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MONETARY POLICY RULE IN INFLATION TARGETING EMERGING EUROPEAN COUNTRIES: A DISCRETE CHOICE APPROACH

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Abstract

The paper explores all six emerging European countries that target inflation, showing that a discrete choice model captures well the behavior of their central banks, 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. Estimates of Taylor rule contain relevant economic variables, including real exchange rate. However, evidence is offered that in Romania, Serbia and Albania the exchange rate is a goal for itself, while in the Czech R., Poland and Hungary it is an instrument to achieve inflation target, and this is related to different features of these two sets of economies. The use of the nonstationary discrete choice approach is well motivated as some explanatory variables are nonstationary.

JEL Classification Numbers: E52, P24, C25

Keywords: Monetary policy Taylor rule, inflation targeting, exchange rate, emerging Europe, nonstationary discrete choice model

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I. *Introduction*

This paper empirically assesses monetary policy rule in all emerging Europe inflation targeters, examining in particular the role of exchange rate, and explores operational behavior of the central bank in setting its target rate. Specifically, it estimates Taylor-like interest rate reaction function, while it is assumed and tested that the central bank changes its target rate in a discrete fashion. The methodology used is a nonstationary discrete choice approach of Hu and Phillips (2004a, 2004b).

It is empirically well established that the monetary policy of inflation targeting central banks in developed countries can be described by some form of Taylor function (Svensson, 2010, and Clarida et al., 1998), but the evidence for emerging economies, particularly the European ones, is scarce. Thus, a recent paper (Frommel et al., 2011) has estimated monetary policy rules in six emerging Central and Eastern European economies, however, encompassing both periods of exchange rate and inflation targeting. The sample ends in August 2008 to avoid potentially distorting effects of the subsequent Great Recession; nevertheless, it sharply decreases inflation targeting periods in each country. Other estimates of Taylor rule in emerging central European countries (e.g. Maria-Dolores, 2005, and Paez-Farell, 2007) cover even shorter periods of inflation targeting in these economies.

As to the role of exchange rate in emerging economies monetary policy rule, there is some empirical evidence suggesting that it enters as a goal in itself above and beyond its impact on inflation (cf. Mohanty and Klau, 2004, and Aizenman et al., 2011). Thus we shall explore whether the same holds for any of the inflation targeting emerging European countries.

This paper adds to the literature in several ways: Firstly, it examines monetary policy rule in all emerging European inflation targeters: the Czech Republic, Hungary, Poland and Romania, but also Albania and Serbia, i.e. the countries that have not been analyzed yet. Slovakia is skipped since even during its (informal) inflation targeting period (1998-2008) it still focused on exchange rate movements (cf. Frommel et all., 2011). Secondly, we explore a longer period of inflation targeting in emerging European economies than the previous studies do, i.e. through December 2013. The large sample enables us to omit the first 18 to 24 months of inflation targeting in each country treating it as a transitional period. Thirdly, our sample encompasses the Great Recession, hence allowing us to assess whether estimated monetary rule can describe central bank monetary policy even in these extreme conditions. Fourthtly, this paper opts for a discrete choice model in order to capture the stylized fact that the 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 0.25pp. Within this framework, one can jointly estimate the monetary policy rule and determine the timing of changes in policy interest rate. There are just a few studies of developed countries pursuing this approach, i.e. for the US (see Hu and Phillips, 2004b, and Danis, 2009), Canada (see Hu and Phillips, 2004a) and UK (Bhattacharjee Holly, 2005), but no research for emerging economies. In addition, the discrete choice model used allows for nonstationary explanatory variables, as some of the variables in Taylor-like interest rate reaction function definitely are.

Policy ramifications of our findings are multifold. Exploring whether the same fundamental economic variables: inflation, output gap and inertia, enter monetary policy rule in emerging Europe inflation targeters as they do in their advanced countries counterparts, should indicate whether there is a room for improvement and hence for corresponding policy measures in the former set of central banks. Moreover while examining inflation targeters across emerging Europe we shall be looking whether some heterogeneity emerges, notably in the role played by exchange rate, as well as the possible asymmetrical central banks' behavior while respectively cutting and raising its policy rate. Differences across emerging Europe if any would then ask for diverse policy measures in order to remove respective hurdles to effective inflation targeting. Similarly, it has been already found that that the impact of inflation targeting varies across individual regions of the world, hence asking for specific policies design fitting each region (see Ayres et al., 2014).

The paper continues as follows. Section II puts forward discrete choice model of monetary policy using Taylor rule, while section III gives corresponding empirical estimates. Section IV assesses how well the estimated models predict across all six countries. The role of the exchange rate in monetary policy rule is empirically assessed in section IV, indicating different patterns in the two sets of economies. Section V offers conclusions and policy implications.

II. *A Model of Central Bank Behavior*

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

As to the monetary regime, a country has a choice either of 'permanent' fixing of its exchange rate or the trinity of 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, the central bank adjusts its instrument – policy interest rate. Monetary policy rule is a contingency plan that determines how the 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 the 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 a 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 (z), but also real exchange rate (e) to capture open economy effects:

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

i_t^* is optimal interest rate, i.e. the one that the central bank would choose to achieve its goal, while i is actual policy rate. 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 the central bank to raise its policy interest rate, i.e. $d_1>0$ and $d_2>0$.

There are two broad reasons for the exchange rate to enter the 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 the central bank attitude to smooth interest rate changes, i.e. to move in small steps, usually 0.25pp, in the same direction. The rationale for this central bank behavior is multifold. Firstly, in that way the central bank influences expectations of market participants that the interest rate changes will carry on for some time and thus affects the long-term interest rate. Additional rationale is that gradual changes diminish the risks of policy mistake that could emerge either due to uncertainty about model parameters used by the central bank or it being forced to decide upon partial information. Moreover, moving in small steps helps the central bank to avoid reputation risks that might come from sudden reversals of interest rate. Lastly, large and abrupt interest rate changes may hurt the financial system as it has limited capacity to hedge the interest rate risk.

There is some empirical evidence that central banks smooth interest rate changes. Thus, the US Federal reserve board took ten decisions in a row to lower interest rate in 2001, and later from June 2004 onwards, in the two years, it undertook 17 consecutive increases of its policy rate. Moreover, all major central banks had prolonged periods of consecutive policy rate cuts upon financial crisis outburst. Six emerging Europe central banks we are looking at also tend to smooth policy interest rate changes.[1]

The interest rate reaction function may also include non-fundamental variables that nevertheless forecast well (leading indicators) inflation and/or output (e.g. Hu and Phillips, 2004a, 2004b).

2. Empirical model

Monetary policy rule (1) discussed above determines the central bank's optimal 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 a discrete fashion, i.e. it adjusts policy rate i_t at its monthly or so meetings, and even then, we conjecture, only when optimal rate (i_t*) surpasses certain threshold. What one observes, therefore, is actual policy rate i_t but not the optimal one i_t*, and we want to recover the latter, i.e. to estimate the 'true' underlying monetary policy rule.

The 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 model-implied optimal target rate, which is unobservable. X_t is a vector of exogenous explanatory variables such as those in eq. (1), and some of them may also be nonstationary, specifically *I(0), I(d)* or *I(1)* processes or a mixture of these (cf. Park and Phillips, 2001, and Phillips, Jin 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:

$$y_t = -1 \text{ if } -\infty < y_t^* < \mu_1$$
$$y_t = 0 \text{ if } \mu_1 \le y_t^* \le \mu_2$$
$$y_t = 1 \text{ if } y_t^* > \mu_2 \qquad (3a)$$

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), the 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, the 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 (OPROBIT) where dependent variable y_t takes values -1, 0 and 1, when one observes that the 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 that will also be pursued.

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 $\mu_1$and μ_2. Statistical significance of these parameters would support assumption that the central bank adjusts policy rate in a discrete fashion i.e. only after its optimal but unobservable rate (i^*) exceeds certain threshold. This would furthermore suggest that one should estimate monetary policy rule by employing true although unobservable policy rate, and not the actual one.

III. *Empirical Estimates*

1. Monetary policy rule

The monetary policy rule is estimated for all six emerging European economies that target inflation: the Czech Republic, Poland, Hungary, Romania, Albania and Serbia. Standard fundamental economic determinants as suggested by eq. (1) are used as explanatory variables. Interest rate (i_{t-1}) as an explanatory variable turns out to be I(1) in the Czech R., Hungary and Poland, and probably in Romania (ADF and KPSS tests give different outcomes), hence motivating the use of Hu and Phillips (2004a, 2004b) nonstationary discrete choice approach. Since these central banks take decisions approximately at monthly frequency[ii], we use monthly data lagged one period i.e. the latest available information when decision is taken. The samples across countries skip first 18 to 24 months of inflation targeting (cf. Table 1) i.e. the transition period that might be somewhat erratic. The data used and its sources are explained in Table A1 in the Appendix.

The 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.

Table 1

Estimates of monetary policy rule: Three way choice model

	Czech Republic	Poland	Hungary	Romania	Serbia	Albania
adoption of IT	1997:12	1998:1	2001:8	2005:8	2006:8	Lite 2004; Full-Fledged 2008
sample period	1999:6-2013:12	2000:1-2013:12	2003:1-2013:12	2007:1-2013:12	2008:1-2013:12	2008:1-2013:12
inflation_gap(-1)					0.27458 (4.009)***	0.633239 (3.073)***
inflation(-1)	0.1770840 (2.191)**	0.3793 (4.8363)***	0.2887450 (3.513)***	0.439933 (4.353)***		
gdp_gap(-1)	0.2386180 (2.207)**	0.237648 (2.2842)**	0.496218 (5.400)***	0.512118 (4.954)***	0.327873 (2.425)**	0.480012 (2.510)**
ir(-1)	-0.222508 (-3.206)***	-0.154662 (-4.7092)***	-0.162921 (-2.439)**	-0.3639560 (-3.016)***		
exr_gap(-1)	0.159042 (3.965)***		0.1979170 (5.633)***		0.2718 (4.217)***	
exr_gap(-4)		0.045507 (2.4008)**				
Δexr(-2))				0.225665 (2.226)**		
Δexr(-3))						0.452905 (2.2639)**
μ_{1n}	-1.23163 (-5.986)***	-1.1525 (-4.9701)***	-0.221265 (-0.507)	-1.077983 (-1.398)	-0.76429 (-4.366)***	-0.97960 (-4.9102)***
μ_{2n}	1.59821 (7.927)***	1.44674 (5.8353)***	1.769825 (3.676)***	2.583707 (2.905)***	0.76730 (4.202)***	2.78288 (6.2778)***
Wald test ($\mu_1=\mu_2$) (prob)	1.04082 (0.299)	0.69572 (0.4876)			0.01093 (0.991)	3.70835 (0.0004)
Observations	175	164	132	83	71	72
decrease	28	39	49	21	22	12
no change	136	109	67	55	28	51
increase	11	16	16	7	21	1
log. likelihood	-102.93760	-109.4430	-99.945	-42.87492	-58.76994	-31.431560
pseudo R^2	0.112897	0.205673	0.217682	0.376855	0.240803	0.162414

Note: Significance of coefficients at 1% and 5% are denoted by *** and **, respectively.

Emerging European inflation targeters share almost common pattern. Inflation entered significantly and with the positive sign in all interest rate reaction functions. Thus, the rise in inflation in a month prior to the central bank committee meeting increased the probability that the policy rate would be raised. The output gap, as expected, had significant and positive impact on policy rate in all the countries.

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 Euro. Thus when currency depreciates, and hence this gap increases, one might expect that the 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 the Czech Republic, Poland, Hungary, and Serbia. In Romania and Albania, the rate of change of real exchange rate significantly entered monetary policy rule equation. 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 similar pattern, i.e. policy interest rate changes only when real exchange rate appreciates/depreciates faster than envisaged by its (HP) trend. Hence, all six countries exhibited similar pattern.

Finally, all six central banks smoothed changes in their policy rates, i.e. lagged interest rate appeared with a positive coefficient in each estimated monetary policy rule equation (4). In the case of the Czech Republic, Poland, Hungary 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 the Czech Republic, was $(1 - 0.222) \approx 0.8$, i.e. positive suggesting that the increase in policy rate in previous period raises probability that it will also be increased in the current period. The same applies to corresponding estimates for Poland, Hungary and Romania. In the case of Serbia and Albania, lagged policy rate i_{t-1} did not enter significantly in linear index function y_t* and consequently it appeared 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.

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

2. Operational behavior of central banks: Cut-off points estimates

As explained above, it is assumed that the 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 the central bank.

Estimates in the three-way choice model reported in Table 1 give some support for assumed behavior of the central bank as most of cut-off points are significantly different from zero. Nevertheless, we shall explore a finer cut, i.e. the five way choice model to assess assumed operational behavior of inflation targeting central banks in emerging Europe.

Thus, 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

Again, we assume that the 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 greatly above the ruling policy rate i_{t-1}, i.e. the difference between the two (y_t^*) is larger than the threshold value (μ_4), the central bank will opt for a big increase of its policy rate i_t, i.e. by 0.5pp or more, and the same goes for the remaining four cases. The results are reported in Table 2 below.

(Table 2 here)

Estimates of the monetary policy rule for the five choice model are essentially the same as those in the triple choice model above, i.e. identical sets of variables with corresponding signs significantly entered corresponding relation for each country (see Table 2). Thus the same discussion as above for the triple-choice model applies here while analyzing the estimated interest rate reaction function.

Concerning operational behavior of central banks, we found that the five way choice model gives statistically significant estimates of all cut-off points μ which was not the case in the three way model above (cf. Table 1 and 2). These findings first strongly support the discrete choice model of inflation targeting central banks. Then, they suggest that the considered central banks discriminate between small and large changes of their policy rates as in all cases (except the Czech R. and Albania) we found four statistically significant cut-off points. In the Czech R. and Albania μ_4 was non-existent since there was no big increase in policy rates i.e. changes of 0.5pp or more did not appear in their samples.

Table 2

Estimates of monetary policy rule: Five way choice model

	Czech Republic	Poland	Hungary	Romania	Serbia	Albania
period	1999:6-2013:12	2000:1-2013:12	2003:1-2013:12	2007:1-2013:12	2008:1-2013:12	2008:1-2013:12
inflation_gap(-1)					0.221897	0.635151
					(3.883)***	(3.540)***
inflation(-1)	0.14757	0.386136	0.332323	0.3912270		
	(1.847)*	(5.1014)***	(4.178)***	(4.221)***		
gdp_gap(-1)	0.25132	0.248089	0.5079910	0.5075460	0.419932	0.411006
	(2.736)***	(2.4341)***	(5.985)***	(5.011)***	(3.074)***	(1.722)*
ir(-1)	-0.23601	-0.163162	-0.268691	-0.4284840		
	(-3.595)***	(-5.1194)***	(-3.877)***	(-3.179)**		
exr_gap(-1)	0.159143		0.2132730		0.258703	
	(3.967)***		(5.472)***		(4.275)***	
exr_gap(-4)		0.06185				
		(3.3230)***				
Δexr(-2))				0.265675		0.43319
				(2.485)***		(2.460)***
μ_{1n}	-2.08364	-1.820	-1.853	-2.4301	-1.037965	-2.116224
	(-9.947)***	(-7.232)***	(-5.171)***	(-2.994)***	(-5.157)***	(-6.852)***
$\mu 2_n$	-1.34142	-1.225	-0.769	-1.6897	-0.811898	-1.031593
	(-6.584)***	(-5.366)***	(-1.975)**	(-2.266)**	(-4.336)***	(-5.256)**
$\mu 3_n$	1.48722	1.420	1.259	1.822853	0.72503	2.65818
	(7.622)***	(5.841)***	(2.954)***	(2.560)***	(4.159)***	(6.818)***
$\mu 4_n$	/	2.401	1.69122	2.3983	1.267643	
		(7.007)***	(3.846)***	(2.974)***	(5.435)***	
Wald test (μ_1=μ4)		1.193981	-0.225228	-0.021945	1.08321	
(prob)		(0.234)	(0.822)	(0.982)	(0.283)	
Wald test (μ2=μ3)	0.426554	0.472383	0.629023	0.097184	-0.02090	3.68940
(prob)	(0.670)	(0.637)	(0.530)	(0.922)	(0.983)	(0.0005)
Observations	175	164	132	83	71	72
big decrease	9	21	18	10	18	2
small decrease	19	18	31	11	4	10
no change	136	109	67	55	28	59
small increase	11	13	7	3	8	1
big increase	/	3	9	4	13	
log. likelihood	-119.9035	-138.4802	-135.3475	-60.55884	-82.60093	-37.73565
pseudo R^2	0.1027	0.1968	0.20821	0.312743	0.188571	0.12106

Note: Significance of coefficients at 1%, 5% and 10% are denoted by ***, ** and * respectively

Cut-off point estimates imply that all central banks, except the Albanian one, behaved symmetrically when deciding about rate cuts and hikes. This follows from the results of Wald test indicating that the (absolute value) of corresponding cut-off points are equal ($\mu_1 = \mu_4$, and $\mu_2 = \mu_3$, see Table 2).Thus these central banks were indifferent to whether they had to increase or decrease the policy rate. However, in the case of Albania, the same test suggests that its central bank acted asymmetrically i.e. $\mu_2 < \mu_3$, hence opting more easily for rate cut, than for rate hike (1.03 < 2.66, cf. Table 2).

The magnitude of the estimated threshold values varied across central banks, being the smallest in Serbia and the highest in Romania (see Table 2), suggesting that the central bank of Serbia was, among the considered central banks, most sensitive to the discrepancy between optimal and actual policy interest rates. Thus in Serbia, cut-off point for a big rate cut was -1.04, meaning that the rate cut of 0.5pp or more will occur when optimal rate (i_t*) becomes lower than the ruling policy rate (i_{t-1}) by more than 1.04 percentage points, i.e. $| i_t^* - i_{t-1}| > 1.04$pp. Similarly, the big rate hike of 0.5pp or more will occur if optimal rate exceeds actual one by 1.27pp (see Table 2).These estimates suggest that the central bank of Serbia, would in one shot, i.e. by 0.5pp change of policy rate *i,* approximately half the discrepancy between optimal (i^*) and actual (i) rates. This finding looks plausible having in mind inertia in the central bank's behavior, i.e. that it tends to change the rate gradually in several steps in the same direction.

Similar finding holds in Serbia for the case of small policy rate changes i.e. 0.25pp. The corresponding threshold values for rate cut and increase were -0.81 and 0.72 respectively (see Table 2), and hence the discrepancy between the two rates: optimal (i^*) and actual (i), was decreased right away by one third upon 0.25pp change in policy rate.

Finally, comparing corresponding (absolute) threshold values for rate cut and hike: 1.04 vs. 1.27, and 0.81 vs. 0.72, shows that they were approximately equal, which has been confirmed by the Wald test (see Table 2).

3. Does the same set of variables influence rate cut and hike?

One may now relax the assumption implied by ordered probit model (OPROBIT) used in the previous sections, that all coefficients β are identical across each choice, i.e. irrespective of whether the central bank decides to cut or increase interest rate. Generalized order probit (GOPROBIT) model does not impose the above parallel line assumption (PLA), thus allowing that the central bank might look at different set of variables when deciding to cut and raise interest rate.

Standard test examining whether PLA holds or not, i.e. Brant test for ordered probit model shows that the central banks in the Czech R. and Poland exhibited asymmetric behavior (PLA was rejected), while those in Romania, Serbia and Albania did not (PLA accepted), and the result for Hungary was somewhat ambiguous[iii]. However, since dependent variable $y_t^* = i_t^* - i_{t-1}$, is I(1) in the Czech R., Polandand Hungary, the Brant test is biased (i.e. corresponding standard errors are biased) in these cases. Therefore, we proceeded and used minimum AIC to find out whether PLA holds, and if not what variables caused PLA rejection (cf. Danis, 2009).Thus, beside OPROBIT model (cf. Table 1), for these countries, we estimated GOPROBIT models- general and partial ones - and chose the ones with minimum AIC for each country. As shown in Table 3, minimum AIC criteria suggest that partial GOPROBIT model held in the Czech R., Poland and Hungary, although it varied across these countries.

Table 3

Partial GOPROBIT Models

Interest rate	Czech Rep. inflation	Czech Rep. gdp_gap	Poland exr_gap	Hungary inflation
cut vs. no change or hike	0.03548 (0.39)	0.44038 (3.49)***	0.07505 (3.07)***	0.30977 (3.40)***
cut and no change vs. hike	0.46192 (3.91)***	-0.01695 (-0.12)	-0.00147 (-0.05)	0.12267 (1.00)
AIC of partial GOPROBIT (vs. OPROBIT)	213.4735 (217.8751)		228.5629 (230.8860)	210.5549 (211.8899)

Note: *** denotes coefficient significance at 1%.

Thus, it was found that the Czech central bank reacted differently to inflation and output gap, depending on whether it was contemplating rate cut or hike. Specifically, the estimates in Table 3 suggest that the central bank was ignoring inflation (i.e. insignificant, cf. Table 3) when deciding to cut the rate and was concentrating on the output gap (significant, cf. Table 3) as well as on the other two variables (exr and i_{-1}). However, when deciding to raise the rate, the Czech central bank disregarded the output gap (insignificant, cf. Table 3) and focused on inflation rate (significant, cf. Table 3) and the other two variables (exr and i_{-1}).Let us add that in the chosen partial GOPROBIT model the coefficients on the other two variables (exr and i_{-1}) were the same for rate cut and hike, and hence (approximately) equal to OPROBIT ones reported in Table1above.

In case of Poland, a partial GOPROBIT model that minimizes AIC suggests that the central bank ignored the exchange rate (insignificant, cf. Table 3) when deciding to raise the rate, while considering all variables when choosing to cut it.

Similarly in Hungary, the central bank focused on all variables when choosing to cut the rate, while ignoring inflation (insignificant, cf. Table 3) when deciding to hike it.

IV. *Assessing the estimated model: How well does it predict?*

In order to further assess estimated monetary policy rule in a three-way model one can confront model's predictions with actual decisions. The results for all six countries are summarized in Tables 4 and 5.

Table 4

Actual and model predicted policy rate decisions in six emerging European economies

Czech Republic		Actual decisions			**Romania**		Actual decisions		
		Rate cut	No Change	Rate hike			Rate cut	No Change	Rate hike
Model	Rate cut	**3**	0	0	Model	Rate cut	**12**	0	0
predicted	No Change	25	**131**	11	predicted	No Change	9	**47**	3
	Rate hike	0	5	**0**		Rate hike	0	8	**4**
Poland		Actual decisions			**Serbia**		Actual decisions		
		Rate cut	No Change	Rate hike			Rate cut	No Change	Rate hike
Model	Rate cut	**19**	0	0	Model	Rate cut	**11**	8	0
predicted	No Change	23	**97**	16	predicted	No Change	11	**16**	5
	Rate hike	0	9	**0**		Rate hike	0	4	**16**
Hungary		Actual decisions			**Albania**		Actual decisions		
		Rate cut	No Change	Rate hike			Rate cut	No Change	Rate hike
Model	Rate cut	**30**	0	0	Model	Rate cut	**3**	0	0
predicted	No Change	19	**51**	9	predicted	No Change	9	**58**	1
	Rate hike	0	16	**7**		Rate hike	0	1	**0**

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

Table 5

Correct model predictions: Summary

	Czech Rep.	Poland	Hungary	Romania	Serbia	Albania
% of all decisions	76.57	70.73	66.67	75.90	60.56	84.72
% of rate change	7.69	34.54	56.92	57.14	67.44	23.08

As seen from tables 4 and 5, 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 were predicted correctly. Nevertheless, when one focuses on predicting changes in policy rate, performance of the model varies widely: from an outstanding share: 67% of correct predictions in case of Serbia to the very poor 8% hits in the Czech R. These divergences in predictive power do 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 (61% in Serbia), estimated model can predict changes well, as opposed to an unbalanced sample case with minor share of rate changes in all decisions (22% in the Czech R.).

Comparing optimal rate i_t*, obtained from the estimated monetary policy rule (4), with actual policy rate, indicates that in most cases the former exhibited larger variations than the latter as shown by reported standard deviations. Moreover, the optimal rate leads the actual one, which is demonstrated by Granger causality testing (see Table 6). 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 the 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 6

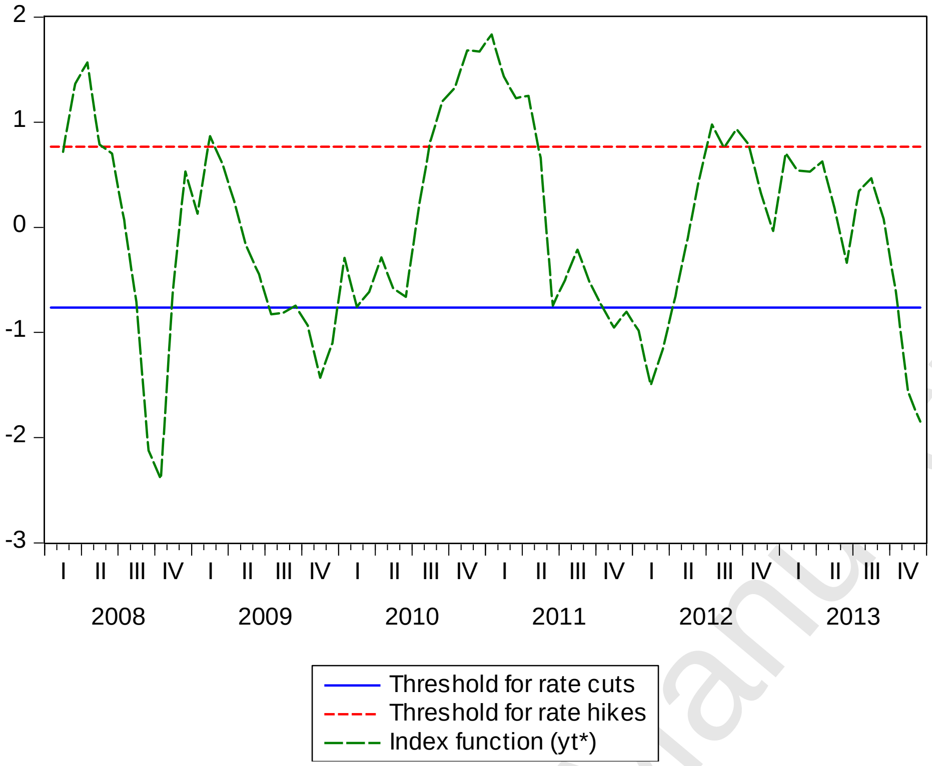
Estimated vs. actual policy rate: Further assessment of the model

				Granger causality testing		
		standard deviation				Ho: optimal rate (i^*) does not
Country	period	i_t	i_t*	F-Stat.	Prob.	Granger cause actual rate (i_t)
Czech Rep.	99:6-13:12	1.69	1.61	5.93	0.0033	rejected
Poland	00:1-13:12	5.02	5.01	22.13	0.0000	rejected
Hungary	03:1-13:12	2.11	2.21	2.43	0.0923	rejected
Romania	07:1-13:12	1.80	2.47	4.40	0.0155	rejected
Serbia	08:1-13:12	2.48	2.65	3.64	0.0103	rejected
Albania	08:1-13:13	0.91	1.26	1.95	0.1500	accepted

We also report in Figure 1 estimate of linear index function $\hat{y}_t^*$ (cf. 2a) together with cut-off points for Serbia only, as the other five index functions have broadly the same features.

Figure 1

Estimated index function



The model estimates imply inertia in the central bank behavior, since for almost all cases $\hat{y}_t^*$ was above/below corresponding threshold values for several consecutive months (cf. Figure 1).The latter indicates that the central bank undertakes rate cuts/hikes in several successive steps. This model's prediction concurs with observed inertia in actual central bank's behavior.

V. *The Role of the exchange rate in a monetary policy rule: An empirical assessment*

The 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 the central bank is concerned about the exchange rate above and beyond its impact on inflation and actively tries to influence its level.

Thus, the central bank, particularly in emerging economies, might aim at stabilizing the real exchange rate as a separate policy target beyond the inflation one. There are several potential reasons for this. In a number of emerging economies liabilities of corporations, households and banks are highly dollarized/euroized, forcing the 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 the motivation for the central bank to curb its volatility. Exchange rate management also helps the central bank to address the adverse consequences for external stability of either a large inflow of capital (e.g. in emerging Europe 2005 -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, the 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 have found above that real exchange rate entered significantly monetary policy rules in all six emerging Europe inflation targeters. Against the backdrop above, we shall assess whether there is some pattern related to the role of the exchange rate in the interest rate reaction function of the corresponding central banks.

Thus, we shall examine whether our finding implies that stabilization of real exchange rate appears as a separate policy target beyond the 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., 2011). 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 7

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 Rep.	2	3.8252	0.0237	rejected
Poland	2	2.8108	0.0633	rejected
Hungary	2	10.1756	0.00008	rejected
Romania	2	0.1121	0.8941	accepted
Serbia	4	1.0094	0.4100	accepted
Albania	2	0.46380	0.6309	accepted

In the Czech R., Poland and Hungary real exchange rate Granger caused inflation, indicating that the former is a good predictor of the latter, while this was not the case in Romania, Serbia and Albania (see Table 7).

This evidence suggests that in Romania, Serbia and Albania, real exchange rate stabilization comes out as a separate policy target beyond the inflation one, and that respective central banks actively try to influence the level of exchange rate. On the contrary, the central bank in the Czech R., Poland and Hungary seemed to be using real exchange rate to predict inflation, and that explains its appearance in the interest rate setting equation.

These results, i.e. active exchange rate policy stand in Romania, Serbia and Albania vs. the passive one in the Czech R., Poland and Hungary seem to be supported by different features of these two sets of economies as summarized in Table 8.

Table 8

Determinants of the exchange rate policy stand

Country	Euroization Of deposits and loans, end of 2013	Inflation: 2002-2013	Inflow of capital: CA%GDP 2005-2008 and 2009-2013	Financial sector: Stock market total value traded as % of GDP, 2011
Czech R.	8.5% and 9.5%	2,3%	-2.4% and -2.5%	7.1%
Poland	10 and 30	2,6	-4.8 and -3.8	17.1
Hungary	21 and 52	4,9	-7.4 and 0.9	16.9
Romania	34.5 and 61	8.5	-11.0 and -3.7	1.39
Serbia	77 and 73	9.1	-14.6 and -7.6	0.66
Albania	41.5 and 61	2.9	-13.4 and -9.4*	n.a.

*2007-2009 and 2010-2014. Sources: for inflation and current account (CA) World Economic Outlook, IMF, April, 2014; for euroization, i.e. share of total foreign currency deposits and loans, respective central banks; for financial sector: Global Financial Development Database (GFDD), World Bank, 2013.

Thus, the degree of euroization, measured as (share of) deposit and loans in foreign currency, clearly divides considered economies in the two groups mentioned above, and so does the corresponding indicator of financial sector development. Likewise, external vulnerability and swings in capital flows were more pronounced in Romania, Serbia and Albania than in the other three economies. The same is with inflation apart from Albania (cf. Table 8).

The aforementioned analysis suggests that Romania, Serbia and Albania are more akin emerging economies where the exchange rate is a goal for itself above and beyond its impact on inflation (cf. Mohanty and Klau, 2004, and Aizenman et al., 2011), while this is not the case in the Czech R., Poland and Hungary which are therefore more resembling developed countries.

VI. *Conclusion and policy implications*

The paper shows that a discrete choice model captures well the behavior of inflation targeting central banks in emerging European economies, 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 a 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. Moreover, this model describes well monetary policy of the considered central banks even during the Great Recession.

Additional support for the estimated model is found in its very good forecasting performance: around 70% of all central banks' decisions were correctly predicted by the model. Faced with even more challenging task of forecasting only policy rate changes, the estimated model fared well provided that a decent number of rate cuts or hikes were contained in the sample. Finally, it is found that central bank's modeled-implied optimal rate leads (Granger-causes) actual policy rate, indicating 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 six emerging Europe inflation targeters contains standard fundamental economic variables, as envisaged by the Taylor rule, such as inflation rate, 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 recoursed to in empirical assessment.

The significant actual (lagged) policy interest rate in the monetary policy rule found in emerging European inflation targeters shows that their central banks smoothed changes in their policy rates as did their counterparts in developed economies. The obtained positive coefficient implies that the policy rate increase in one period raises the probability of its increase in the next period, and the likewise for the case of rate cut.

We found some evidence that a few emerging Europe central banks behaved asymmetrically, notably that the central bank of Albania opted easier for the rate cut than the raise. Moreover in the Czech Republic, Poland and Hungary a different set of variables are taken into account while deciding on policy rate cuts and hikes respectively.

As to the role of the exchange rate in Taylor-like interest rate reaction function, it is found that real exchange rate entered significantly monetary policy rules in all six emerging European inflation targeters. However, in the Czech Republic, Poland and Hungary it was primarily used to predict future inflation, while in Romania, Serbia and Albania the exchange rate entered monetary policy rule on its own, i.e. beyond inflation targeting. Namely, in Romania, Serbia and Albania real exchange rate did not predict (Granger-cause) future inflation, while in the Czech Republic, Poland and Hungary it did, hence the grouping above.

These results, i.e. active exchange rate policy stand in Romania, Serbia and Albania vs. the passive one in the Czech Republic, Poland and Hungary 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. However, this is not the case in the Czech Republic, Poland and Hungary, which are also OECD countries. Our findings are supported by those acquired in a different set-up showing that the Czech Republic, Poland and Hungary, early in their transition, explicitly switched from defending the exchange rate peg to targeting inflation subsequently (cf. Frommel et all., 2011).

Finally, the use of the nonstationary discrete choice approach of Hu and Phillips (2004a, 2004b) is well motivated as some explanatory variables are nonstationary.

The main policy implication of our results relates to the role of exchange rate played in inflation targeting, i.e. we found that in one set of countries, as opposed to another, the exchange rate appears as a goal in itself and beyond its impact on inflation, hence impeding the very effectiveness of inflation targeting. In order to improve the latter, policy should address root causes, advanced above, that led to extraordinary role of the exchange rate, and some are easier to treat than others. Thus anchoring the low inflation expectations is now within the reach of these economies as inflation has been curbed due to the Great Recession and ensuing incidences of deflation[iv] as well as the already prolonged period of inflation targeting that even in emerging economies leads to lower inflation (see Abo-Zaid and Tuzemen, 2012). Also, swings in capital flows are expected to dampen since these countries have recently decreased substantially its current account deficits, as a result of post-crises rebalancing of its economies away from consumption and imports towards exports. Lowering high euroization will however remain the major policy challenge, as illustrated by very modest results achieved in Serbia upon almost four years of pursuing de-euroization policy[v]. Deepening of the financial sector would also ask for thorough policy measures and will take time to achieve it. Both will for quite some time impede inflation targeting in Serbia, Albania and Romania.

A side policy implication of our results is that the central bank of Albania could improve its anti-inflationary credentials, as we found that it behaves asymmetrically i.e. opting easier for the rate cut than the raise. Nevertheless the other five central banks acted symmetrically indicating their sound anti-inflationary stand. In addition we found that the main fundamental factors determining decisions of inflation targeting central bank in advanced economies: inflation, output gap and inertia, enter also monetary policy rule in emerging Europe, indicating that the latter central banks are mostly in the line with their counterparts in developed countries.

Appendix A.

Table A1

Data definitions and sources

Variable	Definition	Sources
inflation	CPI inflation rate, monthly data (in %).	Database of corresponding central bank: Czech Rep., Poland, Hungary Romania, Serbia and Albania.
inflation gap	Deviation of the CPI inflation rate which is computed using Hodrick-Prescott filter with a smoothness parameter of 100.	Authors' calculations.
gdp	Gross domestic product, quaterly data, seasonally adjusted (in constant prices). Constructing monthly time series data by temporal disaggregation from quarterly data.	Country Statistical Office Databases; Authors' calculation of disaggregated data of monthly frequency.
output gap	Deviation of the monthly GDP (nathural logarithams) from it's trend, which is computed using Hodrick-Prescott filter with a smoothness parameter of 100 .	Authors' calculations.
interest rate	Key policy interest rate (in %).	Database of corresponding central bank: Czech Rep., Poland, Hungary Romania, Serbia and Albania.
exr	Real exchange rate to euro (nominal exchange rate/CPI, corrected for HCPI for 17 Euro area countries)	Database of corresponding central bank: Czech Rep., Poland, Hungary Romania, Serbia and Albania. for EU17 Euro area: Eurostat database.
exr_gap	Deviation of the real exchange rate (nathural logarithams) from it's trend, which is computed using Hodrick-Prescott filter with a smoothness parameter of 100.	Authors' calculations.

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[i] See respective central bank data bases.

[ii] The exceptions are National Banks of the 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.

[iii] Results are available from the authors upon request.

[iv] There are five to six occurrences of negative monthly inflation in each of three countries: Albania, Serbia and Romania, in 2014 (cf. Respective central bank and statistical office data bases).

[v] Thus since the introduction of de-euroization policy in the early 2011 through January 2015, the share of foreign currency deposit decreased by 4pp while that of loans in fact increased by 1.7pp,while both still remaining extremely high: 78% and 70% respectively (cf. National Bank of Serbia, Monetary and Financial Statistics).