

# A Markov Switch to Inflation Targeting in Emerging Market Peggers with a Focus on the Czech Republic, Poland and Hungary

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*The objective of this paper is to empirically examine if monetary policy conduct has significantly changed in nine emerging economies, including the Czech Republic, Poland and Hungary, after the switch from exchange rate targeting to inflation targeting. An augmented Taylor rule is estimated with a Markov switching method for each of the nine countries on the basis of monthly data over the period from the early 1990s to end-2009. In general, the results suggest that inflation targeting represented a real switch in eight emerging economies. We identified the following differences for the period of inflation targeting compared to the preceding period of exchange rate targeting: (1) The economic environment became more stable; (2) the central bank's reaction to inflation deviations from the target moderated (as it was probably possible to share the burden of inflationary pressures between interest rate increases and currency depreciations); (3) the central bank's response to the output gap also moderated although it was statistically significant in only half of the countries; this is an indication of strict inflation targeting whereby meeting the inflation target is the primary objective. For the Czech Republic and Poland, an intermediate regime is identified, which is associated with the economic developments in these two countries prior to establishing a full-fledged inflation targeting regime. For Hungary, we identified only one regime, which is likely to reflect the combined strategy of targeting both the exchange rate and inflation that the country followed nearly over the entire period under review.*

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## 1 Introduction and Motivation

“Throughout the world, monetary policy regimes have changed dramatically over the decade of the 1990s. [...] The biggest transformation has been the move away from focusing on intermediate objectives, such as money and exchange rates, toward the direct targeting of inflation.” (Cecchetti and Ehrmann, 1999, p.1). Inflation targeting (IT) as a monetary regime is relatively new, dating back to the beginning of the 1990s, when New Zealand was the first country to adopt an official inflation target. IT is a regime based on rules and objectives that have to be achieved and which is free of any other monetary policy target. By this definition, there are 26 inflation targeters in the world today (plus three that have switched regimes to join the euro area; see table A1 in the annex).

As a monetary regime, IT emerged in the developed world. Chart 1 depicts the time of IT adoption and the income level per capita in the same year in the countries under review. We denote the adoption of IT by advanced economies as the first wave, which terminated in the mid-1990s (chart 1, blue diamonds). In these countries, the initial results of the new monetary regime were satisfactory: Although the decline in inflation had started before the introduction of IT, “inflation did not bounce back up afterwards as expected” (Mishkin and Posen, 1998, p.90). The majority of quantitative studies on IT are conducted on datasets

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for those countries. However, there is no overwhelming evidence that the new regime significantly affected inflation expectations or that it significantly reduced output volatility. It is important to note that the central banks of these countries enjoy high credibility, which is important for this monetary regime. After the first inflation targeters had successfully established and maintained a low inflation level, a new wave of inflation targeters formed at the end of the decade, namely a number of emerging economies (chart 1, red squares). There has been a growing body of studies on IT in emerging economies, but the review in Petreski (2009a) finds that these studies are merely descriptive. A third wave of IT adoption has been underway in a range of developing countries since 2005 (chart 1, purple triangles); most of these countries used to rely on alternative strategies but embarked on IT expecting their economies to benefit from this regime switch. Finally, a growing number of economies are currently examining the introduction of targets, and several have already launched preparations for formally adopting them. This group includes Albania, Armenia and Kazakhstan, which already have price stability as a stated objective but have yet to adopt a formal IT regime. The world economic crisis might postpone such plans, which are currently not high on the agenda in these countries.

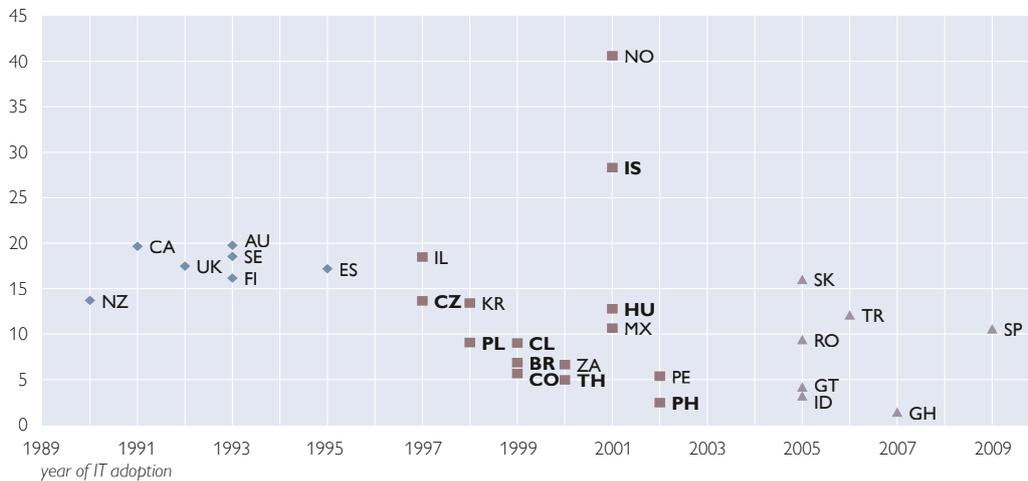
Some of the current inflation targeters switched to the new regime because they faced pressures in the foreign exchange market or even a demise of the fixed exchange rate system. To start with, the United Kingdom and Sweden abandoned the Exchange Rate Mechanism (ERM) due to its crisis in 1992–93. However, the majority of countries that experienced market pressure on the pegged rate of their currencies were emerging economies. Brazil, for instance, abandoned the peg after its real exchange rate crisis in early 1999, embarked on a floating regime and officially adopted IT. In Thailand, following the Asian financial crisis in 1997 and the demise of the Thai baht exchange rate system, a floating rate was introduced alongside a money base target. The latter suffered from the weak link between money and prices and, ultimately, the central bank adopted an IT framework. After the boom of capital inflows in Hungary in the late 1990s, the pressures on the foreign exchange market resulted in a widening of the forint's exchange rate band to  $\pm 15\%$  in 2001 and the adoption of IT. The Czech Republic and Poland also introduced IT after exchange rate regime turbulence, albeit the establishment of the new regime in Poland was more gradual. In total, 14 exchange rate peggers embarked on IT. However, it is reasonable to suspect that the switch in developed countries (the U.K., Sweden, Finland and Spain) might have been a different process, which may be ascribed to the higher credibility of these countries' central banks or to the fact that these countries were part of ERM. Moreover, Finland, Spain and Slovakia no longer apply IT, as they have all joined the euro. Nine switchers analyzed in this paper are emerging economies, including three Central, Eastern and Southeastern European emerging economies (CESEE-3) – the Czech Republic, Poland and Hungary – as well as Brazil, Chile, Colombia, Israel, Philippines and Thailand. Of these countries, only Hungary switched to IT but kept the exchange rate target, while all the others introduced a form of managed floating along IT.

The argumentation and empirical evidence (summarized and empirically explored in Petreski, 2009b and 2010) suggest that exchange rate pegging may not be important in affecting the long-term growth performance of an economy but plays a key role in stabilizing output fluctuations. However, when large real shocks

Chart 1

### Three Waves of Inflation Targeters

GDP per capita (PPP) in the year of IT adoption in thousand



Source: IMF.

Note: Countries in bold indicate emerging economies that switched from ERT to IT and have therefore been chosen for this paper's investigation.

hit, it may spur output volatility. It is argued that as the links between the real economy and international financial markets increase, real shocks become likely. Further, Petreski (2009a) suggests that the exit from an exchange rate peg will provide the economy with more flexibility in buffering real shocks, but the economy will still need a monetary anchor. IT along with a managed floating exchange rate regime is argued to provide a nominal anchor and to take into consideration the need to reduce output and exchange rate volatility (Goldstein, 2002). Yet, opinions in the literature as to how effectively such a policy can smooth output fluctuations remain divided. Moreover, the role of the exchange rate has been neglected for advanced economies, but has become more important for emerging and developing economies (1) because the exchange rate is the core transmission channel for monetary policy, (2) because of its complex macro-relationships, like the level of currency substitution, and (3) because of these economies' exposure to capital inflows reversals and sudden stops (Eichengreen et al., 1999, and Chang and Velasco, 2000).

The aim of this paper is to empirically examine the monetary policy responses during a switch from exchange rate targeting (ERT; fixed exchange rate) to IT in nine emerging economies. The paper is organized as follows: Section 2 discusses the theoretical background and the empirical methodology. Section 3 discusses data issues. Section 4 reports and discusses the findings. The last section concludes.

## 2 Theory and Empirical Methodology

### 2.1 Theoretical Model

Given the objective of the paper to investigate monetary policy responses during a switch from exchange rate targeting to inflation targeting, the first step is to establish a representation of the monetary policy stance. A large strand of the monetary economics literature suggests the Taylor interest rate rule (Taylor, 1993

and 2001), as a neat way to represent monetary policy. In general, such a monetary policy reaction function explains reactions of the central bank to macro variables (like the output gap and inflation), which at the same time is consistent with the description of the IT regime (see, for instance, Svensson, 2000). The economic model is therefore:

$$r_t = \alpha + \rho r_{t-1} + \beta_1 \pi_t + \beta_2 (y_t - y_t^*) + \beta_3 \Delta e_t + u_t \quad (1)$$

where  $r_t$ ,  $\pi_t$ ,  $(y_t - y_t^*)$ , and  $e_t$  denote the nominal interest rate, inflation, the output gap and the nominal exchange rate, respectively, at time  $t$ ;  $\Delta$  is the first difference operator;  $\rho$  is the smoothing parameter to be estimated;  $\beta$ s are coefficients to be estimated, measuring the central bank response to the changes in these variables, which can partly reflect authorities' preferences in designing monetary policy; and  $u_t$  is the error term. This is an interest rate rule augmented with the exchange rate due to the latter's role in the monetary policy of emerging economies (see Frankel, 1979). Moreover, interest rate smoothing is allowed for in the equation by adding a lagged endogenous variable. Mohanty and Klau (2005) offer several reasons for smoothing: (1) the reduction of the risk of policy mistakes when uncertainty about model parameters is high and when policymakers have to act on partial information; (2) the authorities' concern about the implications of their actions for the financial system: If markets have limited capacity to hedge interest rate risk, a sudden and large change in the interest rate could expose market participants to capital losses and may raise systemic financial risks; and (3) the avoidance of reputation risks to central banks from sudden reversals of interest rate directions, to mention just a few.

## 2.2 Empirical Methodology

### 2.2.1 Nonlinear Switching Regression

The second step in achieving the objective of the paper is to design a methodological framework for analyzing a switch from one monetary regime to another. A switch in the data itself represents a source of nonlinearity in the data. Hence, a nonlinear method will be used. The last two decades marked a substantial increase in the application of this type of methods to macroeconomic and financial data. The regime switching methods can be largely classified in two groups: threshold autoregressive (TAR) methods and Markov switching (MS) methods. The threshold autoregressive method models the behavior of a variable in relation to a threshold value (Tong, 1983) and depends on two factors: (1) the choice of the threshold variable and (2) the information about the official switch. In contrast to the TAR approach, the structural break in the MS approach is the outcome of an unobserved discrete random variable, which is assumed to follow a Markov process.<sup>2</sup> This strand of the literature was steered by the seminal contributions of Hamilton (1989 and 1994), although the work was originally motivated by Goldfeld and Quandt (1973). Since then, a growing literature on regime switching in applied macroeconomic time series analysis has emerged. However, these applications are

<sup>2</sup> A Markov process is a stochastic process in which only the present value of the variable is relevant to predict its future behavior, i.e. its past values and the way in which the present value has emerged from the past are irrelevant. Hence, Markov processes are not path dependent.

still largely limited to business cycle analysis (Cecchetti et al. 1990; Ravn and Sola, 1995; Diebold and Rudebusch, 1996). A small part of the literature (Ang and Bekaert, 2002; Valente, 2003; Sims and Zha, 2006; Vázquez, 2008) analyzes interest rates but – to our knowledge – no study has used these methods to analyze monetary policy in the context of a monetary regime switch. Also, these empirical applications are largely limited to developed countries.

Why should we use the MS approach? Firstly, Ball and Sheridan (2005) argue that a simple switching approach whereby a dummy is added to capture the switch in the switching group is still open to the identification strategy problem, i.e. whether the chosen comparison group is indeed a reliable control group. Moreover, Creel and Hubert (2009) point out that contrary to the simple switching approach and the TAR methods, MS methods will circumvent the task of pre-defining a switch or a threshold and will simply reveal if and when different regimes occurred in the switching economies. Letting data speak freely will address the concern that investigating the presence of distinct regimes rather than assuming a strict break would enable checking if anti-inflation policies existed in the past (i.e. the authorities might have started to target medium-term inflation before they officially announced a switch) or if the exchange rate target was not fully abandoned even after the official switch to IT (i.e. the authorities continued to target the exchange rate for a certain period after they officially switched). Finally, by allowing the variance of residuals to differ in both regimes, MS methods make it possible to investigate whether the economic environment changed due to monetary policy.

### 2.2.2 Designing a Markov Switching Regression

In an MS regression, explanatory power is assigned to the existence of a few “states” (regimes) among which the economy shifts:

$$y_t - \mu_{s_t} = \sum_{i=1}^4 \phi_i (y_{t-i} - \mu_{s_{t-i}}) + \varepsilon_t \quad (2)$$

where  $y_t$  is a univariate time series to be explained;  $s_t$  is a latent dummy variable taking the value of 0 or 1 and representing two states in which the economy could fit; and  $\varepsilon_t$  is Gaussian white noise (Hamilton, 1989).  $\mu$  is a mean term conditional upon the state in which the economy is; the state is assumed to be unobservable and has to be inferred from the data. In cases where the null of  $\mu = 0$  cannot be rejected, only one state governs the process and this could be represented by the standard AR model.

To complete the description of the dynamics of (2), we need to define a probability rule of how  $y_t$  changes between regimes. A Markov chain is the simplest time series method for a discrete-valued random variable, such as the regime variable  $s_t$ .  $s_t$  is assumed to follow an ergodic<sup>3</sup> first-order Markov process (and is, hence, serially correlated) and is characterized by the matrix  $\Pi$ , consisting of the transition probabilities  $p_{ij}$  from state  $i$  to state  $j$ :

<sup>3</sup> Similarly, a stochastic process is said to be ergodic if no sample helps meaningfully to predict values that are very far away in time from that sample. To put it differently, the time path of the stochastic process is not sensitive to initial conditions.

$$\Pi = \begin{bmatrix} p_{11} & p_{21} & \dots & p_{N1} \\ p_{12} & p_{22} & \dots & p_{N2} \\ \cdot & \cdot & \dots & \cdot \\ p_{1N} & p_{2N} & \dots & p_{NN} \end{bmatrix}$$

$$p_{ij} = p(S_t = j | S_{t-1} = i, S_{t-2} = k, \dots) = p(S_t = j | S_{t-1} = i) \quad (3)$$

$$\sum_{j=1}^N p_{ij} = 1; i = 1, 2, 3, \dots, N; 0 \leq p_{ij} \leq 1$$

For a two-regime state space, transition probabilities can be expressed as follows:

$$\begin{aligned} p[S_t = 1 | S_{t-1} = 1] &= p \\ p[S_t = 2 | S_{t-1} = 1] &= 1 - p \\ p[S_t = 2 | S_{t-1} = 2] &= q \\ p[S_t = 1 | S_{t-1} = 2] &= 1 - q \end{aligned} \quad (4)$$

Here, the probability that the economy has been in regime 1 and will stay in the same regime is  $p$ ; the probability that it was in regime 1, but it is now in regime 2 is  $1-p$ , and so on. With these transition probabilities the regime switch is dependent only on the state before the switch, while the expected duration of each regime is constant (Kim et al., 2008). In other words, Hamilton's (1989) approach does not require any prior information to characterize the current state of the economic series. Hence, the evolution of the regime switch occurs exogenously. However, this specification appears very restrictive in the description of regime changes.

### 2.2.3 Endogeneity in a Markov Switching Regression

As argued above, Hamilton's (1989) model is a univariate framework that assumes the regime shift being exogenous to all realizations of the regression disturbance. Since Hamilton (1989), many applications have used MS models that included additional explanatory variables (see Maddala and Kim, 1998, pp.463, for a review). In these models, however, independent variables, as in every other form of regression, may be endogenous and the switch may evolve endogenously. Neither source of endogeneity in the MS regression was resolved until Krolzig (1998), who developed the MS methods in the area of vector auto regressions (hereafter MS-VAR; see Krolzig, 1998). These are standard VAR models, in which some or all of the parameters are allowed to switch when the regime changes. In its most general form, the MS-VAR process has the following form:

$$y_t = v(S_t) + \sum_{i=1}^p A_i(S_t) y_{t-i} + \varepsilon_t \quad (5)$$

where  $y_t = (y_{1t}, \dots, y_{nt})$  is an  $n$ -dimensional transposed vector,  $v$  is the vector of intercepts,  $A_1, \dots, A_p$  are the matrices with the autoregressive parameters and  $\varepsilon_t$  is the white noise vector process; all can be dependent on the switching variable  $S_t$ .

By allowing the potential determinants of the switch to interact in a dynamic framework, the endogeneity arising from the selection of observables is addressed. However, given that transition probabilities are constant, one may still be concerned about switch endogeneity stemming from unobservables. Moreover, it is reasonable to believe that a regime's duration may inflict a switch and hence duration can be another source of switch endogeneity. The possible presence of remaining switch endogeneity can be checked only indirectly, though. Vázquez (2008) argues that there would be a cause for concern if estimated probabilities differed under alternative MS-VAR specifications, that is, the switching variable would exhibit endogeneity stemming from unobservables if the probabilities depended on the MS-VAR specification. Any remaining endogeneity because of duration is checked following the procedure of Pelagatti (2008) (see section 4.2). At present, hence, the non-comprehensive approach to dealing with switch endogeneity seems to be the major drawback of the MS-VAR.

### 2.3 Derived Estimation Equation

After defining the representation of monetary policy (section 2.1) and the MS method for capturing nonlinearities in the data (section 2.2), our economic model (1) needs to be defined in a reduced Markov-switching vector autoregressive (MS-VAR) form, as follows:

$$y_t = v(S_t) + \sum_{i=1}^p A_i(S_t)y_{t-i} + \sum_{i=0}^p B_i(S_t)x_{t-i} + \varepsilon_t \quad (6)$$

where  $y_t$  is our four-dimensional vector comprising the nominal interest rate  $r_t$ , inflation  $\pi_t$ , the output  $gap_t$ , and changes in the nominal exchange rate  $\Delta er_t$ ;  $x_t$  is a vector of exogenous variables, which could enter contemporaneously or with a lag, but is not mandatory;  $v$  is the vector of intercepts,  $A_1, \dots, A_p$  and  $B_0, \dots, B_p$  are the matrices containing the autoregressive parameters and  $\varepsilon_t$  is the white noise vector process. The model is set as *MSIAH(2)-VAR( $\rho$ )*, allowing the intercept ( $I$ ), autoregressive terms ( $A$ ) and the variance ( $H$ ) to switch between two regimes. The intercept and regressors are allowed to switch, but additionally, by allowing the overall variance of the vectors to change and be part of the regime switching identification, we may check if the monetary environment changed between the two regimes. No exogenous regressors are included in the baseline specification.  $\rho$  denotes the number of lags, which is chosen by appeal to the Schwarz information criterion (SIC), after serial correlation has been eliminated. Based on the statistical properties of the identified regimes, we will argue later if these can be reconciled with the switch from ERT to IT. Some authors (for instance, Clarida et al., 2000, or Rudebusch, 2002) suggest and estimate empirical Taylor rule versions which are based on lagged variables only, which is the case with any VAR framework, including MS-VAR. To estimate our MS-VAR model, the expectation-maximization (EM) algorithm (Dempster et al., 1977) is used.

### 3 Data Issues

For the estimation of equation (6), monthly data from the beginning of the 1990s to the end of 2009 are used, with the starting date depending on data availability. The use of monthly data is justified by the fact that almost all central banks decide on the interest rate at a fortnightly frequency. The data are from the IFS database. The policy interest rate  $r_t$  is represented by the money market rate, as it best mirrors the monetary policy stance; the discount rate is used in cases where the money market rate was not available. Inflation, output gap and the exchange rate enter the baseline specification as potentially endogenous regressors. Inflation ( $\pi_t$ ) is calculated as the year-on-year monthly percentage change of the consumer price index. The output gap ( $gap_t$ ) is calculated by applying a Hodrick-Prescott (HP) filter to the industrial production index since GDP is not available on a monthly basis. The difference in the exchange rate ( $\Delta er_t$ ) is approximated by the year-on-year monthly percentage change of the nominal exchange rate of the national currency against SDRs, since other series, like the nominal effective exchange rate, were missing for a major part of our sample. Reserves growth and currency substitution enter as exogenous variables ( $x_t$ ) in the robustness checks (the conceptual reasons for including these variables are provided in section 4.2). Reserves growth is calculated as the year-on-year monthly percentage growth of the official reserves minus gold. Currency substitution in the economy is approximated by net foreign assets in the banking system as a percentage of GDP. Further data-related details are provided in table A2.

## 4 Empirical Results

### 4.1 Baseline Results

Table 1 provides the results of our study for each country. It includes only the vector for the interest rate because it represents our economic model (1). The linearity test is provided in the last row of table 1. This test is based on the likelihood ratio statistic between the estimated model and the derived linear model; under the null hypothesis the linear model is preferred (Doornik and Hendry, 2009). The first p-value is based on the conventional chi-squared distribution, while the second one is derived by Davies (1987). In all cases, the linearity test suggests that the model is significantly nonlinear (i.e. the variation in interest rates can be described by more than one single regime) and that parameters switch between regimes. The remaining diagnostic tests are available on request. They suggest that the errors can be considered normally and independently distributed, while the model is stable. All the remaining vectors are similarly well specified; they are also available on request.

Now we focus on four aspects in explaining the results in table 1: (1) the persistence of the system in each regime, (2) the volatility of innovations in each regime, (3) estimates of the model in each regime, and (4) the date of switching inferred from the data. Note that since we have not yet related the identified regimes to ERT or IT, the reporting in table 1 and the explanation henceforth is set so that regime 1 corresponds to the earlier regime in time and regime 2 to the later one.

The transition probabilities  $p_{11}$  and  $p_{22}$  refer to the probability that the regime which prevailed in the previous period will continue to operate in the current period and, in that way, are an indication of regime persistence. The reported transition probabilities suggest that regimes are highly persistent, i.e. there are no

Table 1

### Baseline Results

Dependent variable	Czech Rep.	Hungary	Poland	Brazil	Chile	Colombia	Israel	Philippines	Thailand
Interest rate	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
<b>REGIME 1</b>									
Constant	3.048***	7.007	5.160***	14.862**	4.078***	-3.372	0.311	10.565***	2.580**
Σ Interest rate lags	0.695***	0.797***	0.672***	0.599***	0.075	0.532***	0.947***	0.352***	0.762***
Σ Inflation AR lags	0.071**	-0.192	0.069*	-0.48	1.232*	0.801***	0.036	-0.186	-0.111
Σ Gap AR lags	0.056	0.161*	0.204*	0.575*	0.791*	0.169*	0.058	-0.089	0.062*
Σ Exchange rate AR lags	0.067**	0.13	0.021	-0.011	0.05	0.148*	0.008***	0.018	0.053*
Regime volatility	1.636	0.685	1.857	4.399	3.705	4.805	0.556	4.003	2.356
Rough regime timing	1994:4 - 1999:2	1992:7 -1996:10	1992:5 - 1998:7	1997:3 - 1998:8	1993:8 - 2001:8	1995:4 - 2000:3	1992:3 - 1998:4	1992:2 - 1999:5	1992:2 - 1999:1
<b>REGIME 2</b>									
Constant	0.052***	0.09	0.163	0.033	-0.066**	-0.433	0.012	0.359***	0.086*
Σ Interest rate lags	0.960***	0.949***	0.931***	0.999***	0.933***	0.828***	0.989***	0.954***	0.910***
Σ Inflation AR lags	0.022***	0.045***	0.041***	0.024***	0.031***	0.258***	0.004***	-0.012	0.048***
Σ Gap AR lags	-0.003	-0.009	0.018**	0.026*	-0.006	0.009	0.007*	0.002	0.003*
Σ Exchange rate AR lags	0	0.004	-0.004	0	-0.007***	-0.001	0.006	0.006*	-0.006*
Regime volatility	0.147	0.329	0.394	0.248	0.245	0.374	0.159	0.287	0.221
Rough regime timing	1999:3 - 2009:10	1996:11 - 2009:10	1998:8 - 2009:11	1998:9 - 2009:7	2001:9 - 2009:9	2000:4 - 2005:9	1998:5 - 2009:10	1999:6 - 2008:12	1999:2 - 2009:11
p11	0.984	0.682	0.969	0.695	0.969	0.964	0.971	0.927	0.988
p22	1	0.949	0.981	0.928	0.979	0.984	0.982	0.959	1
No of observations	188	211	211	153	194	126	212	203	214
Lags (based on SIC)	2	3	4	2	4	1	2	1	1
Inferred switch	1999:03	1996:11	1998:08	1998:09	2001:09	2000:04	1998:05	1999:06	1999:02
Official switch	1997:12	2001:06	1998:01	1999:06	1999:09	1999:10	1997:06	2002:01	2000:05
Linearity test Ho: The linear model is preferred									
(chi-stat)	0	0	0	0	0	0	0	0	0
(Davies)	0	0	0	0	0	0	0	0	0

Source: Author's calculations.

Note: \*, \*\*, \*\*\* indicate significance at the 10%, 5% and 1% level, respectively. Σ indicates that whenever more than one lag was used, the estimated cumulative effect (the sum of the lags for each variable) is reported along with the Wald test of joint significance. Regime volatility is measured by the standard error of the residuals of the interest rate vector. "Rough regime timing" indicates periods in which the respective regime prevailed for a longer period (and not only for a few months).

temporary and frequent switches between regimes. In particular, in the cases of the Czech Republic and Poland both identified regimes are highly persistent, while in the case of Hungary regime 1 is not as persistent as regime 2, i.e. regime 1 appears only sporadically.<sup>4</sup>

The standard error of the residuals of the interest rate equation in each regime, which approximates the overall volatility of the economic environment in the respective regime, is reported within each regime's panel in table 1. The volatility is much higher in regime 1 than in regime 2. Therefore, regime 2 can be identified as the regime with a lower volatility compared to regime 1. In the case of the Czech Republic and Poland, the volatility of the residuals under regime 1 is eleven and five times higher, respectively, than the volatility under regime 2. In Hungary, the economic environment under regime 1 is only twice more volatile than under regime 2.

<sup>4</sup> Note that linearity was also rejected in the case of Hungary. Thus, despite a comparatively small persistence of regime 1, the nonlinear (two-regime) model should be more informative than a simple linear (one-regime) specification.

The estimated coefficients are given in the panels headed “Regime 1” and “Regime 2” in table 1. Whenever more than one lag was used, the cumulative effect (the sum of the lags for each variable) is reported, along with the Wald test of their joint significance. The results suggest that the coefficient associated with the lagged interest rate generally ranges above 0.9 in regime 2 and between 0.6 and 0.7 in regime 1, suggesting a higher degree of interest rate smoothing under regime 1. It is likely that under IT, policymakers are more cautious in the conduct of monetary policy, i.e. they are more vigilant to avoid policy mistakes. This is consistent with the view that under ERT, monetary policy depends on the monetary stance in the anchoring country, and hence smoothing might decline.

The estimated coefficients suggest that central banks respond significantly to inflation in regime 2, while the response in regime 1 remains insignificant in five out of nine countries. In regime 2, the central bank response to a change in inflation of 1 percentage point ranges from very mild in Israel (0.004 percentage points) to considerable in Columbia (0.26 percentage points), with the median being a 0.03 percentage point increase of the interest rate (in Chile). Still, if the significant coefficients between the two regimes are compared, we observe that the reaction to inflation in regime 2 has moderated. In the case of the Czech Republic and Poland, the central banks significantly react to inflation under both regimes, but the reaction moderates two to three times under inflation targeting. A coefficient on inflation similar to that in the Czech Republic and Poland in regime 2 is observed in Hungary, but the respective coefficient under regime 1 is insignificant.

The output gap effect in both regimes is significant in about half of the countries, frequently only at the 10% level. The estimated responses, where significant, suggest that the policy reaction to output fluctuations in regime 2 has moderated as well. Moreover, when compared to the response to inflation, the response to the output gap in regime 2 is found to be milder, ranging from 0.003 percentage points in Thailand to 0.026 percentage points in Brazil. Within the CESEE-3, only in Poland the policy response to the output gap is significant under both regimes and suggests a response moderation of about ten times. But can this be interpreted as evidence that these central banks were less concerned with the level of economic activity than with inflation? The answer is no, because of Svensson’s (1998) argument that the size of the estimated coefficient on the output gap does not necessarily reflect the importance of that variable in the central bank loss function, but that the weight and the size of the coefficient are related in a nonlinear fashion. The objective here is not to find out the weight, because the obtained information that the central bank started to take into consideration, albeit partially, the movements in the real economy, besides inflation, is sufficient for our purpose.

At last, responses to exchange rate movements are largely insignificant under both regimes. Within the CESEE-3, the response to the exchange rate is only significant in the Czech Republic under regime 1, suggesting that the central bank considerably used the exchange rate as a high frequency indicator in guiding monetary policy under regime 1. To check for the concern that the general insignificance of the exchange rate might be due to the fact that pressures on the foreign exchange market are not fully reflected in the nominal rate, which at least under regime 1 was pegged, a robustness analysis with reserves is carried out in section 4.2.

Given the above discussion, we can argue that in our sample of nine emerging market switchers, regime 1 could be reconciled with ERT and regime 2 with IT, for (at least) six reasons:

- (1) The volatility of the residuals under regime 2 is considerably lower than under regime 1. DeBelle (1999) argues that IT is designed to allow moving not only along the (inflation-output volatility) trade-off curve, but also to the left on a new, lower volatility curve. Also, by allowing for a discretion constrained by a pre-set inflation target and a horizon to achieve it, the central bank is able to manage a multitude of objectives (nominal and real), which potentially involves the lowest possible macroeconomic volatility.
- (2) The persistence of both regimes is high in almost all cases, which suggests long-lasting and continuous regimes rather than regimes which appear sporadically and with frequent changes.
- (3) The macroeconomic variables are considerably more often statistically significant in regime 2 compared to regime 1. This has been expected given the nature of the two regimes: Under ERT, monetary policy largely depends on the monetary policy in the anchoring economy, i.e. the room for maneuver for monetary policymakers to achieve domestic goals is restricted (and hence, the estimated effects of variables such as inflation and the output gap are statistically insignificant); on the other hand, IT is a “constrained discretion” strategy whereby the policy is directly geared toward achieving domestic objectives (and hence, variables such as inflation (in almost all cases) and the output gap (only in some cases) are statistically significant).
- (4) The significance and magnitude of the coefficients under regime 2 suggests that these countries embarked on strict IT (i.e. inflation is given prime consideration, output is considered only in some cases). This is expected, given that in the early phases of IT in emerging countries, credibility needs to be built through closely monitoring inflation.
- (5) The sporadically appearing significance and magnitude of the coefficient on economic activity may still suggest that although these economies geared their monetary policy toward strict IT they did to some extent consider the business cycle, which is an attribute of the IT design.
- (6) The date of the switch inferred from the data is close to the official date of the switch from ERT to IT (in all countries except Hungary).

The inferred timing of each regime and, hence, the inferred switch date, is given last in each regime’s panel in table 1. Given the argument about the potential endogeneity of the switch, we expected that the real switch, if it can be inferred from the data, would coincide roughly with the official switch (i.e. it can be just equal to the official switch only by chance). In Brazil, Philippines and Thailand, the inferred switch is found to precede the official switch, while in all remaining countries it followed the official switch. In the Czech Republic and Poland, the inferred switch took place 15 and 8 months after the official switch, respectively, suggesting that these countries officially embarked on the new regime (as a firm way to anchor inflation expectations), but most likely continued to closely target the exchange rate for some time after the official switch. For the Czech case, Hrnčir and Smidková (2004) describe the early phases of IT to involve backward-looking expectations, a still important role of regulated prices and exchange rate uncertainty. For the Polish case, note that the de facto exchange rate fluctuated

considerably even under ERT (see table A1); some (Pruski, 2002) relate this with the approach Poland followed as of 1995, which included a crawling peg of  $\pm 2.5\%$  and under which – temporarily – numerically expressed inflation rates were targeted. In section 4.2 a three-regime specification is estimated in order to check whether some intermediate regime (between ERT and IT) has been in place in the investigated countries.

Hungary is an exception in these considerations, since the inferred switch to regime 2 took place too long before the official switch to IT and the appearance of regime 1 is rather sporadic. Therefore it cannot be argued that regime 2 in Hungary is really an IT regime. Some intuition behind these results is that Hungary published inflation expectations in its monetary policy guidelines already in 1999. Moreover, the crawling peg since March 1995 served for both achieving exchange rate targets and disinflation. The crawling peg continued besides IT until September 2001; until February 2008 a  $\pm 15\%$  band around the central parity was in place. This suggests that Hungary had a de facto mixed system at least until 2008, whereby the exchange rate targets dominated at the beginning and were only gradually substituted by IT. This may be the reason why it is not possible to identify a clear regime switch in Hungary.

What could be caveats to these results? First, the most striking one is that the data may indicate a switch that is not the result of the IT strategy but of something else. For instance, the Czech Republic and Poland went through transition during regime 1, while the largest part of the 2000s was characterized by strong economic growth. But this is not the case in Hungary, which belongs to the same group of countries, geographically and in terms of economic developments. Second, Thailand and Brazil saw financial crises during regime 1 and a more stable period subsequently. Yet, as we argued earlier, a financial crisis can force the country to re-think its monetary regime. Third, these nine countries belong to distinct geographic regions, so the possibility that common regional shocks and potentially strong financial ties drive results is excluded. However, for strengthening confidence in the results, some robustness checks are performed in the subsequent section.

## 4.2 Robustness Checks

We perform three types of robustness checks: (1) allowing for three regimes, instead of two, to check if an intermediate regime between ERT and IT might have existed; (2) adding some exogenous variables and (3) checking for remaining endogeneity.<sup>5</sup>

First, table A3 in the annex gives the transition probabilities and volatilities for the three regimes: The timing in the table is set such that regime 1 corresponds to the potential period of ERT, regime 2 corresponds to the potential period of IT, and regime 3 stands for any other regime. The persistence and timing of regimes 1 and 2 can be reconciled with ERT and IT respectively; also the standard errors within these regimes are similar to those in table 1. In Brazil and Chile, regime 3 reflects some developments in the early 1990s, but these cannot be attributed to any intermediate regime. In Hungary and Philippines, regime 3 appears only sporadi-

<sup>5</sup> Detailed robustness check results that are not explicitly shown in the annex are available from the author on request.

cally (i.e. it has a low probability) and seems to be economically insignificant; moreover, in Hungary even regime 1 has a relatively low probability, as found before (see table 1). In Israel, regime 3 relates to the period of the mortgage crisis. However, in Colombia, the Czech Republic, Poland and Thailand, regime 3 reflects some developments between ERT and IT (bold-typed in table A3). This can be reconciled with the evidence that all these countries embarked on IT in the aftermath of exchange rate turbulence and when the need for disinflation emerged so that some of them pursued a money target for a short period after they had exited the peg and then started to target inflation. In the Czech case, the intermediate regime is likely to reflect the episode of sharp disinflation with a target of  $4.5\% \pm 1\%$  by end-2000, which was accompanied by a slowdown of the economy, a reduction of domestic demand pressures and a decline of inflation expectations (Hrncir and Smidkova, 2004). However, the volatility of the economic environment is found to be only about 1.5 times higher than under the subsequent IT. In the Polish case, we identify the period of the eclectic approach mentioned in section 4.1, when the central bank followed multiple objectives. This was a period of structural changes within the financial system and a period of constant disinflation. However, Poland experienced slower disinflation compared to other transition countries, which may have been the cause for the intermediate regime to have lasted relatively long. Moreover, the volatility of the economic environment is found to have been about 4 times higher than under the subsequent IT.

Second, the robustness of our results is tested by adding foreign exchange reserves growth and net foreign assets as a percentage of GDP as exogenous covariates which are allowed to switch across the two regimes. The intuition behind the inclusion of reserves growth is the same as the one behind the inclusion of the nominal exchange rate; apart from that, it should reflect pressures on the foreign exchange market more tightly. It is argued that for the periods under a pegged exchange rate, the nominal rate might not fully reflect these pressures. The ratio of net foreign assets of the banking system to GDP is included to measure the level of currency substitution to examine how it might have affected the conduct of monetary policy (see, e.g., Leiderman et al., 2006). These two variables were treated as exogenous in order to avoid cumbersomeness in the estimation of the VAR system. The baseline results remain robust to this treatment. Surprisingly, reserves growth is significant only in 3 out of 9 cases in regime 1 (which is associated with ERT), albeit its magnitude and negative sign are as expected: Increasing reserves afforded more space for reducing the interest rate in a pegging country. This result is also intuitive, given that reserves are the most important constraint for monetary policy in pegging countries. Under regime 2 the effect of reserves growth fully vanishes (except for Hungary). This might suggest that under IT, the external sector does no longer play a constraining role in monetary policy. However, this conclusion is very partial, given the limited significance of the external sector variables. Currency substitution is found not to have a systematically significant influence: In some countries it matters, but in others it does not. Moreover, the sign of the coefficient for Brazil and Chile is not as expected. In general, the limited evidence may support the idea that a higher exposure of bank net assets to exchange rate risk precludes the central bank from lowering the interest rate (i.e. restricts the monetary room for maneuver), but it is very feeble.

Third, given our discussion in section 2.2.3, the main challenge of the Markov switching analysis seems to be the approach toward addressing the endogeneity of the regime switch. Indirect ways are used to check for any remaining endogeneity of the switch. Valente (2003) argues that if there is remaining endogeneity in the system, regime probabilities will differ among specifications; duration-dependent MS-VAR (Pelagatti, 2008) is used to check for remaining endogeneity due to a regime's duration. The checks do not suggest that endogeneity remains in the switching variable due to unobservables or duration. In addition, the results regarding the transition probabilities within the duration-dependent MS-VAR suggest a very high probability that in long durations there will be a switch from ERT to IT. This is in line with the findings in Petreski (2010) that long pegs are prone to crises and countries tend to exit from pegs under hard attacks. Conversely, the transition probability that a switch from IT to ERT will occur ranges from 0% to 15% and, as expected, suggests that even after a very long duration, there will be no switch back from IT to ERT. This is in line with the argument in Svensson (1998 and 2000) and Debelle (1999) and could be ascribed to the flexibility of IT.

## 5 Concluding Remarks

The objective of the paper is to empirically examine if the conduct of monetary policy has significantly changed with the switch from exchange rate targeting (ERT) to inflation targeting (IT) in nine emerging economies, including three European countries (the Czech Republic, Hungary and Poland). Only nine emerging markets have so far switched from ERT to IT, while developed switchers are assumed to have followed a different process, which may be ascribed to the higher credibility of the central banks in these countries than in emerging and developing countries or to the fact that they were a part of ERM. The economic model used is a fairly classical Taylor rule augmented with the exchange rate to capture its specific role for emerging countries. The reference period spans from the early 1990s (depending on data availability in each country) until end-2009. The Markov switching vector autoregression was used for each of the nine switchers, allowing the intercept, autoregressive terms and the variance to switch between two regimes.

The conclusion from this investigation is that the switch from ERT to IT represented a real switch in the investigated countries, except Hungary. The results suggest that monetary policy has undergone a significant change in these countries in the late 1990s and/or early 2000s, respectively. First, the evidence provided in this paper opposes the usual statement in the literature that under IT, central banks react strongly – in terms of interest rate setting – to inflation deviations from the target. Compared to the preceding ERT regime, these reactions moderated under IT (although across countries the response to inflation was more often significant under IT than under ERT). One explanation could be that the countries were able to share the burden of inflationary pressures between interest rate increases and currency depreciations (the latter being unfeasible under ERT). Second, the effect of the output gap is found to be statistically significant in only half of the countries and also suggests reaction moderation under IT, pointing to strict inflation targeting, whereby inflation is given prime consideration and output is taken into account only in some cases. Third, exchange rate effects were found to be largely insignificant both under ERT and IT (probably due to the lack

of variability in exchange rates, especially under the former). Fourth, the volatility of the economic environment is found to be lower under IT than under ERT, pointing to more macroeconomic stability under IT. Finally, the inferred timing of the detected regimes can largely be reconciled with the official switch to IT.

In the cases of the Czech Republic and Poland, IT has been clearly identified as a separate monetary policy regime. In both countries the response to inflation moderated under IT. While the Czech Republic did not respond to the business cycle position in either regime, the respective response in Poland moderated under IT. In both countries, a third intermediate regime is identified, which is associated with the economic developments in these two countries prior to the establishment of fully fledged IT. Monetary policy conduct in Hungary is characterized by one regime only, which is likely to reflect the combined strategy of ERT and IT it followed over nearly the entire investigated period.

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## Annex of Tables

Table A1

### Fully Fledged Inflation Targeters and Switch

Country	Inflation targeting introduced in	Inflation rate at the beginning of inflation targeting (%)	Inflation target / band (%)	Monetary regime from which the switch has been made	De facto exchange rate regime (RR classification)			De jure exchange rate regime (IMF classification)		
					De facto ERR before the switch	Duration of ERR (years)	De facto ERR after the switch	De jure ERR before the switch	Duration of ERR (years)	De jure ERR after the switch
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
New Zealand	1989:12	3.3	1–3	Implicit nominal anchor	Managed floating	5	Managed floating	Free floating	6	Free floating
Canada	1991:2	6.9	1–3	Implicit nominal anchor	Limited flexible	20	Lim-flexible and flexible (2002)	Free floating	very long	Free floating
U.K.	1992:10	4	2	ERM I	Fixed	<2	Managed floating	Free floating	20	Free floating
Sweden	1993:1	1.8	2 (±1)	ERM I	Limited flexible	15	Managed floating	Fixed	16	Managed fl. and free fl.
Finland <sup>1</sup>	1993:1	2.6		ERM I	Limited flexible	21	Fixed	Fixed	22	Free floating
Australia	1993:6	2	2–3	Implicit nominal anchor	Free floating	9	Free floating	Free floating	9	Free floating
Spain <sup>1</sup>	1995:1	4.2		ERM I	Fixed	2	Fixed	Limited flexible	6	Limited flexible
Israel	1997:6	8.1	1–3	Exchange rate targeting	Managed floating	6	Managed floating	Managed floating	6	Managed floating
Czech Rep.	1997:12	6.8	3 (±1)	Exchange rate targeting	Limited flexible	6	Managed fl. and lim-flexible (2002)	Fixed	6	Managed floating
Poland	1998:1	10.6	2.5 (±1)	Exchange rate targeting	Managed floating	6	Managed floating	Managed floating	8	Free floating
South Korea	1998:4	2.8	3(±1)	Monetary targeting	Limited flexible	18	Managed floating	Managed floating	17	Free floating

<sup>1</sup> Finland, Spain and Slovakia abandoned IT upon entry into the euro area in 1999 (Finland, Spain) and 2009 (Slovakia) respectively.

Table A1 (continued)

**Fully Fledged Inflation Targeters and Switch**

Country	Inflation targeting introduced in	Inflation rate at the beginning of inflation targeting (%)	Inflation target / band (%)	Monetary regime from which the switch has been made	De facto exchange rate regime (RR classification)			De jure exchange rate regime (IMF classification)		
					De facto ERR before the switch	Duration of ERR (years)	De facto ERR after the switch	De jure ERR before the switch	Duration of ERR (years)	De jure ERR after the switch
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
<b>Brazil</b>	1999:6	3.3	4.5 (±2)	Exchange rate targeting	Limited flexible	6	Managed floating	Managed floating	5	Free floating
<b>Chile</b>	1999:9	3.2	2–4	Exchange rate targeting	Managed floating	7	Managed floating	Managed floating	18	Free floating
<b>Colombia</b>	1999:10	9.3	2–4	Exchange rate targeting	Managed floating	16	Managed floating	Managed floating	20	Free floating
South Africa	2000:2	2.6	3–6	Monetary targeting	Free floating	5	Free floating	Free floating	17	Free floating
<b>Thailand</b>	2000:5	0.8	0–3.5	Exchange rate targeting	Fixed	24	Managed floating	Fixed (1997) Free float (2000)	27	Managed floating
Mexico	2001:1	9	3 (±1)	Monetary targeting	Managed floating	5	Managed floating	Free floating	6	Free floating
Norway	2001:3	3.6	2.5	Implicit nominal anchor	Managed floating	55	Managed floating	Managed floating	6	Free floating
Iceland	2001:3	4.1	2.5	Implicit nominal anchor	Limited flexible	14	Managed floating	Managed floating	4	Free floating
<b>Hungary</b>	2001:6	10.8	3.5 (±1)	Exchange rate targeting	Limited flexible	7	Limited flexible	Managed floating	5	Fixed
Peru	2002:1	–0.1	2.5 (±1)	Monetary targeting	Limited flexible	8	Limited flexible	Free floating	12	Limited flexible
<b>Philippines</b>	2002:1	4.5	4–5	Exchange rate targeting	Limited flexible	5	Limited flexible	Free floating	13	Free floating
<b>Slovakia<sup>1</sup></b>	2005:1	5.8	6 (±1)	Exchange rate targeting	Limited flexible	6	Limited flexible	Fixed	2	Managed floating
Guatemala	2005:1	9.2	5.5 (±1)	Monetary targeting	Limited flexible	14	Limited flexible	Free floating	16	Managed floating
Indonesia	2005:7	7.4	5.5 (±1)	Monetary targeting	Managed floating	6	Managed floating	Managed floating	4	Managed floating
Romania	2005:8	9.3	4 (±1)	Monetary targeting	Managed floating	5	Managed floating	Limited flexible	3	Managed floating
Turkey	2006:1	7.7	4(±2)	Monetary targeting	Free floating	3	Free floating	Free floating	6	Free floating
Ghana	2007:5	10.5	0–10	Monetary targeting	Limited flexible	6	Limited flexible	Managed floating	6	Managed floating
Serbia	2009:1	6.5	8–12	Monetary targeting	Managed floating	6	Managed floating	Managed floating	6	Managed floating

Source: Reinhart and Rogoff (2004), Pétursson (2004), Hammond (2009), Rogoff (2009), IMF, national central banks and Carmen Reinhart's website.

Note: Countries in bold type represent the switchers from exchange rate targeting to inflation targeting.

<sup>1</sup> Finland, Spain and Slovakia abandoned IT upon entry into the euro area in 1999 (Finland, Spain) and 2009 (Slovakia) respectively.

Table A2

### Variables: Definition and Sources

Abbreviation	Description	Unit	Source	Notes
R	Money market interest rate	% per month	IFS <sup>1</sup> and national central banks	Wherever not available, the discount rate is used.
CPI	Consumer prices	Index number	IFS	
INF	Inflation	% per month (year on year)	Author's calculation	Inflation = $\log(\text{cpi}) - \log(\text{cpi}[-12])$
IND	Industrial production	Index number	IFS and national statistics offices	
GAP	Output gap	Percentage points	Author's calculation	The residual series between the actual and the potential output estimated from the industrial production by HP filtering.
ER	Exchange rate	Units of national currency per SDR	IFS	
DER	Change in the exchange rate	% per month (year on year)	Author's calculation	DER = $\log(\text{ER}) - \log(\text{ER}[-12])$
RES	Reserves minus gold	USD million	IFS	
DRES	Change in reserves	% per month (year on year)	Author's calculation	DRES = $\log(\text{RES}) - \log(\text{RES}[-12])$
NFA	Net foreign assets to GDP	National currency (million/billion)	IFS	NFA refers to the difference between foreign assets and foreign liabilities of the banking system, taken as an absolute value. The annual GDP is used for each month.

Source: Author's compilation.

<sup>1</sup> IMF International Financial Statistics.

Table A3

### Regimes' Persistence and Volatility for Three Regimes

Country	Transition probabilities			When does regime 3 ("Other") appear?
	[regime volatility]			
	p11	p22	p33	
	ERT	IT	Other	
<b>Czech Rep.</b>	<b>0.983</b> [1.510]	<b>0.946</b> [0.100]	<b>0.785</b> [0.161]	<b>1998:12–2000:4</b>
Hungary	0.667 [0.553]	0.551 [0.115]	0.106 [1.407]	Very sporadically
<b>Poland</b>	<b>0.974</b> [3.154]	<b>1</b> [0.295]	<b>0.989</b> [1.175]	<b>1995:3–2002:6</b>
Brazil	0.768 [2.167.3]	0.946 [1.328]	0.610 [84.636]	1992:7–1993:8
Chile	0.908 [2.331]	0.989 [0.151]	0.841 [6.165]	1993:8–1994:12
<b>Colombia</b>	<b>0.946</b> [2.934]	<b>0.942</b> [0.091]	<b>0.938</b> [0.700]	<b>1999:4–2004:12</b>
Israel	0.861 [0.892]	0.909 [0.174]	0.859 [0.268]	2009:1–2009:11
Philippines	0.778 [1.070]	0.989 [0.248]	0.640 [4.586]	Sporadically
<b>Thailand</b>	<b>0.988</b> [0.258]	<b>0.988</b> [0.143]	<b>0.946</b> [2.357]	<b>1999:2–2000:10</b>

Source: Author's calculations.

Note: Figures in square brackets are regime volatilities. Serial correlation has been accounted for. Bold type signifies 'other' regime that is identified between regime 1 and regime 2.