forecasting models with money improve the forecasts of inflation in comparison to random walk forecast. In case of the Czech Republic, random walk is beaten by nearly all forecasting models at any horizon. For other countries, there are always at least several forecasting models that give more accurate forecasts of inflation.

Nevertheless, the results indicate that in the case of Hungary and especially 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 a 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 upon request (see Fig. 1).

7. 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 2 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 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 also be interesting to investigate whether and how money matters for the future degree of economic activity.

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Appendix A

See Fig. A1.

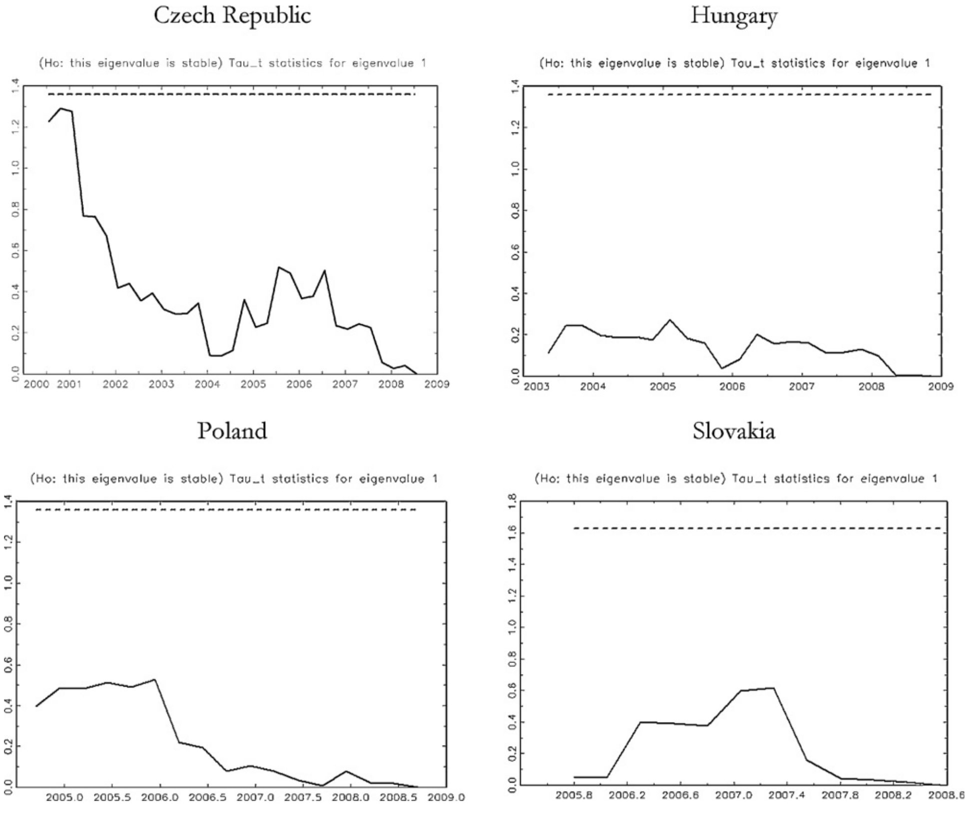

Fig. A1. Stability analysis of money demand equations.

Appendix B

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):

$$m/p = -\underset{(4.00)}{5.49} + \underset{(0.83)}{1.52} \times gdp - \underset{(0.003)}{0.004} \times i - \underset{(0.54)}{0.63} \times s$$

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. 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
Test for coefficient equality, money demand in Central Europe $\Delta(M/P)_{i,t}=\alpha_{0,i}\Delta GDP_{i,t}+\alpha_{1,i}\Delta i_{i,t}+\alpha_{2,i}\Delta s_{i,t}-\beta_{0,i}((M/P)_{i,t-1}-\beta_{1,i}GDP_{i,t-1}-\beta_{2,i}i_{i,t-1}-\beta_{3,i}s_{i,t-1}-\mu_i)+\varepsilon_{it}$.

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

Note. 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.
** Significance at 5% level.
* Significance at 10% level.

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