MONETARY POLICY RULE IN EMERGING EUROPE: A DISCRETE CHOICE APPROACH

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I. *Introduction*

This paper empirically assesses monetary policy rule in a set of emerging Europe inflation targeters, examining in particular a role of exchange rate, and explores operational behavior of central bank in setting its target rate. Methodology used is a nonstationary discrete choice approach of Hu and Phillips (2004a, 2004b).
Opting for a discrete choice model enables one to capture stylized facts that central bank changes its target rate in discrete fashion both in time, i.e. at its meetings that take place monthly or so, and in magnitude i.e. as multiples of 0.25%. Within the framework adopted in this paper one can jointly estimate monetary policy rule and determine the timing of changes in policy interest rate.

Thus the approach taken in this paper, i.e. discrete changes in policy interest rate differs from commonly used one in previous studies, including those for emerging market economies (e.g. Mohanty and Klau, 2004, and Aizenman et al., 2008), where monetary policy rule is assessed while assuming that central bank continuously alters its policy rate with variations of relevant economic fundamentals. The sample used includes all five emerging European economies that adopted inflation targeting: Czech Republic, Poland, Hungary, Romania and Serbia. Being at different stage in transition process these inflation targeters may exhibit different patterns, and we shall explore that while comparing these economies to developed and developing ones. The role of the exchange rate as an instrument to achieve inflation target vs. being a goal for itself above and beyond its impact on inflation will be particularly examined.

II. *A Model of Central Bank Behavior*

1. Monetary policy rule: Central bank's contingency plan

As to the monetary regime country has choice either of 'permanent' fixing of its exchange rate or the trinity encompassing flexible exchange rate, inflation targeting and monetary policy rule (cf. Taylor, 2002).

Inflation target is a rate around which actual rate should fluctuate. In order to achieve the latter, central bank adjusts its instrument – policy interest rate. Monetary policy rule is a contingency plan that determines how central bank sets policy interest rate in order to keep actual inflation around the targeted one. It is this interest rate reaction function, i.e. monetary policy rule that we want to estimate.

There is a time lag between changes in a policy interest rate and its impact on inflation and hence effectively it is future inflation that is targeted (see Svensson, 2010, and Mohanty and Klau, 2004). A stylized description of an interest rate setting committee operation is that it convenes, discusses and revises its inflation forecast, and consequently changes interest rate today to achieve desired future inflation. Therefore it is future actual inflation that is aimed to be close to the targeted one. The above implies that monetary policy rule – interest rate reaction function, is in fact forecasting function that predicts future inflation.

Standard fundamental economic variables that enter interest rate reaction function in an open economy (cf. Taylor, 2001) are inflation rate (π), output gap (y), but also real exchange rate (e) to capture open economy effect:

$$i_t^* = d_1\pi_t + d_2 y_t + d_3 e_t + d_4 e_{t-1} + d_5 i_{t-1} \qquad (1)$$

i_t^* is optimal interest rate, i.e. the one that central bank would choose to achieve its goal, while i is actual policy rate. More lags of the variables entering monetary policy rule (1) could be added.

Inflation and output gap are fundamental variables that almost always appear in central bank monetary policy rule, i.e. its contingency plan, and both higher inflation and increasing output gap invoke central bank to raise its policy interest rate, i.e. $d_2>0$ and $d_3>0$.

There are two broad reasons for the exchange rate to enter monetary policy rule. Firstly, the exchange rate is used for inflation targeting, i.e. central bank manipulates it to influence inflation and hence to achieve an inflation objective. However, the exchange rate may also appear in monetary policy rule as a separate goal above and beyond the inflation target.

Lagged policy interest rate (i_{t-1}) in monetary policy rule (1) captures central bank attitude to smooth interest rate changes, i.e. to move in small steps, usually 0.25%, in same direction. The rational for this central bank behavior is multifold. Firstly, in that way central bank influences expectations of market participants that the changes will carry on for some time and thus affects the long-term interest rate. Additional rational is that gradual changes diminish risks of policy mistake that could emerge either due to uncertainty about model parameters or having to decide upon partial information. Moreover, moving in small steps helps central bank to avoid reputation risks that might come from sudden reversals of interest rate. Lastly, large and abrupt changes may hurt financial system as it has limited capacity to hedge interest rate risk.

There is some empirical evidence that central banks smooth interest rate changes. Thus FED in 2001 took ten decisions in row to lower interest rate, and later from June 2004 onwards in the two years it undertook 17 consecutive increases of its policy rate. Five emerging Europe central banks we are looking at also smooth exchange rate changes, as shown in Fig. 1-5 below.

Interest rate reaction function may also include non-fundamental variables that nevertheless forecast well (leading indicators) inflation and/or output.

2. Empirical model

Monetary policy rule (1) discussed above determines central bank's optimal/true policy rate i_t* that varies continuously with the variables affecting it. Specifically, it is the rate that interest rate setting committee has in mind while observing economic determinants it considers relevant. However the committee acts in discrete fashion, i.e. it adjusts policy rate i_t at its monthly or so meetings, and even then only when optimal rate (i_t*) surpasses certain threshold. What one observes therefore is actual policy rate i_t but not the optimal/true one i_t*, and we want to recover the latter, i.e. to estimate the 'true' underlying monetary policy rule.

Discrete dependent variable model can be used to estimate the underlying monetary policy rule (cf. Hu and Phillips, 2004a, 2004b). Let us define the following model for monetary policy decisions on the target rate:

$$y_t^* = \beta' X_t - \varepsilon_t \text{ , for t= 1,…, T} \quad (2)$$

$$y_t^* = i_t^* - i_{t-1} \text{ .} \quad (3)$$

where i_t^* is the optimal/true but unobservable optimal target rate and X_t is a vector of exogenous explanatory variables such as those in eq. (1), which may be also nonstationary, specifically *I(0), I(d)* or *I(1)* processes or a mixture of these (cf. Park and Phillips, 2001, and Phillips and Hu, 2007). The latent variable y_t* in (3) measures deviation between the underlying optimal target rate i_t^* and the rate that was set in the previous meeting. Both i_t^* and y_t* are unobservable.

Therefore, what is used is the following triple-choice specification for our discrete choice model:

$$\begin{aligned} y_t &= -1 \text{ if } -\infty < y_t^* < \mu_1 \\ y_t &= 0 \text{ if } \mu_1 \leq y_t^* \leq \mu_2 \\ y_t &= 1 \text{ if } y_t^* > \mu_2 \end{aligned} \quad (3a)$$

where μ_1 and μ_2 are unknown threshold parameters, which may be sample size (T) dependent when covariates X_t are integrated time series. Thus, starting from the last line, the model states that if optimal rate i_t^* is well above the ruling policy rate i_{t-1}, i.e. the difference between the two (y_t^*) is larger than a threshold value (μ_2), central bank will increase its policy rate i_t. If the gap between the two rates is modest, i.e. y_t^* falls within μ_1 and μ_2 interval, central bank will not act, and finally when optimal rate is well below actual rate, i.e. $y_t^* < \mu_1$, the policy rate will be decreased.

Thus we have triple choice specification for our ordered probit model where dependent variable y_t takes values -1, 0 and 1, when we observe that central bank has decreased, left unchanged or increased respectively its policy rate. Let us add that this triple-choice specification could be extended to allow five choices, hence allowing for a finer cut, and we shall pursue this as well.

Once the coefficients β are estimated one can get linear index function:

$$\hat{y}_t^* = \hat{\beta}' X_t \qquad (2a)$$

Moreover as

$$y_t^* = i_t^* - i_{t-1}$$

one gets estimate of monetary policy rule as:

$$\hat{i}_t^* = \hat{\beta}' X_t + i_{t-1} \qquad (4)$$

Jointly with estimating coefficients β and ultimately monetary policy rule, this discrete choice model gives estimates of threshold parameters μ_1 and μ_2. Statistical significance of these parameters would support assumption that central bank adjust policy rate in a discrete fashion i.e. only after its optimal/true but unobservable rate (i^*) exceeds certain threshold. This implies furthermore that one should estimate monetary policy rule by employing true although unobservable policy rate, and not the actual one.

III. *Estimates of monetary policy rule*

Monetary policy rule is estimated for all five emerging European economies that target inflation: Czech Republic, Poland, Hungary, Romania and Serbia. Standard fundamental economic determinants as suggested by eq. (1) are used as explanatory variables. Since these central banks take decision approximately at monthly frequency[1], we use monthly data lagged one period i.e. the latest available information when decision is taken. Sample for each country skips approximately first two years of inflation targeting i.e. the transition period that might be somewhat erratic.

Estimation results of the whole model are reported in Table 1, i.e. estimates of parameters in monetary rule equation β, as well as threshold coefficients μ_1 and μ_2. Table 1 also reports respective sample size, and more importantly the number of policy rate changes (decrease or increase) within the sample. The larger proportion of rate changes in the sample allows better estimate of the model.

[1] The exceptions are National Banks of Czech Republic and Romania. The Board of the Romanian National Bank gathers eight times a year. Through the end of 2007, the Bank Board of the Czech National Bank met once a month to discuss monetary issues, but subsequently has adopted a new system of eight prescheduled meetings a year.

Table1

	Czech Republic 1999:6-2011:9	Poland 2000:1-2011:9	Hungary 2003:1-2011:9	Romania (1) 2007:1-2011:9	Romania (2) 2007:1-2011:9	Serbia (1) 2008:1-2011:12	Serbia (2) 2008:1-2011:12
inflation_gap(-1)						0.393998 (4.334)***	0.510825 (4.833)***
inflation(-1)	0.2133270 (2.388)**	0.3219 (4.224)***		0.225018 (1.757)*	0.241611 (1.937)**		
gdp_gap(-1)	0.2924390 (2.412)**	0.401843 (3.869)***	0.3705340 (4.563)***	0.385209 (2.878)***	0.420360 (3.534)***		
ir(-1)	-0.280305 (-3.646)***	-0.166845 (-4.821)***		-0.3382270 (-2.117)**	-0.4617830 (-3.592)***		
M2_gap(-1)						0.17956 (3.170)***	
M2r_gap(-1)							0.20767 (3.653)***
exr_evro_gap(-1)	0.160540 (3.872)***		0.0974540 (3.762)***			0.2063 (3.617)***	0.2101 (3.650)***
exr_evro_gap(-2)		0.03058 (1.532)		0.051316 (1.773)*			
exr_evro_gap(-3)				-0.07475 (-2.002)**			
Δexr(-2))					0.07629 (2.386)**		
μ_{1n}	-1.41544 (-5.664)***	-1.526110 (-5.386)***	-0.632753 (-4.240)***	-2.7492990 (-1.698)*	-3.5582550 (-2.360)**	-0.56519 (-2.507)***	-0.51513 (-2.290)**
μ_{2n}	1.42480 (5.630)***	1.07035 (4.802)***	1.366477 (7.626)***	0.7401930 (0.432)	-0.117860 (-0.081)	1.32606 (5.085)***	1.47435 (5.237)***
Wald test (μ_1=μ_2) (prob)	0.020679 (0.9835)	-1.02229 (0.3085)	3.1591 (0.0021)			2.11276 (0.0405)	2.56465 (0.0139)
Observations	147	139	105	54	54	48	48
decrease	24	31	32	11	11	16	16
no change	112	93	59	36	36	19	19
increase	11	15	14	7	7	13	13
AIC	186.6575	197.6434	175.028	72.55552	70.24773	77.52880	74.73271
log. likelihood	-87.32875	-92.82172	-83.514	-29.27776	-29.12386	-33.7644	-31.95415
pseudo R^2	0.147776	0.208585	0.166867	0.369017	0.372334	0.35277	0.379569
df	6	6	4	7	6	5	5

Almost common pattern emerges among emerging Europe inflation targeters. Inflation enters significantly and with the positive sign in all interest rate reaction functions except Hungarian one. Thus the rise in inflation in a month prior to central bank committee meeting increases the probability that the policy rate will be raised. Output gap, as expected, has significant and positive impact on policy rate in all countries but Serbia. Nevertheless, in Serbia an impact of economic activity is captured with broad money supply (M2) gap, either nominal or real. Significantly positive coefficient on both nominal and real money supply gap, indicates that when broad money supply rises above its trend the probability of policy rate increase also rises. Money supply above its trend indicates that economic activity, e.g. output, is also above its trend.

Exchange rate is not a standard candidate for monetary policy rule equation, but nevertheless it significantly entered in all estimated equations for emerging Europe inflation targeters. Real exchange rate gap is used, where positive value implies that the considered currency is undervalued compared to the Euro. Thus when currency depreciates and hence this gap increases, one might expect that central bank would raise its policy rate to offset undervaluation of the currency and consequent impact on inflation via exchange rate pass-through and/or increased demand for domestic goods.

The above is validated by significant and positive coefficients on real exchange rate gap for Czech Republic, Hungary, Serbia and Poland (at 12.5% level, but at 5% in five choice model below). Romania exhibits somewhat different pattern, where real depreciation first raises the probability of policy rate increase (positive coefficient) only to offset it in next period (roughly the same but negative coefficient). Testing confirms that the sum of these two coefficients is not significantly different from zero (Wald test of coefficient restrictions t=-0.98 (prob. 0.33)), hence implying that the rate of change of real exchange rate should enter monetary policy rule equation. Additional estimation does confirm that change in real exchange rate significantly enters monetary policy rule in Romania with, as expected, positive coefficient. This implies that only accelerated real depreciation or appreciation affects policy decision on interest rate, while the constant rate of change does not trigger shifts in policy rate. Let us note that the real exchange rate gap suggests the similar pattern, i.e. policy rate changes only when real exchange rate appreciates/depreciates faster than envisaged by its (HP) trend.

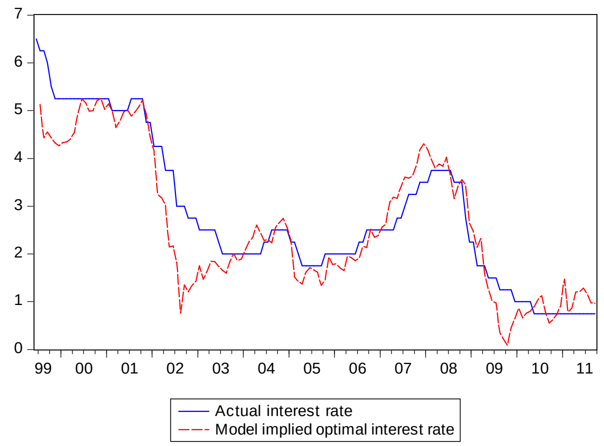
Finally, all five central banks smooth changes in its policy rate, i.e. lagged interest rate appears with a positive coefficient in each estimated monetary policy rule equation (4). In the case of Czech Republic, Poland and Romania, lagged policy rate enters significantly in estimated linear index function y_t* (cf. eq. 2a above) albeit with negative sign (see Table 1). Nevertheless, while switching from $y*$ to monetary policy rule equation i_t* one should add lagged policy rate i_{t-1} to the RHS of y_t* (cf. eq 4). Hence estimated coefficient on lagged policy rate e.g. in Czech Republic is (1 – 0.298) = 0.7, i.e. positive suggesting that the increase in policy rate in previous period raises probability that it will be also increased in the current period. The same applies to corresponding estimates for Poland and Romania. In the case of Hungary and Serbia, lagged policy rate i_{t-1} does not enter significantly in linear index function y_t* and consequently it appears in monetary policy rule equation i_t* (4) with positive coefficient equal to 1. Let us stress however that the estimated coefficients in the probit model indicate just the direction and not the size of explanatory variable's impact.

Movements of actual policy rate in five considered countries, depicted in Figure 1 below, exhibit strong inertia thus supporting our finding that changes in lagged interest rate affects the current rate in the same direction.

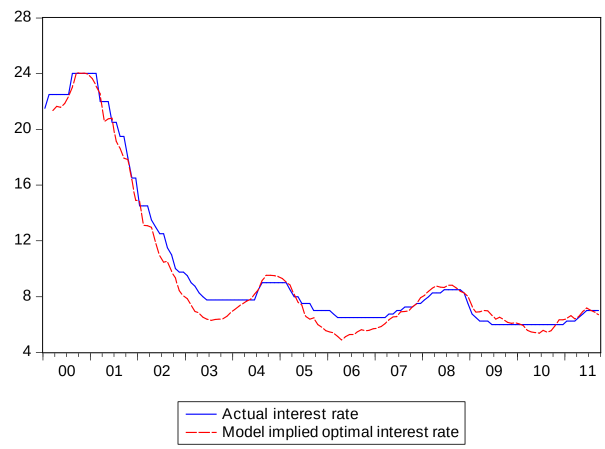
Figure 1

Actual policy rate and model implied optimal rate in five emerging European economies

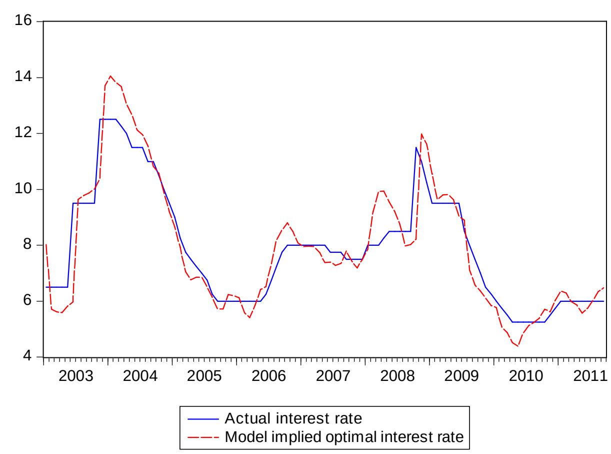
Czech Republic (period 1999:6-2011:9)



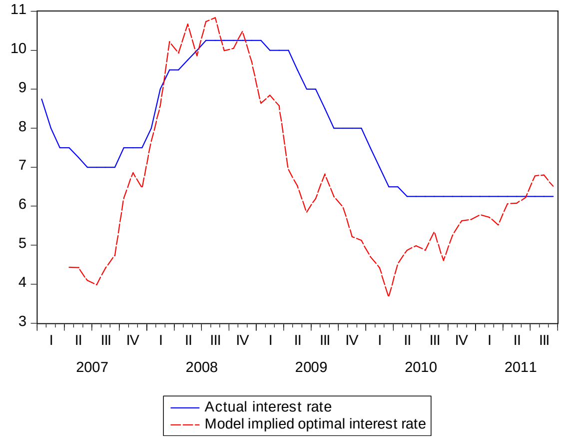
Poland (period: 2000:1-2011:9)



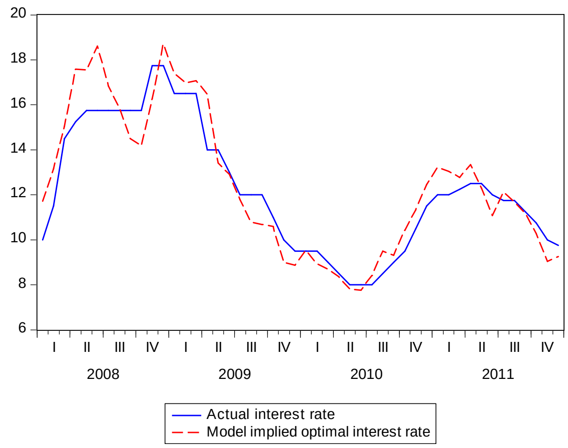
Hungary (period: 2003:1-2011:9)



Romania (period: 2007:1–2011:9)



Serbia (period: 2008:1-2011:12)



Finally, only fundamental economic variables enter interest reaction function in all five cases, i.e. no need for additional economic or financial (leading) indicators.

IV. *Central bank's operational procedure: Empirical assessment*

1. Cut-off points

As explained above, it is assumed that central bank discriminates between true, optimal policy rate and the actual one, where the latter changes only when the former exceeds certain thresholds. Thus finding statistically significant cut-off points would lend important support for the presumed behavior of central bank.

In four cases, i.e. all except Romania, significant threshold values μ_1 and μ_2 are found (see Table 1). Thus e.g. in Czech Republic, cut-off point for a rate cut is -1.41, meaning that the rate cut will occur when optimal rate (i_t*) becomes lower than the ruling/current policy rate (i_{t-1}) by more than 1.41 percentage points, i.e. $| i_t^* - i_{t-1}| > 1.41$pp. Similarly the rate hike would occur if optimal rate exceeds actual one by 1.42pp. Comparable cut-off points are found for Poland, also (-1.53pp and 1.07pp). Upon testing it is obtained both in Czech R. and Poland that the (absolute value of) lower and upper bound are not significantly different (cf. Wald test in Table 1), implying that respective central banks behaves symmetrically when deciding about rate cuts and hikes. However, in the case of Hungary and Serbia, same test suggests that the respective central banks act asymmetrically (Table 1).Thus they are opting easier for rate cut, than for rate hike. Namely estimated lower bounds in Hungary and Serbia: -0.63pp and -0.52pp respectively, are significantly below (in absolute terms) those for a rate hike: 1.37pp and 1.47pp respectively.

2. How well does the model predict?: Relation between optimal and actual policy rate

In order to assess further estimated model one can confront model's predictions with actual decisions. Results for all five countries are summarized in Table 2.

Table 2

Actual and model predicted policy rate changes in five emerging European economies

Czech Republic		Actual decisions			**Romania (2)**		Actual decisions		
		Rate cut	No change	Rate hike			Rate cut	No change	Rate hike
Model	Rate cut	4	0	0	Model	Rate cut	7	5	0
predicted	No change	20	107	11	predicted	No change	4	30	3
	Rate hike	0	5	0		Rate hike	0	1	4
Poland		Actual decisions			**Serbia (1)**		Actual decisions		
		Rate cut	No change	Rate hike			Rate cut	No change	Rate hike
Model	Rate cut	18	4	0	Model	Rate cut	12	3	0
predicted	No change	13	87	15	predicted	No change	4	13	6
	Rate hike	0	2	0		Rate hike	0	3	7
Hungary		Actual decisions			**Serbia (2)**		Actual decisions		
		Rate cut	No change	Rate hike			Rate cut	No change	Rate hike
Model	Rate cut	18	0	0	Model	Rate cut	11	3	0
predicted	No change	14	51	12	predicted	No change	5	13	5
	Rate hike	0	8	2		Rate hike	0	3	8

Note: Elements on main diagonal give the number of model hits.

Table 3

Correct model predictions: Summary

	Czech Rep.	Poland	Hungary	Romania (2)	Serbia (2)
% of all decisions	75.51%	75.54%	67.62%	75.93%	66.67%
% of rate changes	11.43%	39.13%	43.48%	61.11%	65.52%

As seen from tables 2 and 3, estimated model predicts very well when all three decisions: rate cut, no change and rate hike, are considered, i.e. around 70% of these decisions are predicted correctly. Nevertheless, when one focuses on predicting changes in policy rate, performance of the model varies widely: from outstanding share: 66% of correct predictions in case of Serbia to the very poor 11% hits in Czech R. These divergences in predictive power does not necessarily question the model, but rather can be traced to differences in the samples used. In the case of balanced sample where the share of rate changes in all decisions is large (60% in Serbia), estimated model can predict changes well, as opposed to unbalanced sample case with minor share of rate changes in all decisions (24% in Czech R.).

Comparing optimal rate i_t*, obtained from the estimated monetary policy rule (4), with actual policy rate (Figures 1), shows that the former tracks well the latter, including observed actual rate inertia. Moreover, optimal rate in most cases exhibit larger variations than the actual rate as shown by reported standard deviations, and the former leads the latter, which is demonstrated by Granger causality testing (see Table 4). These results further validate the central bank model used in this paper, as the model implies both features above. Namely, higher variability of optimal policy rate than actual one, follows from the model assumption that optimal rate varies continuously while the actual one changes only after optimal rate surpasses certain threshold. The latter component of the model also suggests that optimal rate changes first while actual rate only follows, i.e. that the former leads the latter.

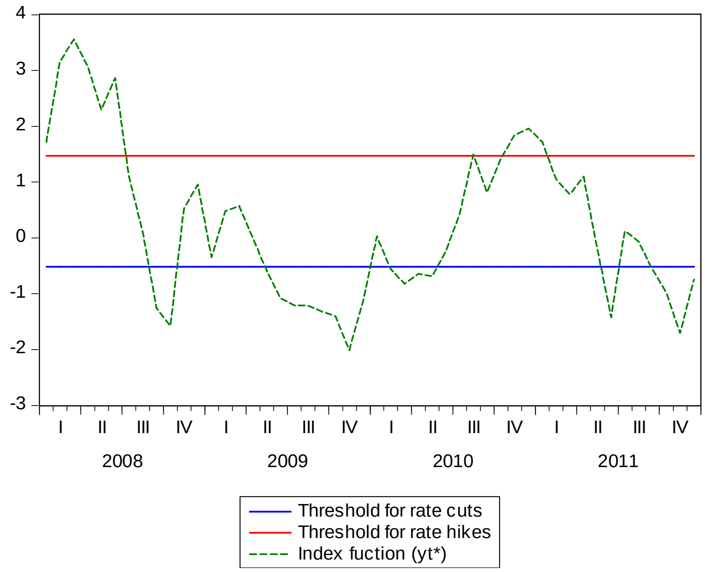
Table 4

		standard deviation		Granger causality testing		
Country	period	i_t	i_t*	F-Stat.	Prob.	Ho: optimal rate (i_t*) does not Granger Cause actual rate (i_t)
Czech Rep.	99:6-11:9	1.51	1.46	5.39	0.0056	rejected
Poland	00:1-11:9	5.48	5.41	13.53	0.0000	rejected

Hungary	03:1-11:9	2.00	2.31	2.43	0.0534	rejected
Romania (2)	07:1-11:9	1.55	2.07	4.21	0.0039	rejected
Serbia (2)	08:1-11:12	2.82	3.18	2.73	0.0367	rejected

We also report estimate of linear index function $\hat{y}_t^*$ (cf. 2a) in Figure 2 for Serbia (2) only, as broadly same features have the other four index functions.

Figure 2



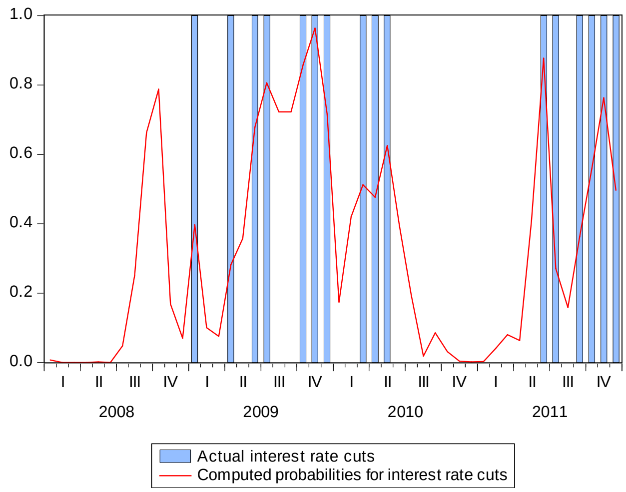
3. Performance of the model estimated with balanced sample: Further assessments

We further appraise performances of the central bank model put-forward in this paper by examining its estimate based on ‘proper’, i.e. balanced sample. The performance of the model, good or bad, could be then attributed mostly to its own features. The sample for Serbia is the case in point with, as reported above, large 60% share of rate changes in all decisions.

Good model of central bank behavior is expected to predict properly policy rate changes, which is more challenging than forecasting no change event. Additional facet of the model used in this paper is that it can give the probability of policy rate cut and hike respectively over the sample used for its estimation. Thus if estimated model delivers e.g. high probabilities of rate cuts when cuts actually occurred, and same for the hikes, the quality of the model is further validated. The corresponding results are reported in Figures 3 and 4

Figure 3

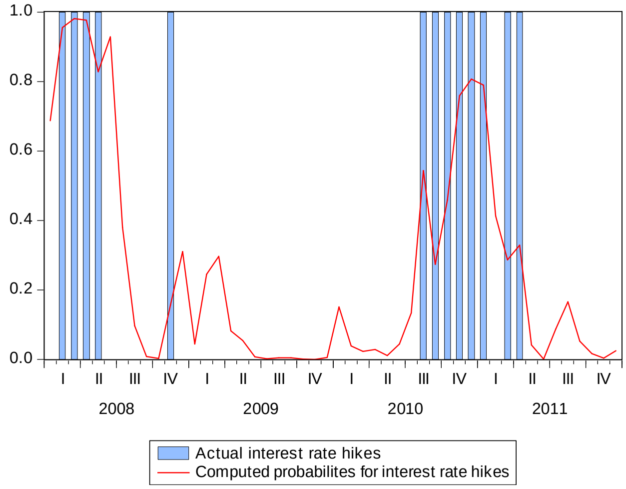
Model's probabilities of rate cuts and actual cuts



While predicting rate cuts, the estimated model performs outstandingly (see Figure 3). Namely, in most instances when actual rate cuts occurs model attaches high probabilities of rate cut, i.e. through 2009 and beginning of 2010, and most of 2011. Likewise, very low probabilities are put-forward for rate cuts during the second half of 2010 and the first half of 2011, when no rate cuts are actually recorded. The estimated model clearly underperforms only for several months in the second half of 2008, and this could be attributed to the sharp reaction of the Serbian central bank to unforeseen outbreak of world financial crisis in September 2008. The central bank reaction was increase in policy rate in October 2008 to mitigate sudden stop in foreign capital inflows, and this policy turnaround is not, and could not be, captured by a model (see both Figure 3 and 4 Table 5 and 6).

Figure 4

Model's probabilities of rate hikes and actual cuts

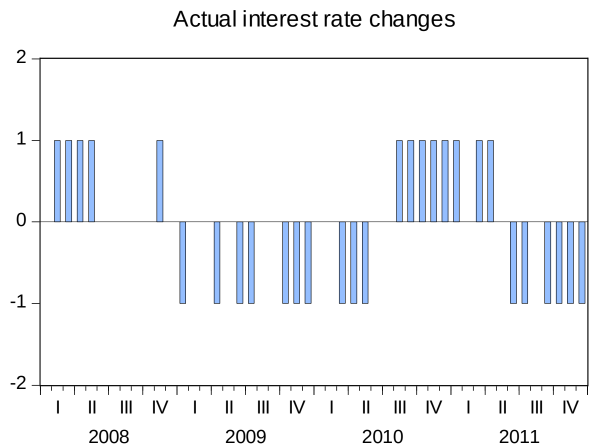


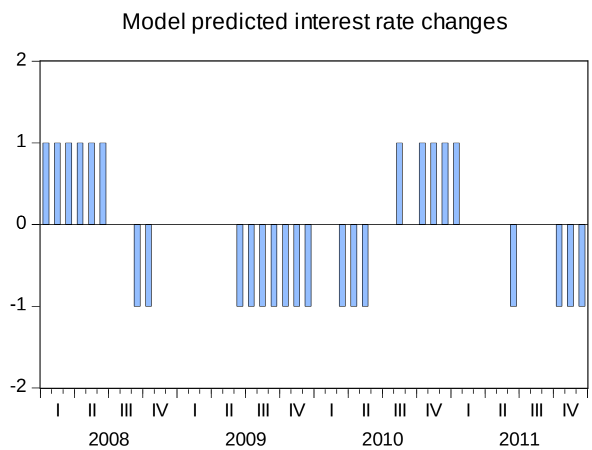
Again excellent performance of the estimated model this time delivering probabilities of policy rate hikes. Model is correct in advancing high probabilities of the rate hikes in the first half of 2008 as well as second half second half of 2010 and beginning of 2011, when all but one hike occurs.

Finally, Figure 5 confronts actual policy interest rate changes with model predictions, lending additional support for estimated model.

Figure 5

Actual changes and model predicted changes





In summary, the results above suggest that the proposed model of central bank behavior, consisting both of monetary policy rule and operational procedure for policy rate changes, fares very well, provided balanced, i.e. ‘proper’ sample is available.

4. Finer cut: Five way choice

Estimates of monetary policy rule for five choice model are essentially the same as those in triple choice model above, i.e. the identical sets of variables with corresponding signs significantly enter corresponding relation for each country (see Table 5). There is also one improvement, i.e. confirmation that real exchange rate gap enters significantly in monetary policy rule for Poland as well. Thus the same discussion as above for triple-choice model applies here while analyzing estimated interest rate reaction function.

Therefore we turn to operational behavior of central banks, i.e. examining now four cut-off points, as this is the main new attribute that the five choice model brings.

The observed dependent variable y now takes five values depending on the size of interest rate (i) change:

$y = -2$ if CB decides on big decrease of i, i.e. 0.5pp or more
$y = -1$ if CB decides on small decrease of i, i.e. 0.25pp
$y = 0$ if CB decides on no change
$y = 1$ if CB decides on small increase of i, i.e. 0.25pp
$y = 2$ if CB decides on big increase of i, i.e.0.5pp or more

Let us add that for Serbia small changes include 0.5pp, so that large changes are above 0.5pp, the reason being that there are very few 0.25pp changes in the Serbian sample.

Again we assume that central bank will change its policy rate (i) only when it significantly deviates from its optimal rate (i^*), while the size of the change in i depends on the magnitude of its deviation from optimal rate, i.e. $y_t^* = i_t^* - i_{t-1}$. Specifically

$y_t = -2$ if $-\infty < y_t^* < \mu_1$
$y_t = -1$ if $\mu_1 \leq y_t^* \leq \mu_2$
$y_t = 0$ if $\mu_2 \leq y_t^* \leq \mu_3$
$y_t = 1$ if $\mu_3 \leq y_t^* \leq \mu_4$
$y_t = 2$ if $y_t^* > \mu_4$

Thus, starting from the last line, the model states that if optimal rate i_t^* is hugely above the ruling policy rate i_{t-1}, i.e. the difference between the two (y_t^*) is larger than a threshold value (μ_4), central bank will opt for a big increase of its policy rate i_t, i.e. by 0.5pp or more, and likewise for remaining four cases.

Threshold value estimates reported in Table 5 once again the pattern already observed in in the triple choice problem above. In four cases, i.e. apart from Romania, cut-off points are significant, except that Czech R. recorded no big policy rate change and hence does not have large upper bound (μ_4). As previously found, the Polish and the Czech central bank behave symmetrically, while the Hungarian and the Serbian central banks are biased towards easier policy rate cuts. The above follows from the results of Wald test that examines whether the (absolute value) of corresponding cut-off points are equal ($\mu_1 = \mu_4$, and $\mu_2 = \mu_3$, see Table 5).

Table 5

	Czech Republic	Poland	Hungary	Romania (1)	Romania (2)	Serbia (1)	Serbia (2)
period	1999:6-2011:9	2000:1-2011:9	2003:1-2011:9	2007:1-2011:9	2007:1-2011:9	2008:1-2011:12	2008:1-2011:12
inflation_gap(-1)						0.385423	0.514764
						(4.643)***	(5.238)***
inflation(-1)	0.17291	0.326371		0.1867520	0.2097890		
	(2.014)**	(4.457)***		(1.532)	(1.806)*		
gdp_gap(-1)	0.28858	0.337982	0.3327250	0.3469720	0.3970430		
	(2.598)***	(3.526)***	(4.585)***	(2.707)***	(3.416)***		
ir(-1)	-0.26737	-0.168004		-0.3386950	-0.5194260		
	(-3.789)***	(-5.008)***		(-2.204)**	(-4.144)***		
M2_gap(-1)						0.189255	
						(3.989)***	
M2r_gap(-1)							0.224925
							(4.399)***
exr_evro_gap(-1)	0.155587		0.0922540			0.193092	0.195736
	(4.001)***		(3.350)***			(3.309)***	(3.337)***
exr_evro_gap(-2)		0.041805		0.0589540			
		(2.203)**		(2.079)**			
exr_evro_gap(-3)				-0.0957240			
				(-2.807)***			
Δexr(-2))					0.093214		
					(3.282)***		
μ_{1n}	-2.193125	-1.919	-1.142	-3.4859	-4.6449	-1.490441	-1.483628
	(-8.471)***	(-6.553)***	(-6.464)***	(-2.037)**	(-3.149)***	(-4.759)***	(-5.092)***
μ_{2n}	-1.47575	-1.525	-0.625	-2.9621	-4.1563	-0.578446	-0.507490
	(-6.265)***	(-5.285)***	(-4.330)***	(-1.763)*	(-2.854)***	(-2.588)***	(-2.220)**
μ_{3n}	1.33718	1.053	1.349	0.477615	-0.793460	1.31260	1.50136
	(5.601)***	(4.626)***	(7.703)***	(0.2902)	(-0.5784)	(5.050)***	(5.152)***
μ_{4n}	/	2.044	1.81598	0.939067	-0.315244	2.265862	2.512823
		(8.894)***	(7.170)***	(0.5672)	(-0.22317)	(5.935)***	(5.442)***
Wald test ($\mu_1=\mu_4$)		0.303955	2.334596			1.87795	2.21500
(prob)		(0.7616)	(0.0216)			(0.0675)	(0.0324)
Wald test ($\mu_2=\mu_3$)	-0.329188	-1.024678	3.224734			2.14942	2.68570
(prob)	(0.7425)	(0.3074)	(0.0017)			(0.0376)	(0.0104)
Observations	147	139	105	54	54	48	48
big decrease	8	20	18	7	7	7	7
small decrease	16	11	14	4	4	9	9
no change	112	93	59	36	36	19	18
small increase	11	12	7	3	3	7	7
big increase	/	3	7	4	4	6	6
AIC	220.9366	254.3288	244.7759	98.65089	97.50630	116.77380	111.95130
log. likelihood	-103.4683	-119.1644	-116.3879	-40.32545	-40.75315	-51.38688	-48.97566
pseudo R^2	0.1213	0.1779	0.11744	0.309388	0.302063	0.28733	0.320773
df	7	8	6	9	8	7	7

V. *The Role of the exchange rate in monetary policy rule: Empirical assessment*

Central bank may include the exchange rate in its monetary policy rule in order to pursue its main goal i.e. inflation targeting, implying that it cares about the exchange rate only to the extent that it affects aggregate demand and inflation rate. Nevertheless there are instances when central bank is concerned about the exchange rate above and beyond its impact on inflation and actively tries to influence its level.

As to the former the exchange rate enters monetary policy rule since it affects inflation and hence helps central bank to control the latter. The exchange rate influence goes through nominal and real exchange rate channel. For the nominal channel the size and speed of the nominal exchange rate pass-through into price level is decisive while determining whether central bank would intervene with its policy rate to prevent e.g. sharp currency depreciation to avert spill over into inflation. On the other hand, the real exchange rate affects future inflation via output, hence e.g. large real depreciation may increase output above the potential level and trigger inflation unless central bank reacts with interest rate hike. Finally, the exchange rate may enter monetary policy rule as a predictor of future inflation.

However central bank, particularly in emerging economies, might aim at stabilizing the real exchange rate as a separate policy target beyond an inflation one. There are several potential reasons to it. In a number of emerging economies liabilities of corporations, households and banks are highly dollarized/euroized, forcing central bank to manage the exchange in order to preclude financial instability. This currency mismatch upon major depreciation could lead to widespread bankruptcy and recession. Even more general, it is found (cf. Aghion et al., 2009) that countries with relatively less developed financial sectors are more prone to output losses associated with exchange rate volatility, hence motivation for central bank to curb its volatility. Exchange rate management also helps central bank to address the adverse consequences for external stability of either a large inflow of capital (e.g. in emerging Europe 2000 -2008) or a subsequent sudden stop (after 2008). In addition short history of low inflation in a number of emerging economies undermines the credibility of inflation targeting, so that prolonged currency depreciation quickly feeds into increasing inflation expectations. So in this case central bank is inclined to prevent larger depreciation, the phenomenon observed in emerging economies and known as ‘fear of floating’ (cf. Calvo and Reinhart, 2002).

We found above that real exchange rate enters significantly monetary policy rules in all five emerging Europe inflation targeters. Against the backdrop above we shall assess whether some pattern emerges related to the role of the exchange rate in interest rate reaction function of corresponding central banks.

We start by asking whether our finding implies that stabilization of real exchange rate appears as a separate policy target beyond an inflation one or the inclusion of exchange rate just helps to target inflation. A way to address this issue is to examine whether the exchange rate in interest rate reaction function is used solely to predict future inflation or it appears on its own (cf. Aizenman et al., 2008). The former implies that real exchange rate is a robust predictor of inflation, while the latter that it is not and the Granger causality test can be used to test this.

Table 6

The Granger causality test: Whether real exchange rate is robust predictor of inflation

Country	*order of VAR*	*F-Statistic*	*Prob.*	*Ho: real exchange rate gap does not Granger cause (predict) inflation*
Czech Republic	*2*	*3.42339*	*0.0354*	*rejected*
Poland	*4*	*2.34774*	*0.0579*	*rejected*
Hungary	*4*	*6.5996*	*0.0021*	*rejected*
Romania	*2*	*0.30001*	*0.7421*	*accepted*
Romania (Δe)	*2*	*0.25599*	*0.7752*	*accepted*
Serbia	*4*	*1.2548*	*0.3056*	*accepted*

In Czech R., Poland and Hungary real exchange rate Granger causes inflation, indicating that the former is a good predictor of the latter, while this not the case in Romania and Serbia (see Table 6).

This evidence suggests that in Romania and Serbia real exchange rate stabilization comes out as separate policy target beyond an inflation one, and that respective central banks actively try to influence the level of exchange rate. On the contrary, central bank in Czech R. and Poland seems to use real exchange rate to predict inflation, and that explains its appearance in interest rate setting equation. Hungary looks like a distinct case and we shall address it separately.

These results, i.e. active exchange rate policy stand in Serbia and Romania vs. the passive one in Czech R. and Poland seem to be supported by different features of these two sets of economies. Thus Serbia and Romania have recent history of relatively high inflation even during the 2000s that stretches up today, while the opposite is the case in Czech R. and Poland. Therefore one may argue that central banks in the former two countries controlled more closely the exchange rate in order to manage inflation expectations while this need not to be pursued in the low inflation Czech and Polish economies. Furthermore, the Serbian and to certain extend the Romanian economies are highly euroized particularly when compared with the Czech and Polish ones, forcing the former central banks to prevent large depreciation and the consequent adverse balance sheet effect in Serbia and Romania. Along the same line, one may argue that Serbia and Romania have relatively less developed financial sectors and hence are more prone to output losses associated with exchange rate volatility compared to Czech R. and Poland, which may be an additional rationale for the tighter management of the exchange rate in the former two countries. Finally, Serbia and Romania experienced large swings in foreign capital flows in the 2000s: large inflows through 2008 and the sudden stop from then onwards. Consequently, their central banks faced the challenge first to avert excessive appreciation of currency and subsequently to avoid deep and abrupt depreciation, and in both cases central bank was forced to manipulate extensively the exchange rate. These swings in capital flows were less pronounced in Czech R. and Poland, as they ran small current account deficits through 2008, compared to large ones in Serbia and Romania.

Apart from the differences associated with factors that influence the treatment of the exchange rate above and beyond its impact on inflation, the two sets of economies also differ with respect to the importance of the nominal exchange rate channel, specifically the size of the exchange rate pass-through. To assess the latter, we examine an extreme event of a large and rapid currency depreciation that occurred at the same time, i.e. from October 2008 to February 2009, in all five studied economies. This 'joint experiment' should reveal to what extend the inflation in considered economies is resistant to sharp depreciation, i.e. exactly the case central bank is interested in. The results are reported in Table 7.

Table 7

Exchange rate pass-through

	Nominal depreciation (%) Oct. 2008-Feb. 2009	Inflation (%), 2009 end of the period	Pass-through upon large and rapid depreciation
Serbia	22.6	6.6	6.6/22.6 = 0.29
Hungary	20.4	5.6	0.27
Romania	19.4	4.8	0.25
Poland	30.9	3.5	0.11
Czech Republic	11.2	1.0	0.09

Source: depreciation: http://ec.europa.eu/budget; inflation IMF. For Serbia: Statistical Office of Serbia, and the National Bank of Serbia.

The estimated exchange rate pass-through coefficients tend to group together in Serbia, Hungary and Romania on one side, and Poland and Czech Republic on the other. Thus again we found that the former set of countries should incline to attach more weight on the exchange rate management compared to latter countries, even in the case when they are solely focused on inflation targeting.

The aforementioned analysis suggests that Serbia and Romania are more akin emerging economies (cf. Mohanty and Klau, 2004, and Aizenman et al., 2008), while Czech R. and Poland resemblance developed ones.

Hungary in our estimation emerges as a distinct case since, contrary to the other four inflation targeters, inflation rate does not appear in its monetary policy rule. This finding could be explained by a commanding role given to the exchange rate in inflation targeting in Hungary. The rational is the perceived exceptional importance of the exchange rate channel for controlling inflation.

Hungary introduced inflation targeting in 2001, but at the same time also kept the exchange rate band (± 15%) with explicit announcement of preferred exchange rate target, through 2004. Subsequently, the announcement was abandoned first, and later on (in February 2008) also the exchange rate band (see Stone et al., 2009). Thus Hungary effectively adhered to dual goals for quite some time, only to shift gradually to fullfledged inflation targeting. Nevertheless, the Hungarian interest rate setting committee has carried on maneuvering the policy rate to guide the exchange rate in line with inflation target. That is to say that a change in the policy rate is aimed primarily at affecting the exchange rate, which (supposedly) affects strongly aggregate demand and inflation in Hungary.

Stylized facts above point to the exceptional role played by the exchange rate in inflation targeting in Hungary. Its importance for the interest rate setting committee overwhelms that of current inflation rate, making the latter rate redundant (i.e. non-significant) in estimated interest reaction function above (see Table 1). Moreover, the stylized facts suggest that Hungary is closer to Romania and Serbia than to Czech R. and Poland, regarding the role of the exchange rate. The exchange rate pass-through in Hungary is, as in Romania and Serbia, on the higher side, and this may partly justify its heavy reliance on the exchange rate while targeting inflation. Nonetheless, the dual goal regime that Hungary pursued for the extended period of time while only gradually shifting to pure inflation targeting shows that its central bank has been concerned about the exchange rate above and beyond its impact on inflation and actively has tried to influence its level. In this respect Hungary is more like an emerging economy, together with Romania and Serbia, and less akin to developed one as Czech R. and Poland.

Conclusions

The paper shows that a discrete choice model captures well behavior of inflation targeting central banks in emerging Europe, i.e. both their monetary policy rule and operational behavior. As to the latter, our findings suggest that these central banks change their policy rates in discrete fashion, i.e. only when the deviation between its (unobservable) optimal rate and actual rate surpasses certain threshold values. Namely it is found that these cut-off points are statistically significant, and that estimated monetary policy rules contain relevant economic variables that are also statistically significant. Both results above lend strong support for the discrete choice model used in this paper.

Additional support for the estimated model is found in its very good forecasting performance: about 70% of all central banks' decisions are correctly predicted by the model. Faced with even more challenging task of forecasting only policy rate changes, the estimated model fared well provided that decent number of rate cuts or hikes is contained in a sample. Finally, it is found that central bank's optimal rate leads (Granger-causes) actual policy rate, implying that only upon the change in the former a central bank will change the latter. This finding is exactly what the discrete choice model assumes, hence validating it further.

The estimated monetary policy rule for all five emerging Europe inflation targeters contains standard fundamental economic variables, as envisaged by the Taylor rule, such as inflation rate (except Hungary), output gap, ruling policy interest rate, but also the real exchange rate. Thus statistically good estimates of the rule are obtained without additional 'help' of some non-fundamental economic or financial indicators, the practice often recourse to in empirical assessment.

The significant ruling policy interest rate in the monetary policy rule found in emerging Europe inflation targeters shows that their central banks smooth changes in its policy rate as do their counterparts in developed economies. The obtained positive coefficient implies that the policy rate change in one period increases the probability of its change in the next period, and the likewise for the cases of no change and rate decrease respectively.

We also found that real exchange rate enters significantly monetary policy rules in all five emerging Europe inflation targeters. However, in Czech Republic and Poland it is primarily used to predict future inflation, while in Romania, Serbia and Hungary the exchange rate enters monetary policy rule on its own, i.e. beyond inflation targeting. Namely, in Romania and Serbia real exchange rate does not predict (Granger-cause) future inflation, while in Czech R. and Poland it does, hence the grouping above. Hungary is a specific case, as it for quite some time pursued effectively dual goal – inflation one but also the exchange rate band and it still attaches commanding role to the exchange rate in inflation targeting (cf. Stone et al., 2009). This explains our somewhat unexpected result that inflation does not significantly enter monetary policy rule in Hungary, as oppose to the other four inflation targeters.

These results, i.e. active exchange rate policy stand in Romania, Serbia and Hungary vs. the passive one in Czech R. and Poland seem to be supported by different features of these two sets of economies. The former set is more like emerging market economies with recent history of significant inflation, considerably euroized, with less developed financial sector, exposed to larger swings in capital flows, and with higher exchange rate pass-through all compared with Czech R. and Poland.

The grouping above is also supported by estimated threshold values showing that central banks in Serbia and Hungary opt easier for the rate cuts than for the hikes, indicating their greater aversion to recession compared to expansion, the phenomenon observed also in other emerging economies (see Mohanty and Klau, 2004). On the other hand central banks in Czech R. and Poland (results for Romania are statistically insignificant) are unbiased regarding rate cuts or hikes, as are mature central banks in developed countries.

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