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Monetary Policy Rules for Convergence to the Euro

Lucjan T. Orlowski

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Contents

Abstract.....	5
I. Introduction	6
II. Instrument Rule for a Converging Economy – General Assumptions	7
III. Instrument Rule Models for Open Converging Economies.....	10
IV. Stability of the Input Variables.....	15
V. Empirical Tests of Open-Economy Convergence-Consistent Instrument Rule	21
VI. A Synopsis and Policy Recommendations	26
References	28

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Abstract

This paper aims to devise a monetary policy instrument rule that is suitable for open economies undergoing monetary convergence to a common currency area. The open-economy convergence-consistent Taylor rule is forward-looking, consistent with monetary framework based on inflation targeting, containing input variables that are relative to the corresponding variables in the common currency area. The policy rule is tested empirically for three inflation targeting countries converging to the euro, i.e. the Czech Republic, Poland and Hungary. Stability tests of the input variables affirm prudent inclusion of these variables in the suggested policy rule. Empirical tests of the proposed instrument rule point to systemic differences in monetary policies among these euro-candidates. The Czech inflation targeting is forward-looking relying on a sensible balance between inflation and output growth objectives. Poland's policy focuses on backward-looking inflation, while the Hungarian policy on exchange rate stability. Forecasts of policy instruments based on the prescribed rule are more accurate and reliable for the Czech Republic and Hungary, but less for Poland.

I. Introduction

Monetary policies in countries converging to a common currency system cannot be based exclusively on discretionary responses to observed or anticipated shocks to inflation and to other target variables. Since convergence to a common currency is a multifaceted process that is comprised of closing the gaps in inflation rates, interest rates as well as stabilizing exchange rates, a transparent, forward-looking instrument rule would be helpful for achieving these at times exclusive tasks.

This study aims at proposing a forward-looking instrument rule for an open-economy undergoing monetary convergence to a common currency system. Such policy rule ought to include real interest rate, inflation gap, output gap and exchange rate gap as independent or input variables, which guide changes in short-term interest rates as policy instruments chosen by a central bank. By assumption, these input variables shall be devised as differentials between domestic and the corresponding currency area variables in order to monitor and guide the convergence process effectively. The relative treatment of input variables is consistent with the policy framework of targeting inflation forecast differentials proposed for converging economies by Orlowski (2008). Thus in essence, this study examines instrument rules and conditions of their implementation that are consistent with the relative-inflation-forecast-targeting framework.

Feasibility of the proposed instrument rule is examined for the three largest countries pursuing convergence to the euro, i.e. for Poland, Hungary and the Czech Republic. In contrast to smaller euro-candidate countries that follow convergence based on currency pegs to the euro, monetary authorities of these larger states have chosen more flexible policy venues based on inflation targeting. The Czech National Bank (CNB) has been focusing on inflation targeting since January 1998, the National Bank of Poland (NBP) since January 1999 and the National Bank of Hungary (NBH) since May 2001. As these are euro-candidate countries, their instrument rules for monetary policy cannot be fully autonomous, i.e. based on a simple

framework originally proposed by Taylor (1993). Arguably, these three central banks do not follow a homogeneous policy prescription. A more uniform, forward-looking rule would provide them with useful guidance for monitoring and implementing the euro-convergence process.

Section II of our paper is a background discussion on the standard Taylor rule and states assumptions for their extensions for open converging economies. Several models of a forward-looking instrument rule that is conducive for such economies are developed and discussed in Section III. A testable version of the model is presented in Section IV, which also examines the degree of stability of the key independent variables in the three euro-candidate countries. Empirical tests of the heteroscedasticity-consistent OLS regression of the underlying instrument rule model are presented and discussed in Section V. Section VI summarizes the key findings and offers policy conclusions that seem relevant for the euro-candidate countries.

II. Instrument Rule for a Converging Economy – General Assumptions

Monetary policy in an economy converging to a common currency system cannot be implemented exclusively through discretionary reactions. It needs to be guided by predetermined rules for changes in the policy instrument (short-term interest rates) in response to a set of input variables, at minimum, to deviations of actual output from potential output as well as actual from targeted inflation. For a converging economy, the instrument rule should also encompass the main criteria of monetary convergence, such as lowering the gap between the domestic and the currency area inflation, as well as the interest rate gap and securing exchange rate stability. Moreover, a credible policy rule is likely to gear expectations or future predictions of changes in these variables to the convergence thresholds, such as the EU-prescribed Maastricht criteria.

Devising a sensible, robust rule for monetary policy in a converging economy is a complex task. A general assumption for such rule is that changes in the central bank reference interest rates should react to changes in the forecasts of the input variables, i.e. regressors or independent variables in the policy rule function. These input variables for a converging

economy include the inflation gap (the difference between the inflation forecast and the inflation target), the output gap (the difference between the actual and potential output) and the exchange rate gap (deviation between the exchange rate forecast and the officially-declared convergence rate).

Complexity of an open converging economy instrument rule arises from a number of factors. Among them are:

1. Not only domestic, but also the currency-area input variables need to be included in the instrument rule, in order to guide the monetary convergence process more effectively.
2. Determination of the target variables for a converging economy ought to take into consideration the corresponding currency-area targets.
3. The instrument rule should be forward-looking, based on forecast variables in consistency with the forward-looking nature of the convergence process.
4. For the purpose of developing accurate and reliable forecasts, the input variables must be relatively stable. Therefore, a prior record of financial stability shall precede adoption of an instrument rule.
5. Small, converging economies are normally subject to large nominal and real external shocks. Therefore the instrument rule should include exchange rate smoothing, in addition to the standard low inflation and output gap objectives.
6. Data distribution of nominal variables such as inflation, interest rates and exchange rates is usually leptokurtic, thus characterized by thin waist and long tails. This means that their fluctuations are small and well-contained around their mean value at tranquil periods, but their volatility tends to be magnified at turbulent times at financial markets. For this reason, the empirical assessment of the instrument rule must incorporate modules that account for leptokurtosis of the input variables (such as the generalized error distribution parameterization in volatility dynamics tests)¹.

¹ Prevalence of leptokurtosis of the indicator variables has been identified by Svensson (2003) as a factor questioning practicality of standard Taylor rules. However, recent advances in econometric modeling and forecasting allow for correcting this deficiency. In a similar vein, Orphanides (2003) shows that the Taylor rule would have resulted in an inferior macroeconomic performance during the inflation shock of the 1970s.

Instrument rules for monetary policy are derived from the baseline model developed by John B. Taylor (1993). The original Taylor rule is aimed at tracking interest rate decisions of the U.S. Federal Reserve in response to the observed changes in the inflation gap and the output gap.

The baseline Taylor model can be stated as

$$i_t = \hat{r}_t + \pi_t + \alpha_\pi(\pi_t - \bar{\pi}_t) + \alpha_y(y_t - \bar{y}_t) \quad (1)$$

The target nominal short-term interest rate i_t is the dependent variable related to a set of regressors that include the long-term equilibrium (the Wicksellian) real interest rate \hat{r}_t , the rate of inflation π_t (measured in the original Taylor model by the GDP deflator), the “desired” or target-rate of inflation $\bar{\pi}_t$, the log of real GDP y_t , and the log of potential output \bar{y}_t . The feedback coefficients for the inflation gap $\pi_t - \bar{\pi}_t$ and for the output gap $y_t - \bar{y}_t$ are denoted by α_π and α_y respectively.

The original Taylor model included the GDP deflator and the output deviation from its linear trend as input variables, in addition to the steady-state nominal interest rate. The model specification was backward-looking and based on equal 0.5 weights on the inflation and the output gaps. An influential modification to the Taylor model was introduced by Clarida, Gali and Gertler (1998 and 2000). Their model included a Blue Chip inflation forecast, deviation of (log) of industrial production from its quadratic trend as well as one- and two-period lagged federal funds rate as input variables. Unlike the original Taylor model, the Clarida, et al.(1998, 2000), model is forward-looking and it uses variable weights on α_π and α_y parameters as well as interest rate smoothing. Among more recent versions, a noteworthy modification that is particularly useful for forecasting changes in the U.S. federal funds rate has been introduced by Keonig (2006). Comparing to Clarida, et al.(1998, 2000), the Koenig model applies current minus five-year moving average unemployment rates rather than the industrial production as a proxy of the output gap. It also uses a difference between the actual and the trend GDP, as approximated by the Blue Chip GDP forecast, as well as the first-order autoregressive movement of the federal funds rate. The Koenig model is forward-looking and it assumes variable weights on output and inflation gaps as well as interest rate smoothing. According to the empirical evaluation of various types of Taylor rules by Fernandez and Nikolsko-Rzhevskyy

(2007), the Koenig model outperforms the others in terms of most accurate tracking of the pattern in the U.S. federal funds rate.

The empirical tests confirm a notion that the Taylor rule has some unique properties that are helpful for guiding monetary policies under different systemic conditions. One of its foremost properties has been identified by Woodford (2001) as the “Taylor principle”. According to this notion, nominal interest rates must be raised by more than the rise in inflation for the purpose of achieving monetary stability, because as implied by the Taylor formula, inflation will remain under control only if real interest rates rise in response to a surge in inflation. The practical importance of the Taylor principle is highlighted by the empirical results of Clarida, et al., (1998). Their research shows that the U.S. Federal Reserve and several other central banks violated the Taylor principle in the 1960 and 1970 pursuing excessively expansionary policy that resulted in persistently high inflation. This is a valuable lesson for implementing effective monetary convergence in countries aspiring to join a common currency area.

III. Instrument Rule Models for Open Converging Economies

Since its original formulation by Taylor, the interest rate rule has undergone a number of modification and extensions aimed at reflecting policy decisions of various central banks more accurately. The extensions proposed in this paper are geared toward conditions of open economies that are converging to a common currency system. The model is built on the assumption that the monetary authority follows open economy inflation targeting framework along the characteristics originally devised by Ball (1999) and Svensson (2000), and expanded by Kuttner (2004). In an open-economy setting, the objective of lowering the exchange rate gap, i.e. reducing deviations between the actual and the dynamic equilibrium exchange rate is added to the containment of inflation gap and output gap policy goals. In essence, a diminishing tendency of the residuals between the actual and the target (dynamic equilibrium) rate means assuming a monetary policy objective of a declining exchange rate risk (Orlowski, 2003).

Open-economy instrument rule that is derived from the baseline Taylor model supplemented with the exchange rate stability objective can be formulated as

$$i_t = \hat{r}_t + \pi_t + \alpha_\pi (\pi_t - \bar{\pi}_t) + \alpha_y \dot{y}_t + \alpha_s s_t \quad (2)$$

The exchange rate stability objective is specified by $\dot{s}_t = s_t - \bar{s}_t$, i.e. as the difference between the market exchange rate and its long-run equilibrium. For the countries converging to the euro, s_t is the euro-value of the candidate's domestic currency, meaning that a decline in s_t reflects domestic currency depreciation against the euro. The output gap is denoted by $\dot{y}_t = y_t - \bar{y}_t$.

It shall be further noted that the part of Eq. (2) composed of $\alpha_\pi (\pi_t - \bar{\pi}_t) + \alpha_y \dot{y}_t + \alpha_s s_t$ denotes risk components or risk premia stemming from excessive inflation, the output gap and domestic currency depreciation, above the risk-free nominal interest rate $\hat{r}_t + \pi_t$.

Parameterization of the feedback coefficient is likely to evolve along with systemic changes that follow subsequent steps of integration with the EU and convergence to the euro. At the initial stage of integration that prioritizes curtailing high inflation and restoring foundations of price stability, a relatively strict variant of DIT is adopted. Consistently, the weight on α_π is close to unity, with α_y and α_s being close to zero. After the fundamental price stability is achieved, policy-makers may move to the second stage of integration and convergence that is characterized by a more flexible variant of DIT, which combines the goals of low inflation with the output growth that is necessary to develop a competitive modern economy that might adopt the euro without a danger of potentially large structural shocks and institutional disturbances. During the second stage, the feedback parameters α_π and α_y can be assigned equal 0.5 weights, with α_s being kept at zero. By assumption, a smooth adoption of the euro can only take place when competitive business structures and institutions are in place (Kenen and Meade, 2003; Eichengreen, 2005; Kočenda, et.al, 2006). Otherwise, a premature adoption of a common currency may entail excessive opportunity costs; in other words, it may result in significant output losses.

At the final stage of convergence to the euro, the weight on α_s will likely exceed the sum of $\alpha_\pi + \alpha_y$. In particular, this scenario will have to prevail upon the entry to the ERM2 mechanism, which needs to be maintained during a two-year period preceding the official adoption of the euro.

Before developing an instrument rule that might be conducive to the pre-ERM2 stage, it seems useful to overview several extensions of the baseline Taylor model for open economies. Among them, one possible option is a *constant-target interest-rate rule* that can be prescribed as

$$\bar{i}_t = \hat{r}_t + \pi_t + \alpha_\pi(\pi_t - \bar{\pi}_t) + \alpha_y \dot{y}_t + \alpha_s \dot{s}_t \quad (3)$$

This policy scenario assumes that the nominal short-term interest rate remains fixed and possible surges in one or more of the input variables are offset by adjustments in others. Specifically, a rise in inflation can be curtailed by domestic currency appreciation induced by foreign exchange market intervention, i.e. a purchase of domestic currency with foreign currency reserves. Therefore, a policy approach consistent with the constant-target interest-rate rule seems to necessitate a managed floating exchange rate regime. It is because foreign exchange market interventions responding to large capital inflows or outflows will have to be conducted for securing a stable path of the short-term interest rate. However, due to the prevalent inefficiency of market interventions, such policy is generally not sensible (Woodford, 2007).

A more pragmatic approach that is likely to guide expectations to the target and the forecast variables is a *market-forecast interest-rate rule*. It follows the precepts of inflation forecast targeting (IFT) regime originally proposed by Svensson (1999) and more recently discussed among others by Woodford (2007). IFT is an attractive policy approach as its forward-looking or forecast-based specification allows for smoothing deviations between the inflation forecast and the inflation target². In an open-economy setting, it may also entail

² Against the backdrop of the significant easing of U.S. monetary policy in the fourth quarter of 2007 and in the first half of 2008, the arguments in favor of adoption of explicit forecast-targeting framework discussed by Woodford (2007) are particularly relevant. The 'grand easing' by the Federal Reserve in the second half of 2007 and the first half of 2008 created a situation of 'intertemporal inconsistency' between the monetary policy goals (price stability) and the policy actions. For this reason, it ought to be explained as a temporary departure from a disciplined monetary policy that is aimed at cushioning potentially damaging real-economy effects of the sub-prime mortgage and the global credit market crisis. An earliest possible return to a policy based on inflation forecast targeting would allow continuous confidence in the value of the dollar and, at the same time, would facilitate stabilization of the real economy (Woodford, 2007).

forecasts of the exchange rate and the output gap. In consistency with an open-economy IFT, the market-forecast interest rate rule can be specified as

$$i_t = \hat{r}_t + \pi_{t+\tau} + \alpha_\pi (\pi_{t+\tau} - \bar{\pi}_t) + \alpha_y \dot{y}_{t+\tau} + \alpha_s \dot{s}_{t+\tau} \quad (4)$$

The displacement parameter τ reflects the time horizon of the official forecast of policy-makers for the monitored independent variables.

It can be further assumed that the exchange rate gap may be replaced with the available forward market rate for τ -periods ahead, following the principle that the forward rates are normally good predictors of a future path of spot market rates, due to corrective currency arbitraging. Specifically, if the initial forecast for the spot rate of foreign currency is above the forward rate, currency speculators will find incentives to buy foreign currency spot and exercise the forward selling contracts. The increasing speculative demand for foreign currency in spot market trading will adjust the spot rate closer to the path implied by the forward rate. Certainly, a spot-rate forecast above the forward rate path will induce speculative foreign currency selling, thus foreign currency depreciation until the spot rate falls down to the forward path.

The third available policy rule option that is particularly relevant for the euro-candidate countries can be prescribed as *projected interest-rate rule, consistent with the Maastricht convergence criteria*. These EU-imposed monetary convergence benchmarks for the candidates for adopting the euro include the reference rates for inflation, exchange rate and long-term bond yield. Accordingly, the inflation rate of the candidate cannot exceed 1.5 percent above the average of three lowest national inflation rates among the EU members – it can be denoted as $\bar{\pi}_t^M$. The Maastricht-reference domestic 10-year bond yield $\bar{R}_{t+\tau}^{LM}$ cannot exceed two percent above the average of 10-year bond yields of the same three countries. In addition, the candidate country currency rate against the euro shall remain within a ‘normal’ band of permitted fluctuations around an officially-chosen reference exchange rate \bar{s}_t^M , which is usually determined upon entering the ERM2. The instrument rule function consistent with the Maastricht benchmarks can be formulated as

$$i_t = \hat{r}_t + \alpha_R (\bar{R}_{t+\tau}^{LM} - R_{t+\tau}^S) + \alpha_\pi (\pi_{t+\tau} - \bar{\pi}_{t+\tau}^M) + \alpha_y \dot{y}_t + \alpha_s (s_{t+\tau} - \bar{s}_{t+\tau}^M) \quad (5)$$

In this functional relationship, the domestic inflation forecast is proxied by the term spread on government bonds $(\bar{R}_{t+\tau}^{LM} - R_{t+\tau}^S)$, assuming that the projected long-term bond yield is consistent with the Maastricht reference bond yield. More importantly, changes in the target interest rate respond by the α_π parameter to the deviation between the inflation forecast for the τ -period ahead and the anticipated Maastricht reference rate for inflation. The technical problem of such policy implementation is that the Maastricht reference rate for inflation as published by the European Central Bank is not forward-looking; it is ex-ante determined instead. Therefore, the $\bar{\pi}_{t+\tau}^M$ variable shall be treated as the forecast of the reference rate for the τ -period ahead. The exchange rate reference rate $\bar{s}_{t+\tau}^M$ is pre-determined. According to the euro-accession procedure, the official reference value of the euro in local currency is subject to 'normal' currency fluctuations and it cannot be devalued during a two-year period preceding the examination time for the euro adoption. The reference exchange rate can be consistent with the long-run equilibrium rate. Nevertheless, a small disparity between the official and the equilibrium rates might be prudent. A small revaluation margin, i.e. a stronger official than the equilibrium value of the local currency allows room for expected appreciation pressures stemming from the remnants of Balassa-Samuelson effects (Orlowski and Rybinski, 2006).

In essence, parameterization of the Maastricht consistent instrument rule prescribed by Eq.(5) is technically complex, mainly due to the need to forecast long-term interest rate, long-term equilibrium exchange rate and inflation reference rates. In addition, its effective implementation depends on a pre-determined choice of the α parameters, with a gradually increasing weight assigned to α_s . Because of its complexity, the instrument rule prescribed by Eq.(5) may not be transparent to financial markets and institutions, particularly when the underlying forward-looking independent variables are highly unstable. Nevertheless, this multifaceted rule seems to be a logical policy choice upon entry to the ERM2 framework, which is required to be pursued by policy-makers for a two-year minimum period preceding the euro-adoption. Prior to the ERM2-entry, policy-makers will be well-advised to adopt a simpler, more transparent rule, such as the one prescribed by Eq.(4).

IV. Stability of the Input Variables

As argued above, the task of modeling an optimal open-economy convergence-consistent instrument rule for monetary policy is challenging due to its functional complexity. Before estimating robustness of the instrument rule consistent with Eq.(4) for the three selected euro-candidate countries, it is helpful to analyze descriptive statistics of the underlying input variables. In essence, effective implementation of a complex instrument rule that reflects open, converging economy conditions depends on the stability and predictability of the variables used in the instrument rule function. The variables shown in Table 1 include central bank reference interest rates (two-week repo rates), CPI-based annualized inflation rates, local currency values of the euro and annualized rates of monthly changes in the index of industrial output (as a rough proxy of total output). The monthly series of observations for the Czech Republic, Poland and Hungary capture the sample period that begins in January 1999 and ends in January 2008. The earlier period is excluded due to its systemic inconsistency with the current policy and exacerbated volatility of these variables in the presence of contagion effects from the Asian financial crisis. These factors distort fundamental stability of these variables and introduce an irrelevant bias for predicting their future path. The systemic inconsistency pertains to the monetary regimes based on fixed exchange rates that prevailed in these countries in the 1990s and that are fundamentally different from their current inflation targeting policies accompanied by flexible exchange rates³.

³ The fixed exchange rate system was kept in the Czech Republic until mid-1997. The inception of inflation targeting in January 1998 was accompanied initially by the managed float. Poland maintained a crawling devaluation system with a wide band of permitted fluctuations until April 2000 when it moved to a pure float in consistency with the inflation targeting policy that took effect in January 1999. Hungary pursued crawling devaluation with a narrow band until October 2001, six months after enacting inflation targeting. Upon abandoning the crawling devaluation regime, Hungary adopted an ERM2-shadowing policy, officially declaring a reference rate of HUF to the EUR. See for instance Corker, et al., (2000), Jonas and Mishkin (2005), Roger and Stone (2005), and Orlowski (2005) for a detailed discussion of the evolution of monetary policies and exchange rate regimes in these countries.

Table 1: Descriptive statistics for the variables in Eq.(4)

	Czech Republic				Poland				Hungary			
	\bar{i}_t	π_t	s_t	y_t	\bar{i}_t	π_t	s_t	y_t	\bar{i}_t	π_t	s_t	y_t
Mean	3.54	2.57	31.84	6.78	8.96	3.95	4.03	6.90	9.85	6.79	253.5	8.21
Standard deviation	1.64	1.53	3.06	5.28	5.18	3.05	0.29	6.25	2.75	2.57	8.10	7.19
Skewness	0.80	0.20	0.25	-0.84	0.77	0.88	0.77	0.12	0.67	0.01	0.60	0.75
Kurtosis	2.60	2.46	2.04	4.47	2.04	2.67	3.12	2.72	2.78	1.74	3.13	6.21
Linear time trend coefficient	-0.04	-0.01	-0.09	0.09	-0.14	-0.07	-0.01	0.07	-0.07	-0.05	0.00	-0.04
ADF unit root	-1.78	-2.58	0.17	-3.07	-1.08	-1.71	-1.66	-2.66	-2.33	-1.77	-3.22	-2.55

Notes: \bar{i}_t is the central bank reference rate (2-week repo rates), π_t is one-year growth in CPI-based inflation, s_t is local currency value of one euro, y_t is one-year growth in index of industrial output; ADF is augmented Dickey-Fuller unit root τ -coefficient (McKinnon critical value at 5% is -2.88). ARMA(1,1) structure assumes no constant or time trend. Sample period: January 1999-January 2008.

Data source: Czech National Bank, National Bank of Poland, National Bank of Hungary.

As shown in Table 1, central bank reference interest rates, as a dependent variable in our exercise, have been the highest in nominal terms in Hungary and the lowest in the Czech Republic. Real rates measured as a difference between the nominal rates and the average inflation rates are by far the highest in Poland, indicating the most restrictive course of monetary policy during the examined sample period. The standard deviation of reference rates as well as the coefficient of variation (the average percentage variation around the mean) of reference interest rates is the highest in Poland, indicating very active adjustments of the policy instrument variable. In all three cases, distribution of interest rate data is right-skewed, suggesting prevalence of their increases rather than cuts, as well as platykurtic indicating their large dispersions from the mean. They are all non-stationary as implied by the absolute value of ADF unit root statistics lower than the critical value for the tested sample period. Their linear trend is mildly declining, which may suggest gradually improved policy credibility and gains in financial markets confidence about the stabilizing impact of changes in the policy instrument.

The average inflation rate is the highest in Hungary and the lowest in the Czech Republic. Evidently, Hungary faces a serious task of reducing inflation, as the main policy target variable, to a low, sustainable level, thus also a challenge of improving stability of its financial system. Although Poland's inflation has been consistently low, it remains volatile, as implied by its high standard deviation and coefficient of variation. Arguably, the risks associated with inflation variability in Poland remain high. Variations of inflation rates are slightly right-skewed in Poland and in the Czech Republic. They are symmetric in Hungary, which implies their steady path at a consistently high level. The inflation rates are non-stationary in all three cases.

On the basis of the coefficient of variation, nominal exchange rates in all three countries have been remarkably stable, in contrast to their widely-documented volatility during the periods of the Asian and the Russian financial crises in the second half of the 1990s (Kočenda and Valachy, 2006). Unlike in the Czech Republic and Poland, the Hungarian exchange rate is stationary, which suggests a focus on exchange rate stability and active smoothing of exchange rate variations by the NBH. This is also indicated by the stable linear path of the Hungarian forint (HUF) value of the euro (EUR).

Changes in the industrial output are very volatile (in line with their intrinsic variability in the majority of world economies). Therefore, empirical tests of a policy rule function ought to include a smoothed-form of this variable. In contrast to its right-skewed pattern in Hungary and Poland, fluctuations in the industrial output are left-skewed in the Czech Republic, for the

reasons yet to be investigated. Moreover, the Czech industrial output is stationary. During the tested sample period, the linear trend of industrial output has been positive in the Czech Republic and in Poland, but it negative in Hungary. The declining trend of industrial output in Hungary is somewhat puzzling.

In sum, the key instrument (reference interest rate) and the input (independent) variables embedded in Eq.(4) display mostly declining time-trends, thus show gradually increasing stability. They are predominantly non-stationary, thus suitable for OLS regression only at their first-differenced terms, which restore their stationary time trends.

Further insights on the stability and the time-varying volatility of the input variables that are employed in our exercise are provided by the tests of their univariate auto-regressive moving-average ARMA(1,1) structure with generalized auto-regressive conditional heteroskedasticity with in-mean variance and generalized error distribution parameterization GARCH(p,q)-M-GED⁴. The empirical results are shown in Table 2.

⁴ ARMA(1,2) without in-mean GARCH variance has been applied in the Czech case, as the base-line ARMA(1,1) specification has provided inconclusive results.

Table 2: Time-varying volatility of the input variables – univariate ARMA(1,1) with GARCH(1,1)-M-GED

	Czech Republic			Poland			Hungary		
	π_t	s_t	y_t	π_t	s_t	y_t	π_t	s_t	y_t
Cond. mean eq.:									
Constant term	3.42***	45.06**	4.53	-39.13	2.97***	10.82***	1.17	259.3***	8.77***
AR(1)	0.93***	1.01***	0.88***	0.99***	0.96***	0.084***	0.97***	0.88***	0.94***
MA(1)	0.21***	0.26***	-0.78***	0.33***	0.36***	-0.37***	0.30***	0.40***	-0.54***
MA(2)	0.15**	-	-	-	-	-	-	-	-
GARCH variance	-	0.03***	-0.82	-0.05*	-0.01***	0.05***	-0.01	0.48**	-0.01
Cond. variance eq.:									
Constant	0.17***	0.05	7.75	0.11*	0.01***	15.04***	0.29	8.41	27.34***
ARCH(1)	-0.06**	0.06	0.10	0.30	-0.06***	0.55***	0.05	-0.06*	0.57***
GARCH(1)	0.37***	0.58***	0.26	0.16	-0.71***	-0.34***	-0.14	0.34	-0.23*
GED parameter	1.05***	1.09***	1.69***	1.19***	1.14***	3.58***	1.03***	1.24***	1.25***
Equation evaluation:									
\bar{R}^2	0.857	0.980	0.529	0.975	0.932	0.537	0.956	0.801	0.150
Log likelihood	-66.58	-44.07	-287.2	-62.04	144.3	-297.8	-73.44	-284.4	-333.9
SIC	1.566	1.153	5.664	1.483	-2.304	5.862	1.692	5.562	6.530
DW	1.61	2.19	2.09	1.78	2.03	2.25	1.93	2.08	2.63

Notes: π_t is year-on-year CPI inflation, s_t is local currency value of one euro, y_t is annualized growth rate of index of industrial output. Triple asterisk indicates 1%, double 5% and single 1% confidence level; \bar{R}^2 is adjusted R-squared; SIC is Schwartz information criterion; DW is Durbin-Watson statistics. Sample period: January 1999-January 2008.

Data Source: as in Table 1.

During the January 1999 – January 2008 period, a one-period transmission of MA residuals or positive shocks inflation has been very pronounced in the Czech Republic and somewhat weaker in the remaining two countries. The signs of the GARCH variance in the conditional mean equation suggest a diminishing pattern of exchange rate risk only in the case of Poland. In addition, the inflation GARCH variance (a proxy of time-varying inflation risk premium) is declining only in Poland, while it is inconclusive in the Czech Republic and insignificant in Hungary.

In the conditional variance equation, the negative ARCH(1) term for the Czech inflation suggests corrective or offsetting responses to the shocks to volatility in the previous period. The positive ARCH(1) terms for inflation in the remaining two countries would imply propagation of previous-period shocks, but the obtained estimates are not significant. The ARCH(1) term for the exchange rate is significant only in Poland, which is consistent with the pure float mechanism prevailing there. Its negative sign suggests corrective appreciation of previous-period local currency depreciation (or depreciation responding to a prior appreciation). The GARCH(1) terms for the Czech and Polish inflation series are positive, implying inter-period transmission of persistency in volatility. The same term is positive for the Czech and Hungarian exchange rates. It has a negative value for the Polish exchange rate series, implying reverse corrections to the persistency of volatility. It is worth noting that in all examined cases the sums of ARCH and GARCH coefficients do not exceed unity, suggesting an ongoing compression of volatility, or declining risk associated with the time-varying pattern of these variables. This is an important finding for their expected stability in the future and, therefore, for feasibility of application of a policy instrument rule that is based on these indicator variables. It shall be, however, noted that higher order ARMA and GARCH terms would likely yield more robust results, more suitable for forecasting purposes. Nevertheless, from the standpoint of examination of time-varying properties of individual variables their simplified treatment provides some useful information.

All examined input variables, except for the industrial output series in Poland, have statistically significant GED parameters lower than 2, indicating a leptokurtic distribution of their conditional volatility series. Thus evidently, inflation and exchange rate variations in all three countries tend to oscillate around their mean values at tranquil periods, but they experience excessive volatility during more turbulent times of financial instability. For practical reasons, it is prudent to account for leptokurtic data distribution of the variables included in various specifications of Taylor rule functions in order to disqualify a valid criticism of these rules

expressed by Svensson (2003). According to his argument, Taylor rules may be implausible to implement and may misguide policy-makers during periods of financial turbulence, due to the prevalent leptokurtic distribution of data for the variables included in these functions.

In sum, the degree of stability of the examined input variables in the three euro-candidate countries is not uniform, which can be attributed to systemic differences in their specific inflation targeting and exchange rate regimes. Nonetheless, the analysis of their ARMA series with time-varying conditional volatility suggests that these variables are becoming increasingly stable over time, which increases chances for a judicious implementation of the prescribed instrument rule in these countries at the current stage of monetary convergence that precedes the required entry to the ERM2.

V. Empirical Tests of Open-Economy Convergence-Consistent Instrument Rule

In order to make the policy instrument rule more conducive to the current inflation-targeting policies preceding the ERM2 entry, the functional relationship prescribed by Eq.(4) can be modified into

$$i_t = \beta_0 + \beta_1 \pi_{t+\tau} + \beta_2 \tilde{\pi}_{t+\tau} + \beta_3 (y_{t+\tau} - \tilde{y}_{t+\tau}) + \beta_4 (s_{t+\tau} - \tilde{s}_{t+\tau}) + \mu_t \quad (6)$$

Such specification reflects stationary first-differenced changes in the central bank reference interest rate as a function of: the long-term, or Wicksellian-neutral real interest rate β_0 equal to $\hat{r}_t + \pi_{t+\tau}$, the predicted or observed inflation rate with the displacement parameter τ , the smoothed and forwarded inflation rate $\tilde{\pi}_{t+\tau}$ as a proxy of a stable inflation target, deviation between the observed and the smoothed growth rate of the index of industrial output, and the difference between the actual and the smoothed (or ‘targeted’) exchange rate⁵.

The sample period for empirical testing of Eq.(6) remains to be January 1999-January 2008. The individual displacement parameters τ have been determined on the basis of the

⁵ Preliminary tests have also included as a regressor a binary variable denoting one for the period following the May 2004 EU accession and zero before, as well as the interaction variable between this binary and the change in CPI inflation. These modifications have been insignificant in all examined cases. Evidently, the instrument rule has not been altered since these countries joined the EU.

functional form of Eq.(6) for each tested case reaching a minimum Schwartz information criterion. The results of the selected empirical tests are shown in Table 3.

Table 3: OLS estimation of instrument rule Eq.(6)

Dependent variable: change in the central bank reference interest rate

	Czech Republic	Poland	Hungary
Constant term	-0.005 (-0.31)	0.010 (0.16)	-0.044 (-0.77)
$\pi_{t+\tau}$	$\tau = 0$; 0.063 (1.89)**	$\tau = -1$; 0.363 (3.97)***	$\tau = -1$; 0.160 (1.66)*
$\tilde{\pi}_{t+\tau}$	$\tau = 1$; 1.194 (5.21)***	$\tau = 0$; 0.780 (1.32)	$\tau = 0$; 0.632 (1.27)
$\dot{y}_{t+\tau}$	$\tau = 2$; -0.008 (-2.82)***	$\tau = 2$; -0.009 (-0.95)	$\tau = 2$; 0.006 (0.96)
$\dot{s}_{t+\tau}$	$\tau = 0$; 1.728 (1.51)	$\tau = 0$; 1.238 (0.48)	$\tau = 0$; 11.927 (3.38)***
\bar{R}^2	0.290	0.160	0.112
Log likelihood	56.30	-63.73	-81.05
SIC	-0.859	1.423	1.749
DW	1.855	1.906	1.700
<i>Forecast eval.</i>			
Theil U coeff.	0.081	0.213	0.082
Bias prop.	0.015	0.450	0.005
Variance prop.	0.084	0.374	0.019
Covariance pr.	0.901	0.175	0.976

Notes: all variables are in first differences; January 1999-January 2008 sample period; $\pi_{t+\tau}$ is year-on-year CPI inflation with τ lag operator (displacement); $\tilde{\pi}_{t+\tau}$ is HP-filtered CPI inflation; $\dot{y}_{t+\tau}$ is one-year growth rate industrial output minus HP-filtered growth rate of industrial output; $\dot{s}_{t+\tau}$ is log of actual exchange rate minus HP-filtered log of exchange rate in local currency per EUR; t-statistics are in parentheses; triple asterisk indicates 1%, double 5% and single 1% confidence level; \bar{R}^2 is adjusted R-squared; SIC is Schwartz information criterion; DW is Durbin-Watson statistics.

Data Source: as in Table 1.

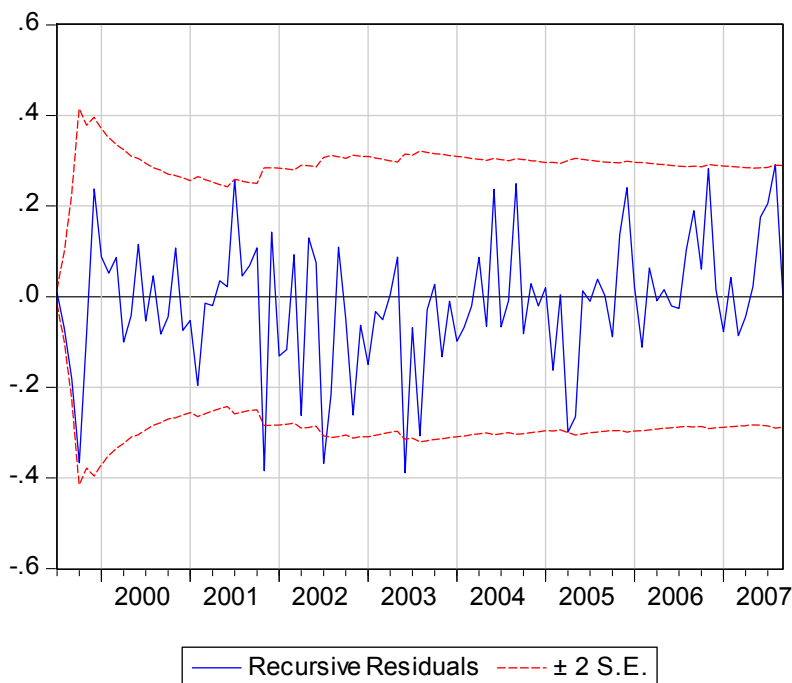
The empirical tests imply that adjustments in the Czech central bank reference interest rate are driven predominantly by the change in the (HP-filtered) inflation forecast for at least one-period ahead. The CNB seems also prone to reduce the reference rate in response to the expected widening of the output gap, at least for the two-periods ahead. It does not react to the current or to the expected path of the exchange rate, which suggests that the CNB allows the Koruna to float freely, in spite of the 'de jure' declaration of the managed float.

The main driver of changes in the Polish central bank reference rate is the inflation rate observed in the previous period. The forwarded inflation path, the output gap and the exchange rate variables are all insignificant. It can be therefore argued that the NBP interest rate decisions react mainly to recently observed changes in inflation and that the policy is consistent with the officially declared clean-floating exchange rate regime.

In contrast to the implementation of inflation targeting policies in the Czech Republic and Poland, the Hungarian monetary policy is geared predominantly toward exchange rate stability. Recently observed changes in inflation play a secondary role, while the forward-looking inflation path and the output gap seem unrelated to the NBH interest rate decisions.

The estimates shown in Table 3 may serve as a basis for predicting future adjustments in central bank reference rates. The indicators of forecast accuracy and reliability reflect consistency and predictability of monetary policy implementation. As indicated by the low values of the Theil-U coefficients, the forecasts based on the examined instrument rule are accurate both in the Czech Republic and in Hungary. In addition, these two forecasts are highly reliable since the sum of the bias and the variance proportion coefficients is very small in relation to the covariance proportion. This is not the case for Poland. The forecast based on its reference rate is less accurate due to the higher Theil-U coefficient, and highly unreliable due to the low covariance proportion. Thus arguably, adjustments in the NBP reference rate have not followed a pattern consistent with the instrument rule prescribed by Eq.(6). In contrast, consistency of interest rate policy is proven to be the case in the Czech Republic and in Hungary whose forecasts are accurate and reliable. Nevertheless, the CNB and the NBH monetary policies follow a different set of preferences, as discussed above.

Figure 1a: Recursive residuals test for OLS regression shown in Table 3 – The Czech Republic



The inconsistency of Poland's monetary policy with the examined instrument rule prevailed mainly during the first four years of the analyzed sample period, i.e. from 1999 until 2002, as shown by the recursive residuals in Figure 1b. Since 2003, the dispersion of the residuals obtained from the functional relationship examined in Table 3 has been considerably tamed. The plus-minus two standard error band has been narrowing since then, suggesting that the instrument rule is now followed by the NBP more closely than before. The dispersion of residuals in Poland is now comparable to that of the Czech Republic (Figure 1a). The time-varying path of the residuals in Hungary (Figure 1c) shows a major turbulence in 2003, which is presumably associated with the elevated political risk and market instability during the period preceding the stormy Parliamentary election accompanied by the deterioration of fiscal discipline (Darvas and Szapáry, 2008).

Figure 1b: Recursive residuals test for OLS regression shown in Table 3 – Poland

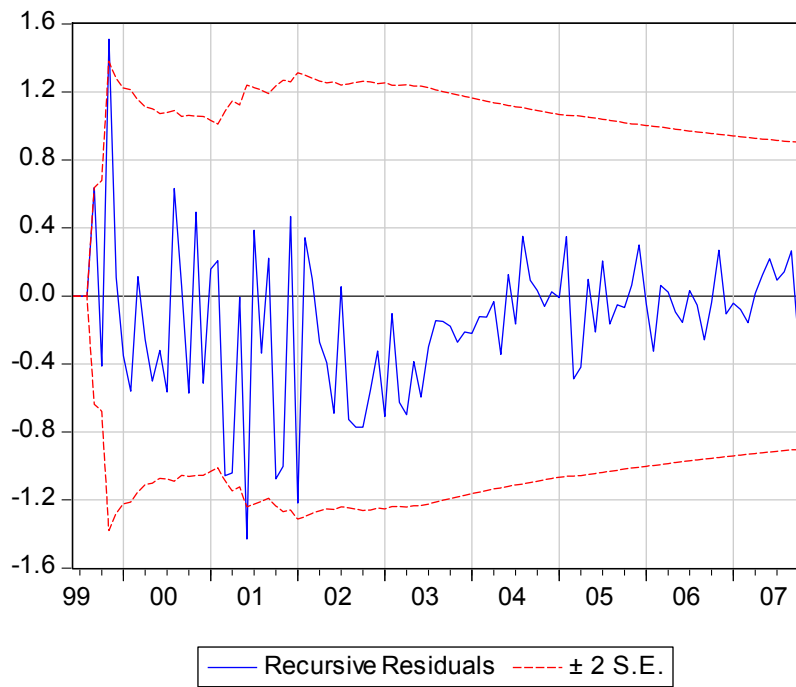
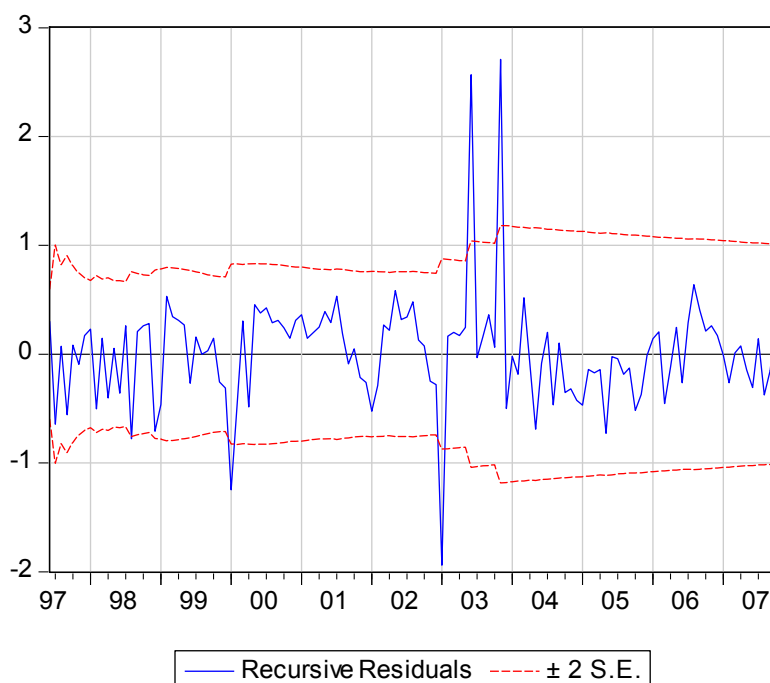


Figure 1c: Recursive residuals test for OLS regression shown in Table 3 – Hungary



Data source: as in Table 1.

VI. A Synopsis and Policy Recommendations

Devising a monetary policy instrument rule for open-economies undergoing convergence to a common currency system whose monetary policies are based on inflation targeting is a complex task. A simple instrument rule in its original form advanced by Taylor (1993) does not adequately reflect hybrid, at times exclusive and contradicting policy objectives for these economies that include: price stability, exchange rate stability, convergence to the common currency area interest rates and, in general terms, integration with global financial markets (Jonas and Mishkin, 2005; Orlowski, 2005 and 2008). This study proposes several parsimonious models of policy instrument rules that seem conducive to the conditions of converging economies. Among them are an open-economy instant target interest rate rule

and a market-forecast rule. For the EU Member States undergoing convergence to the euro, a more complex a projected interest-rate rule that is consistent with the Maastricht convergence criteria is a viable policy option, particularly upon the entry to the ERM2. However, its implementation might be difficult to achieve, due to the assumption of several policy objectives that might be exclusive, particularly in the presence of global financial instability.

In consistency with the proposed instrument rules conducive to convergence to the euro, further modifications of current monetary policies of the Czech Republic, Poland and Hungary seem to be necessary. Due to systemic differences between these inflation targeting policies, there is no uniform policy prescription. However, some general guidelines can be specified based on the proposed models for instrument rules. In particular, monetary policies of the euro candidates ought to be forward-looking, geared toward balancing low inflation and exchange rate stability objectives.

The empirical tests of the policy rule prescribed by Eq.(6) imply that the CNB policy is the closest to our assumptions and recommendations. The policies of the NBP and the NBH ought to be modified for the purpose of pursuing monetary convergence to the euro more effectively. In particular, the NBP will be well-advised to focus on forward-looking inflation expectations with a gradually increasing attention to the exchange rate stability. In contrast, the weighting of the NBH policy decisions ought to be shifted toward price stability and forward-looking inflation expectations. In all three cases, the leptokurtic distribution of almost all variables included in our model implies that a policy instrument rule might be very difficult to implement in the presence of global financial market instability and elevated market risk. For these reasons, some flexibility in adherence to the Maastricht convergence criteria should be allowed.

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