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# The Determinants of Deposit Euroization in the European Post-transition Countries: Evidence from Threshold VECM

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**The determinants of deposit euroization in European post-transition countries: evidence from threshold VECM**

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**Abstract**

This paper investigates monetary determinants of deposit euroization (DE) in European post-transition economies using both linear and threshold models. Results suggest that exchange rates and differences between domestic and euro interest rates are important for explaining DE. Results for two countries with highest macroeconomic and institutional credibility and flexible exchange rate regimes, i.e. Czech Republic and Poland show no sign of nonlinearities, while for other countries we found evidence of nonlinear behavior. Countries with fixed exchange rate regimes seem to react to DE changes with a lag and countries that do not have an exact commitment to neither a fixed nor a fully flexible regime show greater sensitivity and vulnerability to exchange rate changes. Threshold VAR results indicate that depreciations have a stronger effect on DE than appreciations and that interest rate spreads widen by a greater amount after exchange rate depreciations than after appreciations. Moreover, we found evidence that DE rises more strongly after interest rate differentials increase than when they decrease. We differentiate two types of deeuroization policy recommendations: achieving convergence criteria for countries with fixed exchange rates and for different types of managed floaters we suggest increasing macroeconomic and institution credibility in combination with regulatory measures and financial market development.

Key words: deposit euroization, transition, threshold, nonlinear
JEL Classification: C32 ; E44; E58 ; F31; F41

**1. Introduction**

In late eighties and early nineties high inflation dominated European transition countries. In order to restrain inflation expectations that were tied to exchange rate movements, central banks preferred to use the exchange rate as the nominal anchor (Mishkin, 2000; Frankel, 2010). However, due to significant “fear of floating”, exchange rate based monetary regimes continued to persist as an optimal policy choice for many European post-transition countries still pursuing currency boards, pegs, fixed, managed or even dirty floating exchange rate regimes.

As discussed in Calvo and Reinhart (2002), fear of floating is manifested as central banks’ reluctance to allow the exchange rate to adjust significantly and rapidly resulting in episodes of central bank interventions aimed at avoiding major devaluation shifts. Economic agents therefore anticipate exchange rate stability and eventually create very high levels of unofficial dollarization[1] (Levy Yeyati, 2003). Unlike adopting the euro as its official currency (known as official euroization), unofficial euroization is a result of voluntarily using foreign currency for different money functions. That being either medium of exchange function that leads to currency substitution or store of value function leading to asset substitution (Feige and Dean, 2002). The term asset substitution has been replaced by financial euroization (FE), defined as residents’ holding a significant share of assets or liabilities in foreign currency (Ize and Levy Yeyati, 2003). FE can be divided into deposit euroization (DE) and credit euroization (CE) with DE reflecting propensity of the private and public sector to hold deposits in foreign currency and CE a result of commercial banks propensity to grant loans in foreign currency or indexed to foreign currency.

It is argued that high levels of FE limit the choices for monetary policy makers since large exchange rate depreciations increase the cost of servicing foreign currency denominated debt and severely affect probabilities of default (Reinhart, Rogoff and Savastano, 2003). As a result, central banks

[1] Throughout the text, the term euroization will be used instead of dollarization as suggested by Feige and Dean (2002).

respond with a myriad of managed exchange rate regimes biased to depreciation. In line with that, FE indirectly affects the performance of all sectors of the economy, not just monetary policy. For example, Chang and Velasco (2002) find that detaining depreciation eventually pushes output down, Cabral (2010) warns of larger employment losses under "fear of floating" and Tsangarides (2010) reports that pegs have been recovering much slower than floaters in the latest 2010-2011 recovery phase. Although FE is a relevant economic policy issue, we still lack knowledge about that phenomenon, its determinants and influences on the economy. Since due to public debt explosion in some CEE countries like Hungary and Poland, euro adoption is no longer a viable strategy for dealing with unofficial euroization, it is important to provide answers to FE challenges. In order to ensure financial and economic stability in European post-transition countries, FE must be tackled.

Experiences from European post-transition economies show that FE decreases very slowly in periods of macroeconomic stability but increases swiftly in periods of economic uncertainty. Besides, exchange rate depreciations seem to push FE strongly and quickly while the opposite exchange rate changes have a much more moderate impact. This kind of FE dynamics resembles regime dynamics, case in which the variable reacts in one manner when above threshold and in different manner when below threshold. Although nonlinear or threshold effects describe the dynamics of exchange rate changes in partially euroized economies, no research regarding this issue has been carried out. In order to fill this gap, we test for the presence of threshold effects with respect to the level of deposit euroization and interest rate differentials to exchange rate changes. We would like to show how the responses to these changes differ depending on the level of DE and the exchange rate regime in the observed country. For each of these cases and countries we will use a methodology applicable to both the linear and the nonlinear model (Koop, Pesaran and Potter, 1996; Balke, 2000). Namely, we will derive generalized impulse response functions that vary in sign and magnitude and allow regimes to switch after a shock. We expect to show that highly euroized post-transition economies react differently to exchange rate changes than the ones that have a lower degree of euroization. Hence, the goal of this research is to answer two policy questions. What kind of threshold effects characterize an economy with a high level of DE? And if existing, how do these nonlinearities differ with respect to the prevailing exchange rate regime and/or the DE level?
The analysis will contribute to the existing field of knowledge in several ways. Firstly, it will give new insights into the origins, characteristics and consequences of DE in European post-transition economies. Namely, there is very limited research dealing with the influence of exchange rate changes on the level of both dollarization and euroization. Moreover, to the best of our knowledge, none of the existing research on FE tests for nonlinear or threshold effects of exchange rate changes on the level of DE. Since the analysis controls for the DE level, this also enables us to asses the determinants of euroization and its feedback effects. The applied methodology also allows us to see whether the determinants of euroization behave in a nonlinear fashion. As far as we know, there are no studies on euroization determinants using nonlinear methodologies.

The remainder of the paper is organized as follows. The next section presents an overview of the existing empirical literature with an emphasis to the results for FE in European post-transition rather than financial dollarization in Latin America. Sections three and four describe the applied methodology and data. Results of the empirical analysis are given in section five while the last section concludes the paper.

## 2. Literature

While there is no normative consensus on the effect of FE on the economy, researchers find that the relationship between the level of FE and monetary policy, trade balance and consequently output is an important one. In much of the recent literature on FE, the focus lies on detecting the determinants of euroization and the effects it has on the way monetary policy is conducted. In the nineties, it was considered that unofficial euroization was a consequence of high inflation rates and low credibility of monetary authorities as discussed in Levy Yeyati (2003). However, even after inflation moderated and the economy stabilized, euroization persisted (Kokenye, Ley and Veyrune, 2010). The existing literature offers several explanations for the observed FE persistence phenomenon and Levy Yeyati (2006) summarizes them into the currency substitution view, the portfolio view, the market failure view, and the institutional view.

The currency substitution view explains FE as an outcome of a negative relationship between demand for local currency and the rate of inflation (Savastano, 1996; Baliño, Bennett and Borensztein, 1999;

De Nicoló, Honohan and Ize, 2005). The portfolio view, also known as the optimal (minimum variance) portfolio, explains that high FE levels persist (even after prices stabilize) whenever the expected volatility of the inflation rate remains high in relation to that of the real exchange rate (Ize and Levy Yeyati, 2003). This theoretical explanation assumes that the uncovered interest rate parity holds given the real returns on different currencies. In short, if the variance of domestic inflation increases relative to the variance of real depreciation, the local currency becomes less attractive and FE increases.[2] The market failure view points out that the level of FE increases when market participants freely borrow and lend in foreign currency without considering major depreciation exchange rate risks. The behaviour is facilitated by central banks' commitment to maintain a stable exchange rate that creates lower risk of borrowing and lending in foreign currency and hence increases moral hazard and asymmetric information in the system. Lastly, the institutional view explains how FE rises when economic policy makers build their credibility on a stable exchange rate rather than on a strong institutional framework or regulations that favour domestic currency. Such institutional imperfections do not only increase FE but also the cost of exchange rate depreciation that in turn leads to an even stronger commitment of policy makers (Reinhart, Rogoff and Savastano, 2003; De Nicoló, Honohan and Ize, 2005; Rajan and Tokatlidis, 2005).

When testing for these theories empirically, Levy Yeyati (2003) finds that minimum variance portfolio is positively related[3] while average past inflation and GDP are negatively related to DE. He also finds a negative link between DE and financial depth, and that euroization is negatively correlated with output growth. Besides those FE drivers, Reinhart, Rogoff and Savastano (2003) add increased access to global capital markets while Feige (2002), Levy Yeyati (2003) and Stix (2010) emphasize the role of underdeveloped domestic financial market. Literature suggests other factors like massive arbitrage opportunities (Reinhart, Rogoff and Savastano, 2003; Levy Yeyati, 2006; Basso, Calvo-Gonzales and Jurgilas, 2011; Šošić, 2007; Kokenye, Ley and Veyrune, 2010) and the prospect of European Monetary Union membership (Rosenberg and Tirpák, 2008; Neanidis, 2010). In addition, it seems that geographical considerations like closeness to the European Union (ECB, 2010) and country size (Rosenberg and Tirpák, 2008) play a role. One must also not forget that remittances and income from tourism can have a significant impact on currency substitution in some post-transition economies (Stix, 2010).

Literature typically deals with dollarization in Latin America and determinants characteristic for that region, but in the last few years, witnesses a growing body of research on European post-transition countries that show different and very specific determinants of euroization. Therefore, a number of more recent studies on post-transition economies identify exchange rates, especially exchange rate volatility, the role of foreign banks and interest rate differentials as determinants of FE. Ozsoz, Rengifo and Salvatore (2008) estimate the probability of foreign currency intervention in five euroized post-transition economies using a volatility measure of the local exchange rate. Thereby, they demonstrate that central bank behaviour is predetermined by the level of euroization. Kokeyne, Ley and Veyrune (2010) find a positive link between real exchange rate and DE and a negative effect of increasing exchange rate volatility on both foreign exchange deposits and loans. A growing area of research considers financial integration, foreign bank presence and accumulation of foreign liabilities as an important driver of FE in transition economies. Basso, Calvo-Gonzales and Jurgilas (2011) show the interest rate differential has a negative effect on DE while access to foreign funds increases CE but at the same time decreases DE. For a number of transition economies during the period 2000-2006, they observe a negative relationship between FE and the difference between domestic and foreign currency interest rates. Similarly, Piontkovsky (2003) shows that relative returns on assets, defined as bank deposits in the domestic currency relative to deposits in foreign currencies, have a significant effect on the level of FE. Rosenberg and Tirpák (2008) find that rising interest rate differentials, foreign funding and openness promote CE. Luca and Petrova (2008) are not in accordance with Basso, Calvo-Gonzales and Jurgilas (2011) since they empirically show a positive relationship between interest rate differentials and DE and a negative relationship between exchange rate volatility and DE. Since their research is focused on CE, Luca and Petrova (2008) describe banks' "matching behaviour" and stress the role of foreign banks in driving foreign currency holdings in transition economies.

In a panel of more than a hundred countries, Carranza, Cayo and Galdón-Sanchez (2003) confirm that large depreciations have a negative affect on the pass-through coefficient with the impact being higher

[2] This minimum variance theory is discussed also in De Nicoló, Honohan and Ize (2005).
[3] Confirmed in Basso, Calvo-Gonzales and Jurgilas (2011).

the higher the level of dollarization. They also show that the exchange rate regime is important since countries with fixed exchange rates suffer larger balance-sheet effects after depreciations.[4] Moreover, they argue that large exchange rate depreciations can trigger a nonlinear effect to the balance sheet. Nevertheless, within the vast literature on euroization and related topics, these relationships are usually analysed as part of a linear model, more specifically a VAR model. Although persistence of FE and observed "fear of floating" in many post-transition economies imply a nonlinear relationship between the level of FE and the exchange rate, there are no models that take into account these nonlinear dynamics and responses to exchange rate changes. The only exception is Heimonen (2001) who analyses euroization in Estonia and uses threshold cointegration to estimate portfolio shifts between two substitute currencies, Euros and dollars. However, his study does not deal with FE determinants nor it considers substitution between foreign and domestic currency. Additionally, Neanidis and Savva (2009) use an index of asymmetry of exchange rate movements as in Rennhack and Nozaki (2006) and by using a nonlinear variable, they indirectly explore nonlinearities. They find that positive short-run effects of depreciations decrease with the level of euroization because depreciations induce depositors to change their currency compositions in favour of foreign currencies. Besides, they explain that FE is driven by interest rate differentials in line with Arteta (2005a) and Basso, Calvo-Gonzales and Jurgilas (2011) and that inflation changes do not affect short-run DE. Bigio and Salas (2006) build a genuine nonlinear model for a partially dollarized economy using structural VAR and results represented by generalized impulse response functions. They present monetary policy and exchange rate shocks of different size and magnitude and for different initial output gap levels. Their results imply that depreciations show nonlinear dynamics because they have larger negative effects during recessions and grater pass-trough rates during expansions. However, they do not include the dollarization variable in the model but only state that the data come from a highly dollarized economy such as Peru.

## 3. Methodology

### 3.1. Baseline Linear Model

Before conducting any kind of nonlinear modelling, we firstly need to specify a linear model. The most usual way to determine the effects that shocks have on a number of endogenous variables is to set up a VAR model. Normally, VAR is specified in the following form:

$$y_t = \Gamma_0 + \Gamma_1 y_{t-1} + ... + \Gamma_j y_{t-j} + u_t$$

where $y_t = (y_{1t,...,}y_{kt})'$ is a vector of k endogenous variables. $\Gamma_0$ is a k-dimensional vector including deterministic terms like a constant, a linear trend or even dummy variables while the $\Gamma_i$ coefficient matrix with i=1,…,j captures short-run dynamic effects. Finally, $u_t$ is a sequence of serially uncorrelated random variables with mean zero and a constant positive variance-covariance matrix. In case the variables are nonstationary we can rewrite the VAR model in vector error correction form:

$$\Delta y_t = b_0 + b_1 t + \Pi y_{t-1} + \sum_{i=1}^{j-1} \delta \Delta y_{t-i} + u_t$$

where $\Pi = \alpha\beta'$ is a matrix representing cointegrating equations with $\beta$ referring to cointegrating coefficients and $\alpha$ to loading coefficients. More specifically, $\Pi = I_m - \sum_{i=1}^{j} \Gamma_i$ and $\delta_i = -\sum_{i=1}^{j} \Gamma_i$. $b_0$ and $b_1$ are $k \times 1$ vectors and t denotes a time trend that can be included in the cointegrating equations. It follows that y is cointegrated of rank r if there exist r linearly independent vectors in matrix $\beta$ and if $\beta' y_t$ is a stationary process. If there is a cointegrating relationship, $\alpha$ and $\beta$ will be ($k \times r$) matrices of rank r (Engle and Granger, 1987).

[4] A contrary view is expressed in Arteta (2005a) and Arteta (2005b) in which floating regimes seem to be the ones that encourage dollarization. In addition, there is no evidence that currency crashes are more costly in highly dollarized economies.

Cointegration analysis explains long-run equilibrium relations and usually it is based on economic theory. The three-variable model we are developing originates from theory of financial euroization. Levy Yeyati (2006) outlines three dollarization theories (the market failure view, the portfolio view and the institutional view) and a number of possible financial dollarization drivers. Moreover, studies by other authors also define variables that influence the level of dollarization (De Nicoló, Honohan and Ize, 2005). Some of the usual suspects are: average past inflation, dollar share of the minimum variance portfolio, correlation between the probability of default and the real exchange rate (theoretical variable), GDP per capita (depicting development of local currency markets), proxies for institutional development, exchange rate pegs dummy and other. Relationship between dollarization and monetary policy asks for different type of variables and usually exchange rates, inflation and interest rates enter the model. Modelling monetary policy in post-transition economies asks for an altered approach (Frankel, 2010) so we focus on empirical studies conducted for post-transition economies only. Studies by Luca and Petrova (2008), Rosenberg and Tirpák (2008), Kokeyne, Ley and Veyrune (2010), Basso, Calvo-Gonzales and Jurgilas (2011) and others suggest the following variables: inflation, exchange rate, interest rate differential, minimum variance portfolio, GDP per capita, monetary aggregates. Our three variable system uses exchange rate and interest rate differential as potential drivers of deposit euroization. The literature implies the three variables should be cointegrated with the following cointegrating vector (1, -1, -1) where deposit euroization has the coefficient 1 and the other two variables have a negative coefficient. This kind of specification suggests deposit euroization rises after exchange rate depreciation and interest rate differential widening. Experience taught us that exchange rate depreciations are usually followed by interest rate hikes (that eventually lead to a rise in the interest rate differential, if euro rates stay the same) simply because central banks tend to defend the exchange rate and curb depreciation by squeezing liquidity and consequently rising domestic interest rates. As a result of increased domestic currency depreciation risk, demand for deposits in foreign currency or linked to foreign currency rises and the dollarization index rises as well.

### 3.2. The Threshold VAR Model

The baseline linear model is misspecified when the variables actually follow a nonlinear process. Therefore, we expand the model by building a Threshold Vector Autoregressive (TVAR) specification. TVAR is a simple way of capturing nonlinearities suggested in a number of economic and monetary policy models like Teräsvirta and Anderson (1992), Holmes and Wang (2000) and Balke (2000). The nonlinear character of TVAR models comes from a transition variable that separates the baseline VAR into different regimes (Hansen 1996, 1997; Tsay 1998). Each regime is then given a different autoregressive matrix and described as a linear model but taken together those regime-based linear models describe a nonlinear process.[5] A VAR model adjusted for the threshold specification then becomes:

$$y_t = \Gamma_1 X_t + \Gamma_2 X_t I\left[z_{t-d} \geq z^*\right] + u_t$$

where $X_t = (1, y_{t-1}, ..., y_{t-j})'$. Similarly, the Vector Error Correction Model (VECM) is described by the following equation:

$$\Delta y_t = \Gamma_1^v X_t^v + \Gamma_2^v X_t^v I\left[z_{t-d} \geq z^*\right] + u_t$$

with $X_t^v = (1, \beta' y_{t-1}, \Delta y_{t-1} ..., \Delta y_{t-j+1})'$. As usual, gamma matrices are coefficient matrices and $u_t$ is the error matrix. The threshold variable is denoted by $z_{t-d}$ with d being a possible time lag. In order to separate regimes, an indicator function $I$ equals 1 if the threshold variable $z_{t-d}$ is above the chosen threshold value $z^*$ and 0 otherwise. Both the threshold value $z^*$ and the delay lag d are unknown parameters and have to be determined together with other parameters. According to Hansen (1996, 1997), the transition variable can be either the endogenous or an exogenous variable.

[5] First threshold autoregressive methods were developed by Tong (1978, 1983, 1990) who approximated a nonlinear autoregressive structure by a threshold autoregression (TAR) with a small number of regimes. Later on, TAR was extended to a multivariate framework by Tsay (1998) and Hansen (1996, 1997). A number of studies for monetary policy shocks uses TVAR methodology, like Balke (2000), Atanasova (2003), Calza and Sousa (2006) and Jääskelä (2007).

Before TVAR estimation, the threshold model needs to be tested for linearity using the Hansen test (Hansen, 1996, 1997). If linearity is rejected, then the endogenously chosen threshold value separates the observations of the transition variable into different regimes that are described by a linear model. Methodology allows for more than one threshold value, namely more than two regimes, but we will focus on the two-regime case due to simplicity and short data spans. Since this study explores countries with perceived unofficial euroization, the most justifiable candidate for the threshold variable is the level of deposit euroization. That allows us to separate countries into different groups, based on the observed level of euroization.

The Hansen linearity test requires the transition variable $z$ to be stationary with a continuous distribution $-\infty = z_0 < z_1 < ... < z_{s-1} < \infty$ that is restricted to a bounded set $Z = [\underline{z}, \overline{z}]$ with Z an interval on the full sample range of the transition variable. An interval on the transition variable is chosen to provide a minimum number of observations in each subsample and therefore ensure that the model is well identified for all possible values of $z^*$. Before testing the threshold, the lag order $j$ and the threshold delay lag $d$ need to be determined. Therefore, to get the appropriate lag length it is necessary to estimate the linear VAR while some valid economic explanations will help in the choice of the delay lag.

If we rewrite the equation for TVAR we get the following specification:

$$y_t = X_t(z)'\delta + u_t$$

with $X_t(z) = (X_t^{'} X_t^{'} I)'$ and $\delta = (\Gamma_1^{'} \Gamma_2^{'})'$. Following Weise (1999), we employ a general specification and allow all coefficients in the lag polynomials to change across regimes. For each possible threshold value $z$, the equation is estimated using Least Squares (LS) with the belonging estimation of $\delta$ equal to:

$$\hat{\delta}(z) = (\sum_{t=1}^{T} X_t(z) X_t(z)')^{-1} (\sum_{t=1}^{T} X_t(z)) y_t$$

The related residuals are then defined as $\hat{u}_t = y_t - X_t(z)'\hat{\delta}(z)$ and the residual variance as $\hat{\sigma}_T^{\ 2} = \frac{1}{t} \sum_{t=1}^{T} \hat{u}_t^{\ 2}$. For our threshold to be efficient we need the estimate of $\delta$ that minimises the residual variance. Since the minimal variance itself does not guarantee nonlinearity, Hansen developed an additional test. A pointwise F-statistic is a profound linearity test specified as:

$$F_T = \sup_{z \in Z} F_T(z)$$

$$F_T = T\left(\frac{\tilde{\sigma}_T^2 - \hat{\sigma}_T^2(z)}{\hat{\sigma}_T^2(z)}\right)$$

where the estimated residual variance of the corresponding linear model is denoted by $\tilde{\sigma}_T^2$.

The problem arises with the distribution of the derived F-statistic that is not standard or chi-square (Hansen, 1996) since the threshold value is not identified under the null of linearity. Therefore, it is necessary to approximate the asymptotic distribution using a bootstrap procedure. In order to obtain bootstrap F-statistics $F_T^*$, we need bootstrap residual variances $\tilde{\sigma}_T^{*2}$ and $\hat{\sigma}_T^{*2}(z)$. To get those variances we take $y_t^*$ iid N(0,1) random draws and regress them on $X_t$ and $X_t(z)$. Once we have the necessary inputs, the bootstrap F-statistic becomes:

$$F_T^* = \sup_{z \in Z} F_T^*(z)$$

$$F_T^* = T\left(\frac{\tilde{\sigma}_T^{*2} - \hat{\sigma}_T^{*2}(z)}{\hat{\sigma}_T^{*2}(z)}\right)$$

It is then possible to approximate the asymptotic null distribution of $F_T$. Having in mind that the distribution of $F_T^*$ converges weakly in probability to the null distribution of $F_T$ under the alternative, the asymptotic bootstrap p-value can be derived. Percentage of bootstrap samples for which $F_T^* > F_T$ gives the bootstrap p-value.[6]

We test the null hypothesis of linearity against threshold nonlinearity allowing heteroscedasticity in the error terms. Our selection of the threshold value is conditional on the choice of a minimal variance-covariance matrix of the residuals. We generate 1000 realisations of the F-statistics for each grid point and construct the empirical distribution to account for Hansen (1996).

### 3.3. Generalized Impulse Response

Main purpose of this empirical study is to detect how deposit euroization reacts to monetary variables, most importantly to exchange rate shocks. In order to understand the relationship between the level of DE, exchange rate and the interest rate differential, we need to construct impulse responses for shocks in those two variables. To obtain meaningful impulse responses a structural identification is needed. TVAR equation reveals $\Gamma_1$ and $\Gamma_2$ as "structural" contemporaneous relationships in the two regimes. Relying on Christiano, Eichenbaum and Evans (1999), we also assume $\Gamma_1$ and $\Gamma_2$ have a recursive structure with a causal ordering of DE, exchange rate and interest rate differential. The recursiveness assumption is usually used to identify structural shocks in VAR models, especially for monetary and financial variables (Leeper, Sim and Zha, 1996; Bernanke, Gertler and Watson, 1997). We consider different ordering as well, but alternative ordering does not make any significant difference. We use this recursive identification because of its simplicity and we leave other forms of identifying restrictions for future work.

With a structural identification applied to the linear and nonlinear model, we can construct impulse responses (IR). While the linear case is straightforward, the nonlinear model requires further IR definitions that account for nonlinearity of the system. First, the shock must depend on the entire history of the system before the point in which the shock occurs (Gallant, Rossi and Tauchen, 1993; Koop 1996; Koop, Pesaran and Potter, 1996). Moreover, linear IR functions are inappropriate since they are history-independent, symmetric (i.e. negative shocks are exactly the opposite of positive shocks) and proportional to the size of a shock. In a nonlinear specification, we expect that the effect of a shock is not proportional to its size or direction and that it is history-dependent. To fulfil these three conditions, we use generalized impulse response functions (GIRF) that are applicable to both the linear and the nonlinear model.[7]

Koop, Pesaran and Potter (1996) define GIRF as the difference between two conditional expectations with a single exogenous shock $\varepsilon_t$:

$$\begin{aligned} GIRF = {} & E\left[X_{t+m} | \varepsilon_{\mathrm{t}}, \varepsilon_{\mathrm{t+1}} = 0, \ldots, \varepsilon_{\mathrm{t+m}} = 0, \Omega_{t-1}\right] - \\ & E\left[X_{t+m} | \varepsilon_{\mathrm{t}} = 0, \varepsilon_{\mathrm{t+1}} = 0, \ldots, \varepsilon_{\mathrm{t+m}} = 0, \Omega_{t-1}\right] \end{aligned}$$

where $m$ is the forecasting horizon and $\Omega_{t-1}$ the history at time $t-1$. As mentioned, GIRF provides different results for positive and negative shocks since it allows the regimes to switch after a shock. In our case, GIRF allows the shocks in the low euroization regime to differ form shocks in a high euroization regime. Since the computation of GIRF is not trivial, we describe the algorithm step-by-step in the Appendix.

[6] If one wants to account for heteroscedasticity, the standard F-statistic can be replaced by a heteroscedasticity-consistent Wald or Lagrange multiplier test.

[7] Many empirical studies that describe nonlinearities use GIRF, for example Balke (2000), Atanasova (2003), Calza and Sousa (2006) and Jääskelä (2007).

## 4. The Data

In the focus of unofficial euroization in European post-transition economies stands financial euroization, a case in which foreign currency takes store of value and unit of account function. The most accurate way to measure FE is by surveys that collect data on a wide range of assets and liabilities in foreign currency. The problem is that those surveys either have a very short data span or are conducted on a very small number of countries. Therefore, if one wants to study the FE behaviour across time, the alternative is to use aggregate banks' data that provide only levels of time and savings deposits and loans in foreign currency.

This paper considers the level of deposit euroization, defined as a share of deposits in foreign currency (or linked to foreign currency, where available) in total deposits, as our measure of financial euroization. Although DE is not a perfect measure of financial euroization because it incorporates only the liabilities side of banks' accounts, it still reflects differences in unofficial euroization between countries. Other authors also prefer DE as a proxy for financial euroization (Baliño, Bennett and Borensztein, 1999; Levy Yeyati, 2003; Piontkovsky, 2003; Arteta, 2005a; Neanidis and Savva, 2009; Stix, 2010) while some focus on CE and how much countries owe in foreign currency (Luca and Petrova, 2008). Literature also suggests building composite indexes of euroization but there is no consensus on the definition of that sort of an index (Reinhart, Rogoff and Savastano, 2003). The main difficulty with the composite index is that the determination of the weight of a specific component is discretionary and can lead to over or under determination of the real euroization level. Credit euroization, on the other hand, provides a meaningful insight into FE but just as DE it presents only one side of the balance sheet. However, DE provides a very useful advantage to CE. Namely, studies confirm DE is the source and precondition for CE formation and as such, it is defined as one of the CE drivers (Brown, Kirschenmann and Ongena, 2009; Brown, Ongena and Yeşin, 2009; Basso, Calvo-Gonzales and Jurgilas, 2011). Thus, it makes sense to investigate the drivers of DE prior to CE examination.

There is a long list of euroization drivers but we are interested in those variables that capture the influence of monetary policy on DE. The most important variables that seem to affect deposit euroization and derive from the monetary system are the exchange rate and the interest rate differential. Exchange rate influences deposits when confidence in domestic currency is low. If investors expect exchange rate to depreciate they will save in foreign rather than in domestic currency. Therefore, it is justifiable to expect a change in investor behaviour is caused by a reaction to nominal exchange rate changes. The variable we included in our model is the level of the bilateral exchange rate of the domestic currency to Euro calculated as a monthly average. However, for the countries that have a fixed exchange rate regime, real effective exchange rate was used. The interest rate differential is calculated as a difference between domestic and euro area interest rates where the domestic rate is either a 3-month money market interest rate or a short-run deposit rate and the euro area rate is a 3-month money market interest rate. Besides the domestic interest rate reflects central bank activity and even monetary policy stance, the interest rate differential reflects a number of possible situations, from arbitrage opportunities and foreign capital inflow to perceived country risk and even high inflation rates.

We include only three variables simply due to pragmatic reasons. As the number of coefficients in the linearity test and TVAR rises with the number of variables, the test size and power decrease. Besides explanatory variables, we also need a threshold variable in order to distinguish between low and high regimes in the nonlinear specification. In our case, this is an endogenous variable – deposit euroization. Since post-transition economies vary in their DE level, it seems plausible to take that variable as a reliable threshold.

In the paper, we investigate 11 countries so the sample period varies between the countries. Those countries are: Belarus, Bulgaria, Croatia, Czech republic, Hungary, Latvia, Lithuania, Poland, Romania, Serbia and Turkey. The longest data span is for Croatia - 1995M07 to 2010M11 or 185 observations and the shortest for Serbia - 2004M01 to 2010M12 or 84 observations. Data are compiled from central bank statistics and Eurostat with a detailed description presented in the Appendix. All data are seasonally adjusted and deposit euroization together with the exchange rate is in logarithms. In order to achieve stationarity, we take the first differences and test the series with standard unit root methodology. Results presented in Table 1 show all series are stationary in first differences.

## 5. Estimation results

The three variables, deposit euroization, exchange rate and the interest rate differential make the linear baseline reduced form VAR model:

$$y_t = \Gamma X_t + u_t$$

where $y_t = (DE, ER, IRD)$, $\Gamma = (\Gamma_0, \Gamma_1, \ldots, \Gamma_j)$ and $X_t = (1, y_{t-1}, \ldots, y_{t-j})'$. Using this baseline model, we determine the optimal lag length using different criteria. Time series for all countries are in first differences as suggested by the ADF test and presented in table 2. For the linear model, the Schwarz criterion suggests one or two lags in all twelve countries while Akaike and Likelihood ratio criteria propose higher orders. Since every additional parameter decreases the power of estimation significantly (Hansen, 1996) it is recommended to choose a smaller number of lags. Using only one or two lags leads to frequent rejection of the null hypothesis of no serial correlation (as suggested by the Portmanteau test), so we choose the number of lags for the estimation of the nonlinear model equal to three. This structure still gives us good estimation power and somewhat better autocorrelation properties. The variables are detrended to avoid nonlinearity coming from the time trend itself.

### 5.1. Cointegration

After defining the baseline model, we can determine the number of cointegrating relations between the series. Analysis of the cointegration rank and cointegrating matrix $\beta$ is conducted using Johansen's likelihood ratio procedure (Johansen, 1991, 1995). The deterministic term appears significant for all countries except for Poland and Czech Republic and for the case of Lithuania we also needed to include the linear trend term. The results for trace and maximum eigenvalue tests are presented in table 3. For Belarus, Romania and Serbia both tests reject a cointegration relation implying that either there is no relationship between the variables or that the linear model is misspecified and a nonlinear model should be used instead. For all other countries both tests show there is one cointegrating relation.[8] The resulting cointegrating vector can be found in table 4.

In case of Bulgaria, we can restrict the constant to zero because a likelihood ratio test does not reject this restriction. That final vector is given in table 4. The real effective exchange rate coefficient appears to be very small and implies that a rise in the exchange rate (depreciation) leads to a decrease in DE. This result is neither in line with the expected results nor with the existing literature but we must have in mind that Bulgaria has a currency board and therefore the market participants react to real exchange rate changes with a time lag. The coefficient of the interest rate differential is also very small and implies that DE increases when the spread between domestic and foreign interest rates increases. This is so because higher domestic interest rates in transition economies attract investors from abroad who then make large foreign currency inflows. Banks, in order to match their currency structure drive foreign currency holdings. This result is in accordance with Luca and Petrova (2008) and Rosenberg, and Tirpák (2008) although Basso, Calvo-Gonzales and Jurgilas (2011) claim just the opposite. We get very similar coefficients for Latvia that also has a currency board and draw the same conclusions as for Bulgaria.

For Croatia, Lithuania and Turkey we managed to restrict the exchange rate coefficient to 1 implying that depreciation of one percent drives up DE proportionately, also by one percent. This result is in line with previous studies and it identifies a strong relationship between exchange rates and euroization. For the same group of countries, an increase in the interest rate spread also drives up DE. However, while the coefficients for Lithuania and Turkey are very small, coefficient for Croatia is as high as 1. This result, although a bit unusual, emphasizes the importance of the financial sector, namely banks (Luca and Petrova, 2008; Rosenberg, and Tirpák, 2008).

Croatia is not the only exception with a very high interest rate differential coefficient. The other is Czech Republic, for which the coefficient is also restricted but to -1. Therefore, an increase of one percent in the interest rate differential leads to a one percent decrease in DE. As explained in Basso,

[8] The only exception is Czech Republic for which only the Trace test implies one cointegrating relation, while the Max test shows no cointegration relation.

Calvo-Gonzales and Jurgilas (2011), a rise in domestic interest rates stimulates domestic currency savings that eventually decreases DE. The nominal exchange rate coefficient for Czech Republic implies the same relationship, a moderation in DE after exchange rate depreciation. As for Bulgaria and Latvia, this result is not in accordance with our assumptions about post-transition economies. However, these are all countries in which exchange rates are either fixed or flexible (as in Czech Republic) and eventually do not have such an important influence on DE.
Another country with a flexible exchange rate regime is Poland with results for the nominal exchange rate very similar to the ones explained earlier. A negative coefficient of more than one suggests DE decreases by more than 1 percent after a depreciation of one percent. The interest rate differential coefficient is very small and positive leading to a conclusion that a larger increase in local interest rates when compared to interest rates in EMU increases DE but very mildly.
Hungary shows completely different behaviour with the nominal exchange rate reacting similar to Croatia, Lithuania and Turkey and interest rate differentials resembling the Czech case. Therefore, depreciation in Hungary leads to a rise in DE, and interest rate spread widening to a decrease in DE. Surprisingly, the exchange rate coefficient is extremely large, almost 7, suggesting that a depreciation of only one percent would increase DE by 7 percent. One must have in mind that Hungary suffered very large depreciation episodes in 2008/2009 that were followed by an interest rate hike.[9] When we exclude the observations for the crisis years, the exchange rate coefficient is more moderate.

### 5.2. The Threshold Model

To recall, our threshold adjusted VAR model is specified as:

$$y_t = \Gamma_1 X_t + \Gamma_2 X_t I\left[z_{t-d} \geq z^*\right] + u_t$$

where $X_t = (1, y_{t-1}, \ldots, y_{t-j})'$. However, if we allow for changes in contemporaneous relationships between variables then our transformed model becomes:

$$y_t = \Gamma_1^1 y_t + \Gamma_2^1(L) y_{t-1} + (\Gamma_1^2 y_t + \Gamma_2^2(L) y_{t-1}) I\left[z_{t-d} \geq z^*\right] + u_t .$$

In this specification, $\Gamma_1^1$ and $\Gamma_1^2$ reflect the “structural” relationship in the two regimes. Using Cholesky decomposition and the belonging recursive structure with the causal ordering of DE, exchange rate and the interest rate differential, we are able to identify structural errors. Having in mind this kind of identification leads to multiple Cholesky factors, we consider alternative ordering. However, different ordering choices resulted in very small differences. We use this basic identification form mostly due to simplicity reasons. Complicated forms of identifying restrictions together with robustness analysis of our results are left for future work.
To proceed to the Hansen test we need closely to specify our threshold variable, deposit euroization. As in Galbraith and Tkacz (2000), we set the threshold variable $z_{t-d}$ to be a moving average of its past values, or $z_{k,t-d}(d,k) = 1 \big/ {k-d+1} \sum_{i=d}^{k} DE_{t-i}$ for different values of d and k. Based on a minimum residual variance and maximum likelihood, we choose d equal to one and k equal to three.[10]
Bootstrapped p-values for the Hansen test and for the corresponding baseline linear model together with the estimated coefficient for the threshold parameter can be found in table 5. The trimming percentage for the threshold variable is 30 percent and the number of bootstrap replications is 1000. It turns out that the Chi-square test statistic is significant for all countries at the 1 percent level. However, the bootstrap test rejects linearity in a greater part of our country sample: Bulgaria, Croatia, Hungary, Latvia, Lithuania, Romania, Serbia and Turkey.[11] For Bulgaria, Croatia, Lithuania and Turkey linearity is rejected at 1 percent level, and for the other countries at 5 percent level. It is interesting that both Czech Republic and Poland show no sign of nonlinearity. From our sample of post-transition countries, those two have the lowest level of unofficial euroization, both have flexible exchange rate and inflation targeting regimes and both implement policy measures to curtail FE.

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[9] For example, in the period from August 2008 (just before Lehman Brother collapsed) to March 2009, the Hungarian exchange rate towards euro depreciated by 28.9 percent while the interest rate spread widened by 5.3 percentage points with a one-quarter lag.
[10] However, the DE variable enters the VAR in its original form.
[11] For Czech Republic, the linearity is rejected at a 10 percent level only.

The estimated threshold values for a VAR model with three lags and the threshold variable specified as a three-period moving average with one lag are given in table 5. Since these values are in logarithms and moving averages, we report the corresponding original DE values in the last column. We observe that threshold values are country specific and vary between 18.8 percent in Hungary and 81.5 percent in Latvia. One interesting characteristic we find is that for countries with fixed exchange rate regimes (i.e. Bulgaria, Latvia and Lithuania) the threshold value is above the whole-period average DE while in other countries it is below average. This indicates that countries with fixed exchange rates are less sensitive to real effective rate changes than other countries are to nominal exchange rate changes.

Figures 1 to 16 directly compare positive and negative shocks together with the linear impulse response function. Although linear responses are misspecified when tests confirm nonlinearity, we leave them as a reference. We are mostly interested in the effect of exchange rate shocks but we also present interesting results of interest rate differential shocks. We find clear differences between linear IRF and nonlinear GIRFs in all countries. Further, differences between regimes are small and almost never clearly noticeable. The only exception is Romania in which exchange rate appreciation has a larger effect in the low regime than in the high regime. In all other examples, both regimes are very similar but with different GIRFs for positive and negative shocks.
Considering the reaction of DE to exchange rate shocks, we come to the following conclusions. Linear responses are mostly stronger, except in Croatia in which both linear and nonlinear impulse responses coincide during the first quarter but later on nonlinear responses strengthen. Moreover, those impulse responses in Croatia are divergent and indicate that depreciation leads to DE moderation, a result not in line with our expectations. However, the coefficients are very small that is not surprising since the Croatian exchange rate towards euro fluctuates very moderately. Results for Bulgaria, Latvia and Romania are straightforward and indicate DE rises with exchange rate depreciation. Moreover, depreciation effects in Bulgaria are stronger than appreciation effects in both regimes. Lithuania and Turkey also show stronger responses to depreciation in both low and high regimes. DE in Hungary, Lithuania, Serbia and Turkey also react as we would expect, with a hike preceded by exchange rate depreciation. The only difference from Bulgaria, Latvia and Romania is that it takes a month or two for DE to respond. To summarize, from the countries witnessing nonlinear behaviour, only Croatia does not agree with our hypothesis that depreciation drives up DE.
When depreciation pressures arise, central banks that experience “fear of floating” usually react with a liquidity squeeze that eventually manifests in a domestic interest rate increase. If this theory holds, we would observe a positive response in the interest rate differential to a positive exchange rate shock or depreciation. Interest rate differential responses to exchange rate shocks are displayed in figures 1 to 8. We find evidence of the described effect in all countries, except in Lithuania. Moreover, in Bulgaria and Hungary the interest rate differential response is positive even after one year. Linear and nonlinear responses are very similar in shape but in six out of eight countries, nonlinear responses are stronger. The only indication of regime differences is found in Romania where appreciation is much stronger in the low than in the high regime. The only other case where negative exchange rate shocks appear to be stronger is Serbia while in Bulgaria, Lithuania and Turkey we find clear evidence of stronger depreciation effects.
Figures 9 to 16 display the responses to shocks in the interest rate differential. Although these shocks are not our primary goal of research, we have a few interesting remarks. We confirm the results of Luca and Petrova, 2008, Rosenberg, and Tirpák, 2008 and our cointegration analysis results. Namely, in six out of eight countries DE increases after a positive shock in the interest rate differential. Only Bulgaria manifests an opposite response while for Latvia it is impossible to detect the direction of the responses. Although linear and nonlinear responses are very similar and we cannot detect any signs of regime switching, giving preference to linear impulses would be a mistake. Because not only they are misspecified according to the Hansen test, for Hungary we would even get contradictory conclusions. Differences in the sign of the shock can be found in six countries out of which in five countries positive shocks have stronger effects on DE than negative ones.

The above results imply that exchange rate and interest rate shocks affect deposit euroization and play an important role in DE dynamics. Regime switching was evident only in a small number of cases but the differences in positive and negative shocks were obvious and in line with the observed central bank behaviour in our post-transition economies sample.

## 6. Conclusion

Financial euroization in European post-transition region has multiple causes, from which policy credibility, high inflation, low exchange rate volatility and expected euro adoption are the most important ones. Besides, a number of authors stress the influence made by foreign bank financing, capital inflows and credit booms as being in large part responsible for FE persistence in emerging Europe. Nevertheless, FE is not just a temporary consequence of a transition boom but a long-lasting deviation in almost all European post-transition countries.

The latest economic crisis aggravated by large currency depreciations in some and massive defending of hard pegs in other countries emphasized the severity of high FE. In the last few years, a need to deeuroize has grown and European as well as national policy makers are coming out with policy recommendations more frequently. Since any deeuroization policy will have success only if the determinants of FE are correctly specified, we find it necessary to start FE analysis with detecting its determinants. Results of this study show what are the monetary determinants of deposit euroization in European post-transition economies and describe the nonlinear relationships between DE, the exchange rate and the interest rate spread between domestic and euro rates.

Cointegration analysis results suggest monetary variables influence DE significantly and that some countries experience an increase in their DE levels after exchange rate depreciations occur. The only two countries in our sample with flexible exchange rates, i.e. Czech Republic and Poland, show just the opposite and speak in favour of flexible exchange rate regimes. Since TVAR methodology implies that linear results are not misspecified only for Czech Republic and Poland, other countries should be interpreted in nonlinear fashion. It turns out that countries with fixed exchange rate regimes become sensitive at DE levels above their period averages, i.e. they seem to react to DE changes with a certain lag. Other countries that do not have an exact commitment to neither a fixed nor a fully flexible regime react to DE changes at levels below average. Those countries show greater sensitivity and vulnerability to exchange rate changes. Although regime switching was significant in a small number of cases, the differences in the sign of shocks were obvious and in line with the observed central bank behaviour. In seven out of eight countries, depreciations had a stronger effect on DE than appreciations showing clear signs of nonlinear behaviour. That interest rate differentials increase by a greater amount after depreciations is also confirmed in seven out of eight countries. Both results indicate savers react unfavourably to exchange rate depreciations since they increase their deposits in foreign currency. Although one would expect that a rise in domestic interest rates relative to euro ones will decrease DE levels, it does just the opposite. In six out of eight countries, we found evidence that DE rises more strongly after interest rate spread widening than spread narrowing.

These results help us in deciding on the optimal set of policy recommendations aimed at curbing DE in post-transition Europe. The most simple exit strategy would be to adopt the Euro but that scenario is becoming less and less likely due to difficulties in reaching the Maastricht criteria. For countries like Latvia, Lithuania and Bulgaria, this seems to be the most possible scenario. The path these countries are supposed to follow is achieving convergence (by fiscal consolidation and structural reforms) and eventually adopting the Euro as its official currency. Countries like Croatia, Hungary and Romania but to some extent also Serbia and Turkey will probably have to rely on measures other than regulatory because managing euroization risks is already becoming unsustainable. Their only alternative is to decrease DE by using different types of measures. Zettelmeyer, Nagy and Jeffrey (2010) suggest that countries should go through a reform of macroeconomic regimes and institutions in order to increase macroeconomic and institutional credibility. Experience from Latin American countries shows that those policies are usually based on inflation targeting and floating exchange rate regimes. A contribution to that argument is made by countries like Czech Republic and Poland that already have a tradition of such policies and as a result - lowest DE levels.

Our study showed that exchange rates and interest rate spreads have an important influence on DE in emerging Europe. Therefore, it would be justifiable to introduce insurance measures for investors saving in domestic currency. In practice, that implies allowing investors to hedge against domestic currency interest rate risk and developing and deepening domestic money and capital markets. Some kind of preferential treatment for domestic currency savings is also a possible solution for encouraging savings in local currency. One must have in mind that these market development measures are plausible only in countries with strong institutional framework. This indicates that country specific characteristics should be taken into account when designing deeuroization strategies.

**Appendix**

Data Sources and Transformations

| Variable | Source | Description |
|---|---|---|
| Deposit euroization index | National authorities (central banks) and own calculations | Share of foreign currency deposits (where possible, we added deposits linked to the foreign currency as well) in total deposits. |
| Nominal and real effective exchange rate | National authorities (central banks) and Eurostat | Average monthly nominal or real effective exchange rate of the domestic currency to the euro. |
| Interest rate differential | National authorities (central banks), Eurostat and own calculations | Calculated as a difference between interest rates for a respective country and the euro rate. For the euro rate and for some of the national interest rates, interbank 3-month money market interest rates were used. Where not possible, average short-term interest rates on deposits were used. Unit is a percentage point. |

GIRF algorithm

This method of calculating impulse response functions for nonlinear models follows Koop, Pesaran and Potter (1996). GIRF is defined as a response of a specific variable after a one-time shock hits the forecast of variables in the model. To measure the response of the variable we must compare it against a case in which no shocks occur. Mathematically, this formulation can be expressed as:

$$GIRF_y(m,\varepsilon_t,\Omega_{t-1}) = E\left[y_{t+m}|\varepsilon_t,\Omega_{t-1}\right] - E\left[y_{t+m}|\Omega_{t-1}\right]$$

with $m$ the forecast horizon, $\varepsilon_t$ the shock and $\Omega_{t-1}$ the initial values of the variables included in the model. The procedure assumes that the nonlinear k-dimensional model is known and requires GIRF is computed by simulating the model. The shock of one standard deviation occurs to the i-th variable ($i=1,...,k$) of $y_t$ (defined earlier as $y_t = (y_{1t,...,}y_{kt})'$) in period 0 with responses calculated for $p$ periods thereafter. The algorithm is as follows:

1. Pick a history $\Omega^r_{t-1}$ (where $r = 1,...,R$) that refers to an actual value of the lagged endogenous variable at a particular date $r$. Since $R$ relates to the values corresponding to the regime, the algorithm has to be carried out twice, for both lower and upper regime.

2. Pick a sequence of k-dimensional shocks $\varepsilon^b_{t+m}$ with $m = 0,...,p$ and $b = 1,...,B$. These shocks are generated by taking bootstrap samples from the estimated residuals of the TVAR model.

3. Using $\Omega^r_{t-1}$ and $\varepsilon^b_{t+m}$ simulate the evolution of $y_{t+m}$ over $p+1$ periods. The resulting baseline path is given by $y_{t+m}(\Omega^r_{t-1},\varepsilon^b_{t+m})$.

4. Substitute $\varepsilon_{i0}$ for the $i_0$ element of $\varepsilon^b_{t+m}$ and simulate the evolution of $y_{t+m}$ over $p+1$ periods. In this manner you modify the path of $y$ and by simulating over $m$ periods you get the shocked path $y_{t+m}(\Omega^r_{t-1},\varepsilon^b_{t+m})$ for $m = 0,1,...,p$.

5. Repeat steps 2 to 4 B times to get B estimates of the baseline and the shocked path.

6. Take the average over the difference of the B estimates of the baseline and the shocked path. This average will give you an estimate of the expectation $y$ for a given history $\Omega^r_{t-1}$.

7. Repeat steps 1 to 6 R times, that is, over all possible histories.

8. Calculate the average GIRF for a given regime with R observations using the following equation:

$$y_{t+m}(\varepsilon_{i0}) = \frac{\left[ y_{t+m}(\varepsilon_{i0}, \Omega^{r}_{t-1}, \varepsilon^{b}_{t+m}) - y_{t+m}(\Omega^{r}_{t-1}, \varepsilon^{b}_{t+m}) \right]}{BR}$$

As in Koop, Pesaran and Potter (1996), B was set to 100 and R to 500.

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Table 1. ADF test for first differences

| | | Lags (AIC) | t-value (ADF) | t- value (lag) | AIC | | | Lags (AIC) | t-value (ADF) | t- value (lag) | AIC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Belarus | DE | 0 | -6.053*** | - | -9.005 | Lithuania | DE | 2 | -4.491*** | 0.0019 | -8.765 |
| | NER | 1 | -5.965*** | 0.0089 | -8.637 | | RER | 1 | -7.503*** | 0.0078 | -11.02 |
| | IRD | 1 | -3.163** | 0.0951 | -11.86 | | IRD | 0 | -6.439*** | - | -2.055 |
| Bulgaria | DE | 2 | -3.853*** | 0.0430 | -10.52 | Poland | DE | 1 | -9.438*** | 0.0942 | -8.979 |
| | RER | 4 | -4.052** | 0.0345 | -2.915 | | NER | 0 | -7.502*** | - | -9.249 |
| | IRD | 4 | -4.073** | 0.0334 | -13.81 | | IRD | 0 | -6.106*** | - | -2.780 |
| Croatia | DE | 3 | -3.559*** | 0.0705 | -11.69 | Romania | DE | 2 | -3.000** | 0.0389 | -9.179 |
| | NER | 1 | -9.669*** | 0.0379 | -11.69 | | NER | 0 | -4.998*** | - | -9.633 |
| | IRD | 2 | -7.737*** | 0.0674 | -0.511 | | IRD | 4 | -2.975** | 0.5543 | 0.285 |
| Czech R. | DE | 1 | -10.48*** | 0.0355 | -8.244 | Serbia | DE | 0 | -10.26*** | - | -10.36 |
| | NER | 6 | -4.710*** | 0.0013 | -10.22 | | NER | 0 | -5.120** | - | -10.10 |
| | IRD | 1 | -6.338*** | 0.0771 | -3.990 | | IRD | 0 | -7.997*** | - | -2.230 |
| Hungary | DE | 0 | -13.73*** | - | -8.342 | Turkey | DE | 0 | -8.245*** | - | -9.406 |
| | NER | 1 | -7.747*** | 0.0422 | -9.675 | | NER | 1 | -6.359*** | 0.1119 | -8.570 |
| | IRD | 0 | -8.626*** | - | -1.028 | | IRD | 1 | -7.444*** | 0.0007 | -0.6721 |
| Latvia | DE | 8 | -3.543*** | 0.0378 | -11.35 | | | | | | |
| | RER | 2 | -3.134** | 0.0283 | -10.97 | | | | | | |
| | IRD | 11 | -3.557*** | 0.5275 | 0.9193 | | | | | | |

Note: ADF - Augmented Dickey-Fuller; DE – deposit euroization; NER – nominal exchange rate; RER – real exchange rate; IRD – interest rate differential; constant included; maximum number of lags used – 18; optimal time lag chosen according to AIC – Akaike Information Criterion; all series are seasonally adjusted and in logarithms (except for the interest rate differential); *** null hypothesis about existence of unit root rejected on 1 percent level of significance; ** hypothesis about existence of unit root rejected on 5 percent level of significance.

Table 2. Lag length selection criteria

Belarus

| Lag | LR | FPE | AIC | SIC | HQ |
|---|---|---|---|---|---|
| 0 | NA | 0.000 | -13.412 | -13.320 | -13.375 |
| 1 | 575.188 | 0.000 | -21.164 | -20.796 | -21.017 |
| 2 | 68.033 | 0.000 | -21.913 | -21.269* | -21.656* |
| 3 | 18.342* | 0.000 | -21.954 | -21.034 | -21.587 |
| 4 | 16.842 | 0.000* | -21.985* | -20.789 | -21.507 |

Bulgaria

| Lag | LR | FPE | AIC | SIC | HQ |
|---|---|---|---|---|---|
| 0 | NA | 0.000 | -7.397 | -7.312 | -7.363 |
| 1 | 698.151 | 0.000 | -15.503 | -15.166* | -15.367* |
| 2 | 17.860 | 0.000 | -15.519 | -14.928 | -15.281 |
| 3 | 15.399 | 0.000 | -15.512 | -14.668 | -15.172 |
| 4 | 16.374 | 0.000* | -15.526 | -14.428 | -15.084 |
| 5 | 6.400 | 0.000 | -15.410 | -14.059 | -14.866 |
| 6 | 22.820 | 0.000 | -15.536 | -13.932 | -14.890 |
| 7 | 6.227 | 0.000 | -15.426 | -13.568 | -14.678 |
| 8 | 20.047* | 0.000 | -15.540* | -13.429 | -14.689 |

Croatia

| Lag | LR | FPE | AIC | SIC | HQ |
|---|---|---|---|---|---|
| 0 | NA | 0.000 | -15.129 | -15.075 | -15.107 |
| 1 | 58.165 | 0.000 | -15.365 | -15.149* | -15.278 |
| 2 | 31.921* | 0.000* | -15.452* | -15.074 | -15.298* |
| 3 | 10.187 | 0.000 | -15.411 | -14.870 | -15.192 |
| 4 | 10.678 | 0.000 | -15.374 | -14.672 | -15.089 |

Czech R.

| Lag | LR | FPE | AIC | SIC | HQ |
|---|---|---|---|---|---|
| 0 | NA | 0.000 | -4.622 | -4.558 | -4.596 |
| 1 | 1197.06 | 0.000 | -13.558 | -13.301 | -13.454 |
| 2 | 62.630 | 0.000* | -13.911* | -13.462* | -13.729* |
| 3 | 11.006 | 0.000 | -13.866 | -13.224 | -13.605 |
| 4 | 13.568 | 0.000 | -13.844 | -13.009 | -13.505 |
| 5 | 16.744 | 0.000 | -13.852 | -12.824 | -13.434 |
| 6 | 11.905 | 0.000 | -13.821 | -12.600 | -13.325 |
| 7 | 15.211 | 0.000 | -13.822 | -12.409 | -13.248 |
| 8 | 17.357* | 0.000 | -13.846 | -12.240 | -13.193 |

Hungary

| Lag | LR | FPE | AIC | SIC | HQ |
|---|---|---|---|---|---|
| 0 | NA | 0.000 | -3.339 | -3.275 | -3.313 |
| 1 | 985.409 | 0.000 | -10.672 | -10.415 | -10.568 |
| 2 | 46.012* | 0.000* | -10.897* | -10.447* | -10.714* |
| 3 | 16.093 | 0.000 | -10.892 | -10.249 | -10.631 |
| 4 | 6.430 | 0.000 | -10.812 | -9.977 | -10.472 |

Latvia

| Lag | LR | FPE | AIC | SIC | HQ |
|---|---|---|---|---|---|
| 0 | NA | 0.000 | -15.995 | -15.908 | -15.960 |
| 1 | 691.026 | 0.000 | -24.418 | -24.071* | -24.279* |
| 2 | 20.334 | 0.000* | -24.468 | -23.860 | -24.224 |
| 3 | 10.751 | 0.000 | -24.399 | -23.531 | -24.050 |
| 4 | 15.884 | 0.000 | -24.408 | -23.280 | -23.955 |
| 5 | 6.991 | 0.000 | -24.297 | -22.908 | -23.738 |
| 6 | 16.425 | 0.000 | -24.335 | -22.686 | -23.672 |
| 7 | 17.865 | 0.000 | -24.409 | -22.499 | -23.641 |
| 8 | 18.951* | 0.000 | -24.516 | -22.346 | -23.644 |
| 9 | 12.110 | 0.000 | -24.518* | -22.087 | -23.541 |

Lithuania

| Lag | LR | FPE | AIC | SIC | HQ |
|---|---|---|---|---|---|
| 0 | NA | 0.000 | -1.853 | -1.788 | -1.827 |
| 1 | 1253.95 | 0.000 | -11.220 | -10.963 | -11.116 |
| 2 | 50.554 | 0.000 | -11.480 | -11.030* | -11.297* |
| 3 | 6.585 | 0.000 | -11.399 | -10.757 | -11.138 |
| 4 | 21.785 | 0.000 | -11.444 | -10.609 | -11.105 |
| 5 | 11.259 | 0.000 | -11.406 | -10.378 | -10.988 |
| 6 | 19.321 | 0.000 | -11.438 | -10.218 | -10.942 |
| 7 | 36.693* | 0.000* | -11.628* | -10.215 | -11.054 |
| 8 | 7.623 | 0.000 | -11.564 | -9.958 | -10.912 |

Poland

| Lag | LR | FPE | AIC | SIC | HQ |
|---|---|---|---|---|---|
| 0 | NA | 0.000 | -2.192 | -2.128 | -2.166 |
| 1 | 1292.69 | 0.000 | -11.853 | -11.596 | -11.748 |
| 2 | 51.486 | 0.000* | -12.119* | -11.670* | -11.937* |
| 3 | 15.655 | 0.000 | -12.111 | -11.469 | -11.850 |
| 4 | 4.091 | 0.000 | -12.012 | -11.177 | -11.673 |
| 5 | 23.566 | 0.000 | -12.076 | -11.048 | -11.658 |
| 6 | 18.156* | 0.000 | -12.099 | -10.878 | -11.603 |
| 7 | 8.071 | 0.000 | -12.037 | -10.624 | -11.463 |
| 8 | 8.996 | 0.000 | -11.986 | -10.380 | -11.333 |

Romania

| Lag | LR | FPE | AIC | SIC | HQ |
|---|---|---|---|---|---|
| 0 | NA | 0.000 | -5.130 | -5.025 | -5.089 |
| 1 | 332.98* | 0.000* | -10.776* | -10.357* | -10.612* |
| 2 | 15.552 | 0.000 | -10.769 | -10.036 | -10.483 |
| 3 | 5.536 | 0.000 | -10.580 | -9.533 | -10.170 |
| 4 | 7.547 | 0.000 | -10.441 | -9.079 | -9.908 |

Serbia

| Lag | LR | FPE | AIC | SIC | HQ |
|---|---|---|---|---|---|
| 0 | NA | 0.000 | -8.020 | -7.928 | -7.983 |
| 1 | 486.776 | 0.000 | -14.544 | -14.176* | -14.397 |
| 2 | 27.995 | 0.000 | -14.713 | -14.069 | -14.455 |
| 3 | 32.351* | 0.000* | -14.966* | -14.046 | -14.598* |
| 4 | 7.513 | 0.000 | -14.848 | -13.652 | -14.370 |

Turkey

| Lag | LR | FPE | AIC | SIC | HQ |
|---|---|---|---|---|---|
| 0 | NA | 0.028 | 4.953 | 5.018 | 4.979 |
| 1 | 1312.14 | 0.000 | -4.930 | -4.672* | -4.825 |
| 2 | 39.684 | 0.000 | -5.107 | -4.655 | -4.923 |
| 3 | 20.834 | 0.000 | -5.140 | -4.494 | -4.878 |
| 4 | 32.618 | 0.000 | -5.274 | -4.435 | -4.933* |
| 5 | 15.682 | 0.000 | -5.272 | -4.239 | -4.853 |
| 6 | 20.051 | 0.000 | -5.312 | -4.085 | -4.813 |
| 7 | 7.762 | 0.000 | -5.247 | -3.827 | -4.670 |
| 8 | 26.410* | 0.000* | -5.354* | -3.740 | -4.698 |

Note: * indicates lag order selected by the criterion; LR – sequential modified likelihood ratio test statistic; FPE – Final Prediction Error; AIC - Akaike Information Criterion; SIC - Schwartz Information Criterion; HQ – Hannah-Quinn Information Criterion.

Table 3. Cointegration test results

| | Number of cointegrating equations | | Eigenvalue | Test statistic | Probability# | | Eigenvalue | Test statistic | Probability# |
|---|---|---|---|---|---|---|---|---|---|
| Trace test | None | *Belarus* | *0.119* | *19.26* | *0.770* | *Lithuania* | *0.195* | *38.07* | *0.004*** |
| | At most 1 | | *0.103* | *10.62* | *0.586* | | *0.043* | *8.62* | *0.409* |
| | At most 2 | | *0.047* | *3.26* | *0.544* | | *0.019* | *2.58* | *0.108* |
| Maximum eigenvalue test | None | | *0.119* | *8.65* | *0.912* | | *0.195* | *29.45* | *0.002*** |
| | At most 1 | | *0.103* | *7.36* | *0.633* | | *0.043* | *6.04* | *0.614* |
| | At most 2 | | *0.047* | *3.26* | *0.543* | | *0.019* | *2.58* | *0.108* |
| Note | | *Unrestricted constant and 4 lags.* | | | | *Unrestricted constant and 2 lags.* | | | |
| Trace test | None | *Bulgaria* | *0.248* | *38.63* | *0.019** | *Poland* | *0.463* | *38.61* | *0.003*** |
| | At most 1 | | *0.095* | *12.41* | *0.421* | | *0.188* | *11.28* | *0.198* |
| | At most 2 | | *0.035* | *3.27* | *0.541* | | *0.047* | *2.11* | *0.146* |
| Maximum eigenvalue test | None | | *0.248* | *26.22* | *0.011** | | *0.463* | *27.33* | *0.004*** |
| | At most 1 | | *0.095* | *9.14* | *0.431* | | *0.188* | *9.17* | *0.278* |
| | At most 2 | | *0.035* | *3.27* | *0.540* | | *0.047* | *2.11* | *0.146* |
| Note | | *Restricted constant and 1 lag.* | | | | *Unrestricted constant and 7 lags.* | | | |
| Trace test | None | *Croatia* | *0.137* | *36.54* | *0.034** | *Romania* | *0.139* | *24.48* | *0.046** |
| | At most 1 | | *0.039* | *10.56* | *0.591* | | *0.027* | *4.20* | *0.675* |
| | At most 2 | | *0.019* | *3.47* | *0.508* | | *0.004* | *0.55* | *0.524* |
| Maximum eigenvalue test | None | | *0.137* | *25.98* | *0.012** | | *0.139* | *20.27* | *0.018** |
| | At most 1 | | *0.039* | *7.10* | *0.663* | | *0.027* | *3.65* | *0.684* |
| | At most 2 | | *0.019* | *3.47* | *0.507* | | *0.004* | *0.55* | *0.518* |
| Note | | *Restricted constant and 8 lags.* | | | | *No constant and 2 lags.* | | | |
| Trace test | None | *Czech R.* | *0.133* | *25.74* | *0.031** | *Serbia* | *0.291* | *27.87* | *0.084* |
| | At most 1 | | *0.077* | *9.24* | *0.156* | | *0.073* | *7.21* | *0.560* |
| | At most 2 | | *0.000* | *0.00* | *0.990* | | *0.043* | *2.66* | *0.103* |
| Maximum eigenvalue test | None | | *0.133* | *16.50* | *0.076* | | *0.291* | *20.66* | *0.057* |
| | At most 1 | | *0.077* | *9.24* | *0.110* | | *0.073* | *4.55* | *0.794* |
| | At most 2 | | *0.000* | *0.00* | *0.988* | | *0.043* | *2.66* | *0.103* |
| Note | | *No constant and 7 lags.* | | | | *Unrestricted constant and 2 lags.* | | | |
| Trace test | None | *Hungary* | *0.195* | *38.08* | *0.004*** | *Turkey* | *0.164* | *21.57* | *0.333* |
| | At most 1 | | *0.058* | *8.59* | *0.412* | | *0.117* | *9.36* | *0.339* |
| | At most 2 | | *0.004* | *0.53* | *0.468* | | *0.013* | *0.91* | *0.339* |
| Maximum eigenvalue test | None | | *0.195* | *29.49* | *0.002*** | | *0.164* | *12.21* | *0.540* |
| | At most 1 | | *0.058* | *8.06* | *0.381* | | *0.117* | *8.45* | *0.343* |
| | At most 2 | | *0.004* | *0.53* | *0.468* | | *0.013* | *0.91* | *0.339* |
| Note | | *Unrestricted constant and 2 lags.* | | | | *Unrestricted constant and 4 lags.* | | | |
| Trace test | None | *Latvia* | *0.417* | *45.96* | *0.002*** | | | | |
| | At most 1 | | *0.157* | *13.61* | *0.208* | | | | |
| | At most 2 | | *0.055* | *3.38* | *0.066* | | | | |
| Maximum eigenvalue test | None | | *0.417* | *32.35* | *0.002*** | | | | |
| | At most 1 | | *0.157* | *10.24* | *0.383* | | | | |
| | At most 2 | | *0.055* | *3.38* | *0.066* | | | | |
| Note | | *Restricted constant, unrestricted trend and 9 lags.* | | | | | | | |

Note: ** denotes rejection of the hypothesis at the 0.01 level; * denotes rejection of the hypothesis at the 0.05 level; # critical values for p-values can be found in MacKinnon, Haug and Michelis (1999).

Table 4. Cointegrating vectors

| Country | Variable | Cointegration vector | Cointegrating vector with restrictions |
|---|---|---|---|
| Bulgaria | DE | *1* | *1* |
| | RER | *1.335* | *0.107* |
| | IRD | *-0.199* | *-0.073* |
| | Const. | *-2.716* | *0* |
| Note | *Chi square = 2.5601 [0.1096]* | | |
| Croatia | DE | *1* | *1* |
| | NER | *-1.371* | *-1* |
| | IRD | *-0.055* | *-1* |
| | Const. | *1.431* | *3.397* |
| Note | *Chi square = 3.4030 [0.1824]* | | |
| Czech R. | DE | *1* | *1* |
| | NER | *0.911* | *1* |
| | IRD | *0.955* | *1* |
| Note | *Chi square = 0.0777 [0.9619]* | | |
| Hungary | DE | *1* | |
| | NER | *-6.936* | |
| | IRD | *0.018* | |
| Note | *No restrictions accepted.* | | |
| Latvia | DE | *1* | *1* |
| | RER | *0.136* | *0.105* |
| | IRD | *-0.001* | *-0.001* |
| | Const. | *-0.058* | *0* |
| Note | *Chi square = 0.254 [0.614]* | | |

| Country | Variable | Cointegration vector | Cointegrating vector with restrictions |
|---|---|---|---|
| Lithuania | DE | *1* | *1* |
| | RER | *-3.250* | *-1* |
| | IRD | *-0.086* | *-0.080* |
| Note | *Chi square = 0.7642 [0.3820]* | | |
| Poland | DE | *1* | |
| | NER | *1.132* | |
| | IRD | *-0.001* | |
| Note | *No restrictions accepted.* | | |
| Turkey | DE | *1* | 1 |
| | NER | *-0.454* | -1 |
| | IRD | *-0.014* | -0.026 |
| Note | *Chi square = 2.475 [0.116]* | | |

General note: all coefficients are in vector notation.

Table 5. Estimation of TVAR and test of nonlinearity

| Country | Estimated threshold | Sup F | Bootstrapped p | Chi-square p | Corresponding DE (in %) |
|---|---|---|---|---|---|
| Belarus | -0.287 | 41.3653 | 0.174 | 0.000 | - |
| Bulgaria | -0.252 | 46.8602 | 0.008*** | 0.000 | 56.1 |
| Croatia | -0.125 | 51.8103 | 0.007*** | 0.000 | 74.4 |
| Czech R. | -1.011 | 45.5666 | 0.054 | 0.000 | - |
| Hungary | -0.718 | 47.8170 | 0.018** | 0.000 | 18.8 |
| Latvia | -0.086 | 45.3061 | 0.033** | 0.000 | 81.5 |
| Lithuania | -0.426 | 53.5303 | 0.002*** | 0.000 | 37.2 |
| Poland | -0.685 | 40.8365 | 0.240 | 0.000 | - |
| Romania | -0.433 | 41.7328 | 0.034** | 0.000 | 37.0 |
| Serbia | -0.171 | 43.8639 | 0.040** | 0.000 | 67.7 |
| Turkey | -0.383 | 59.9263 | 0.000*** | 0.000 | 41.9 |

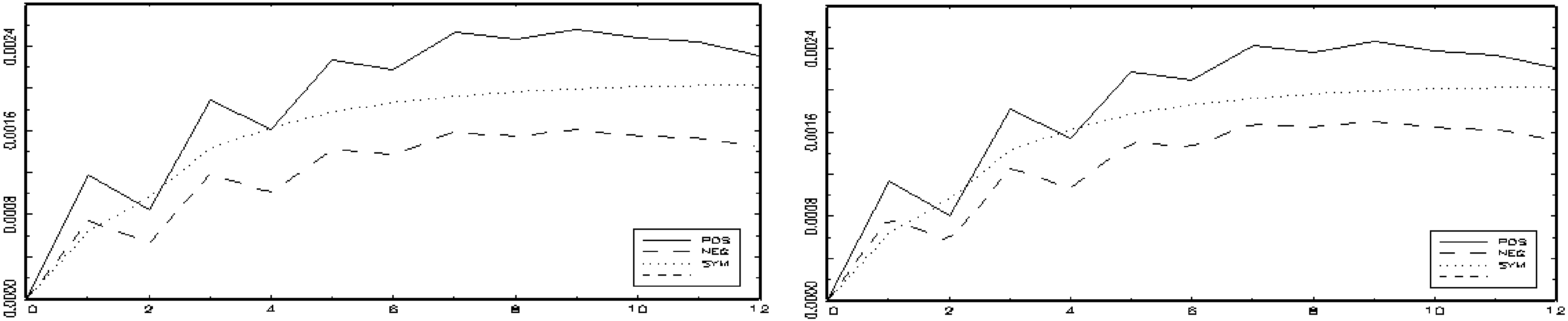
Note: *** null hypothesis about linearity rejected on 1 percent level of significance; ** hypothesis about linearity rejected on 5 percent level of significance.

Figure 1: Effect of positive and negative (one-standard deviation) exchange rate shocks

**Bulgaria**

LOW REGIME | HIGH REGIME

Cumulative response of deposit euroization




Cumulative response of interest rate differential

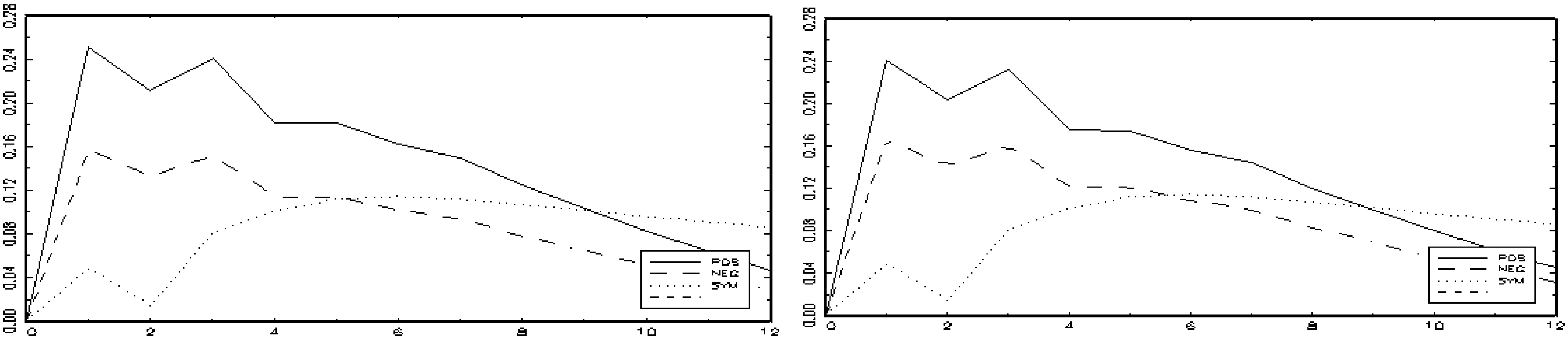
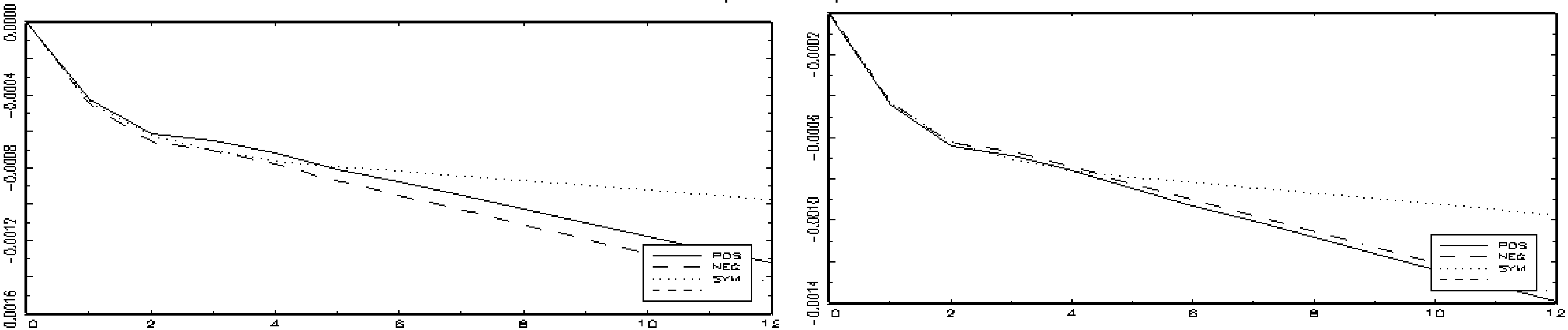


Figure 2: Effect of positive and negative (one-standard deviation) exchange rate shocks

**Croatia**

LOW REGIME | HIGH REGIME

Cumulative response of deposit euroization




Cumulative response of interest rate differential

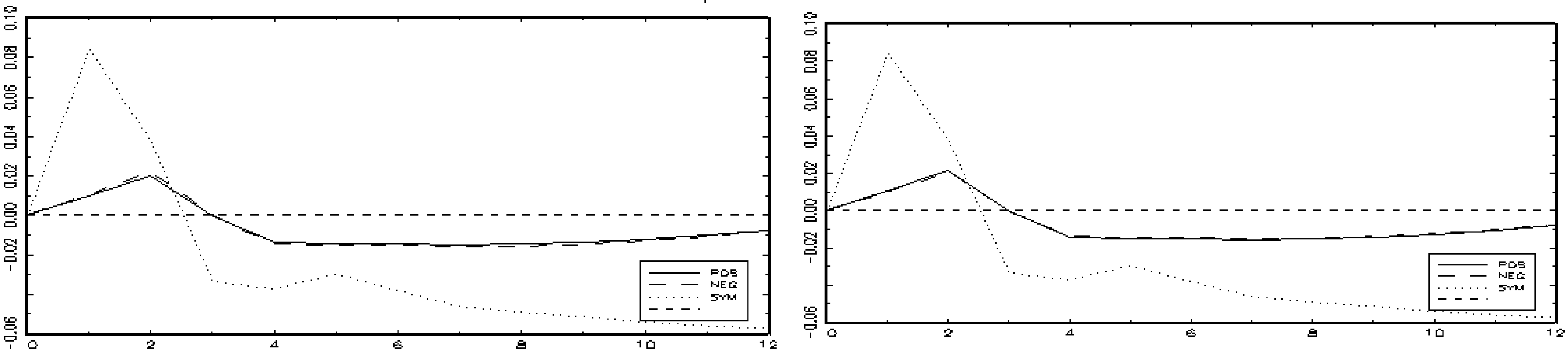


Figure 3: Effect of positive and negative (one-standard deviation) exchange rate shocks

**Hungary**

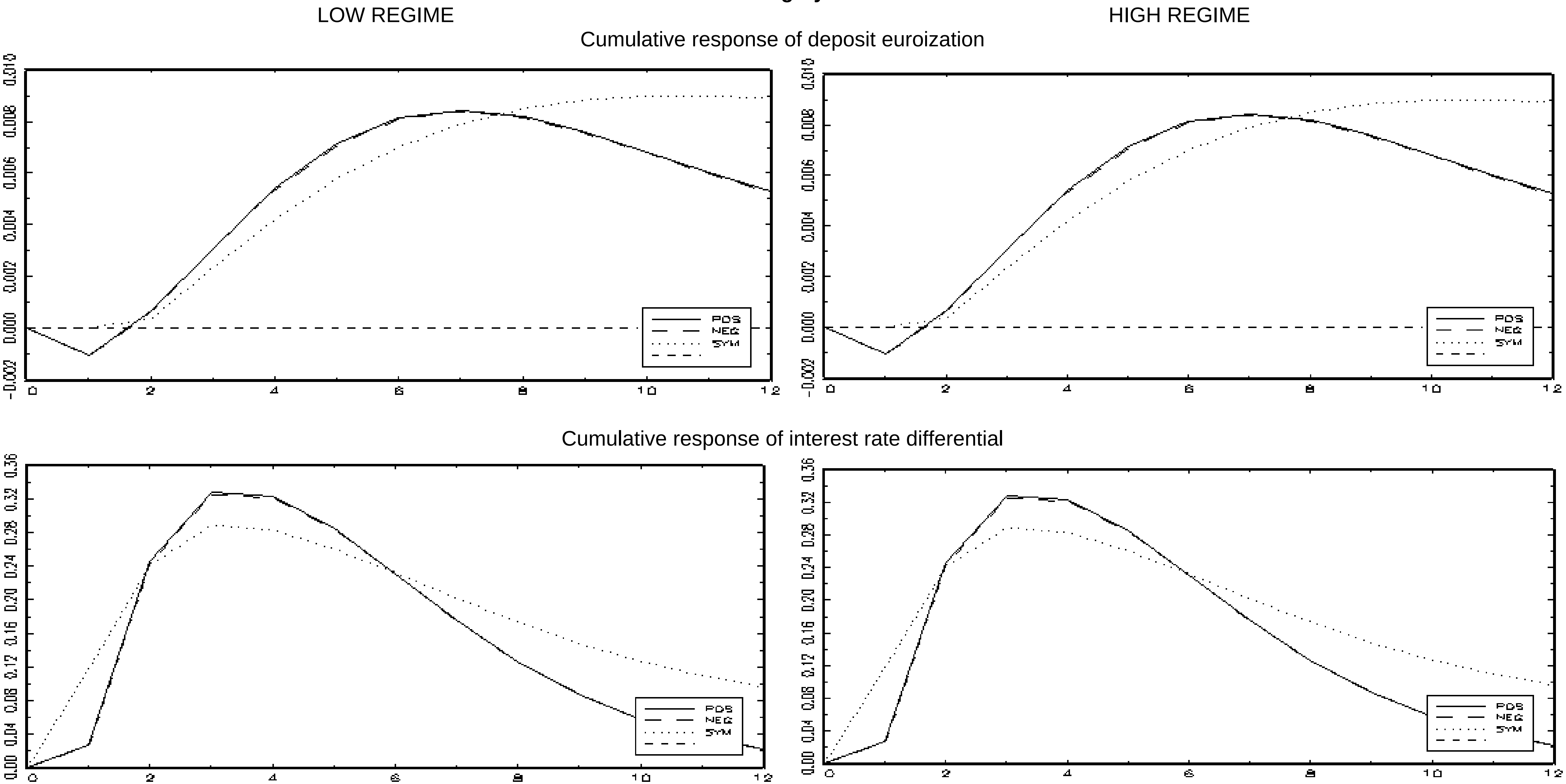
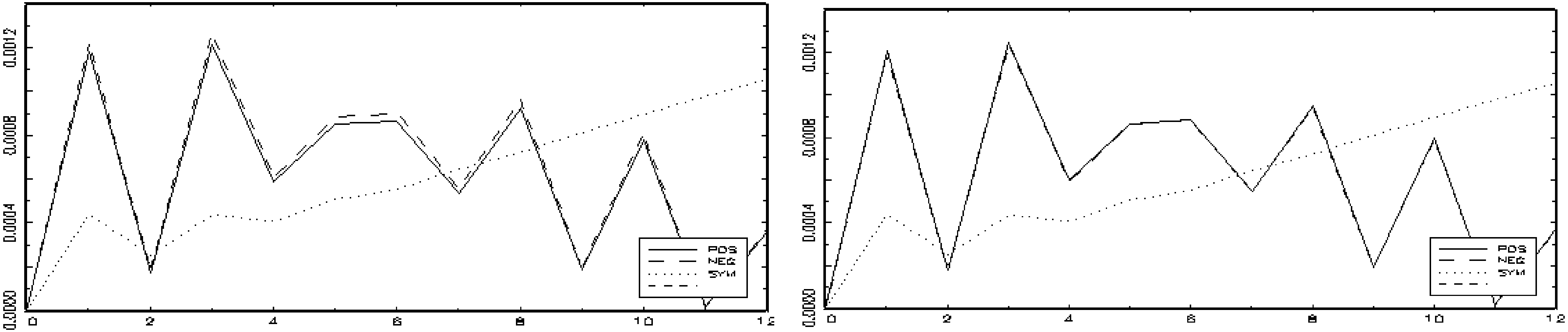


Figure 4: Effect of positive and negative (one-standard deviation) exchange rate shocks

**Latvia**

LOW REGIME HIGH REGIME

Cumulative response of deposit euroization




Cumulative response of interest rate differential

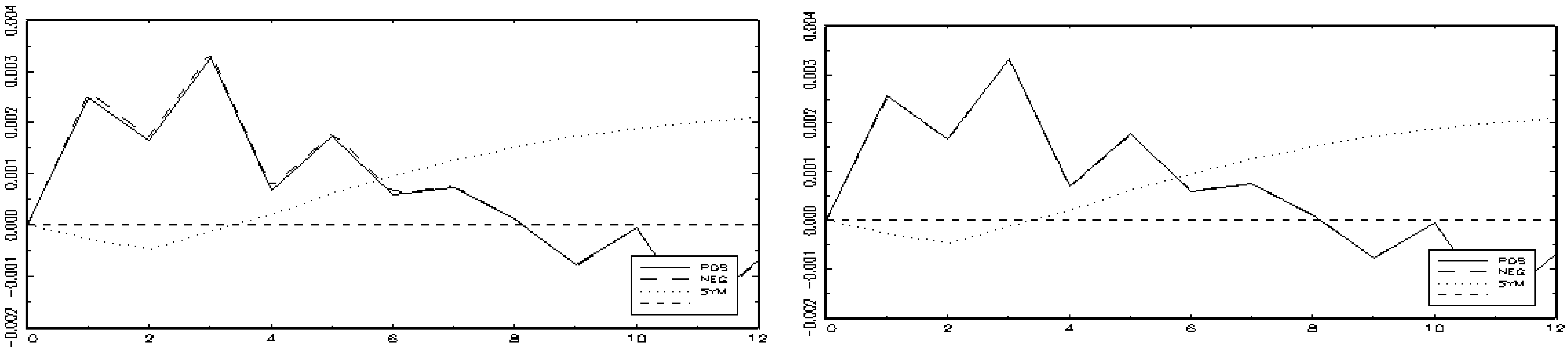
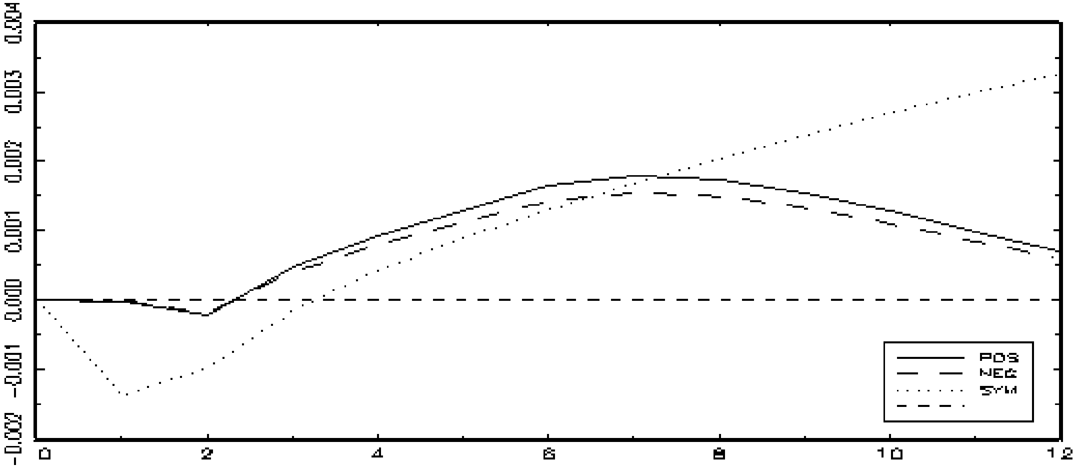


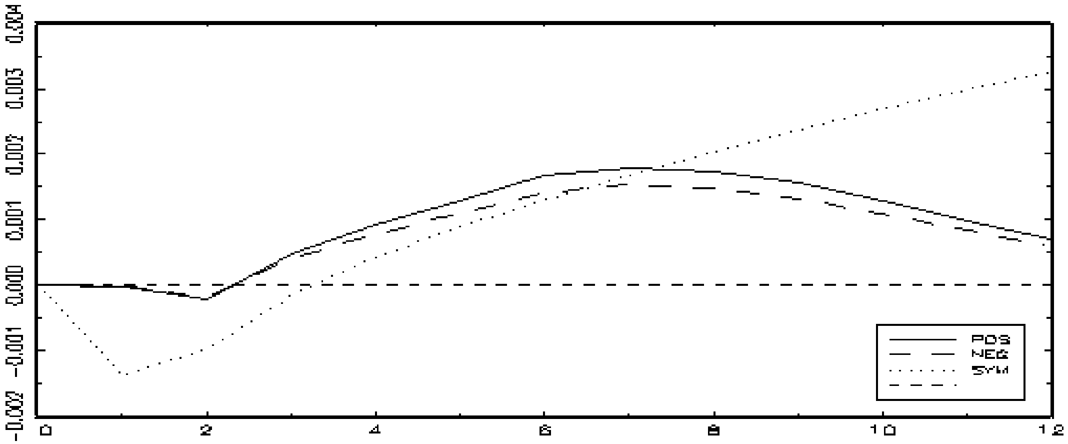
Figure 5: Effect of positive and negative (one-standard deviation) exchange rate shocks

**Lithuania**

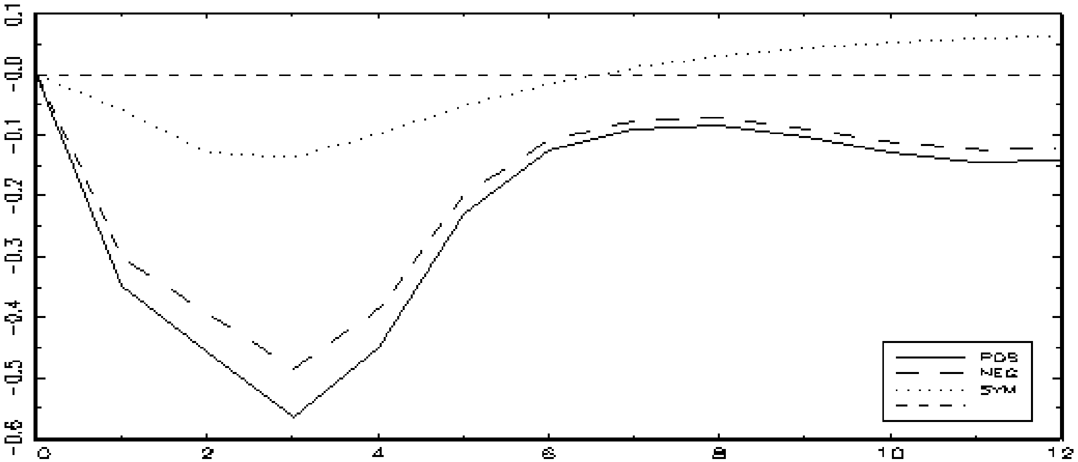
LOW REGIME HIGH REGIME

Cumulative response of deposit euroization




Cumulative response of interest rate differential



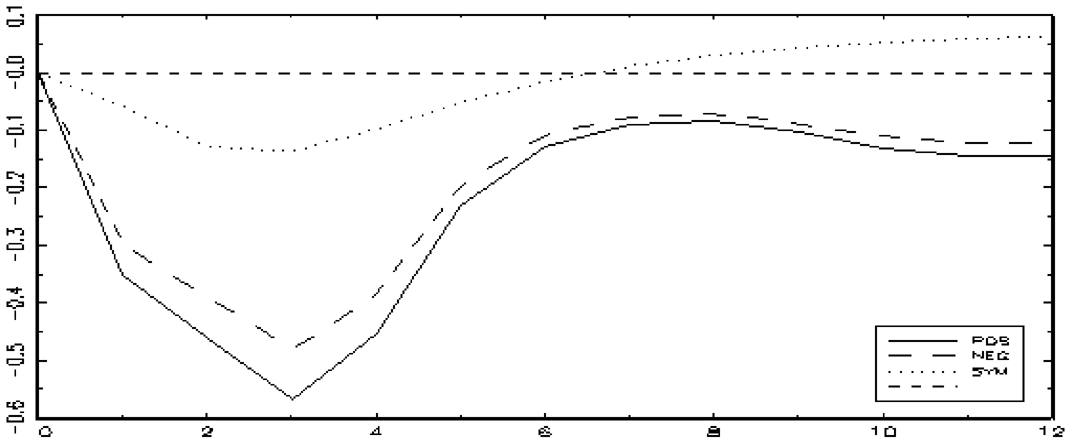
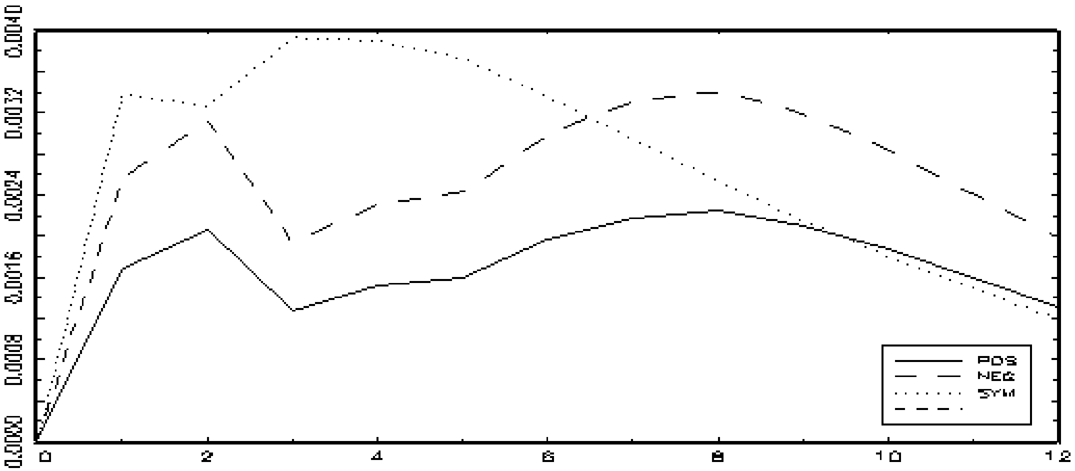



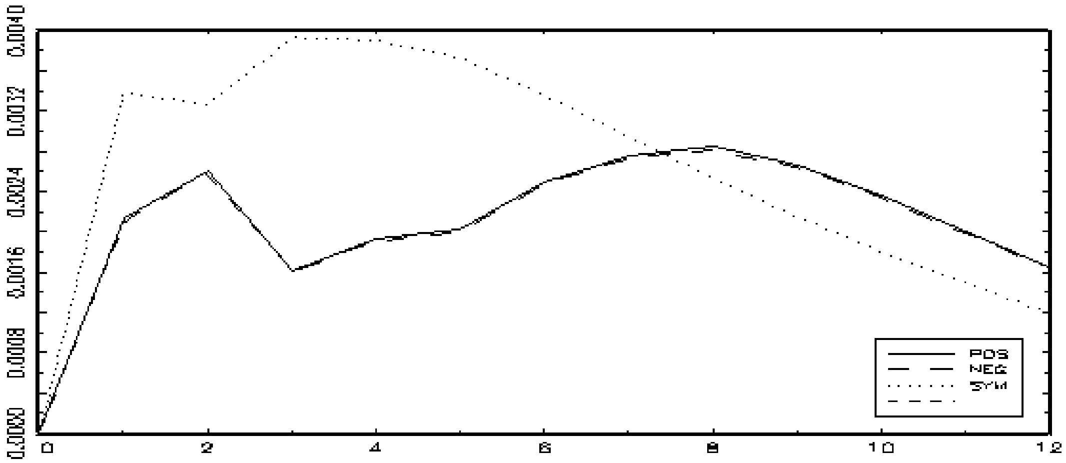
Figure 6: Effect of positive and negative (one-standard deviation) exchange rate shocks

**Romania**

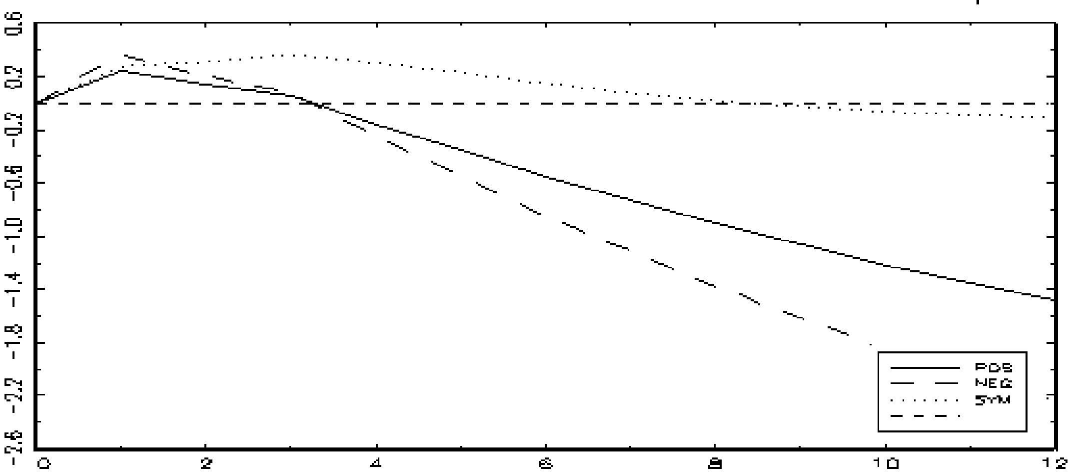
LOW REGIME | HIGH REGIME

Cumulative response of deposit euroization




Cumulative response of interest rate differential



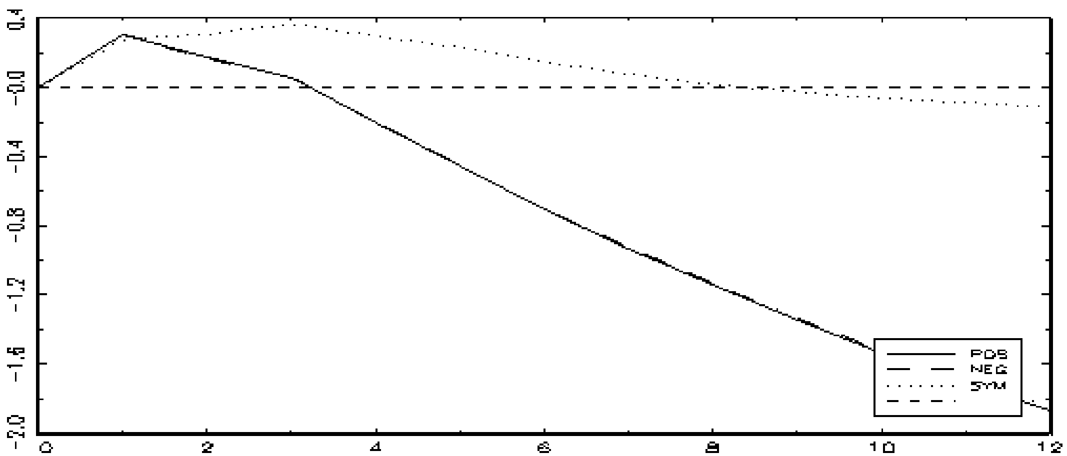
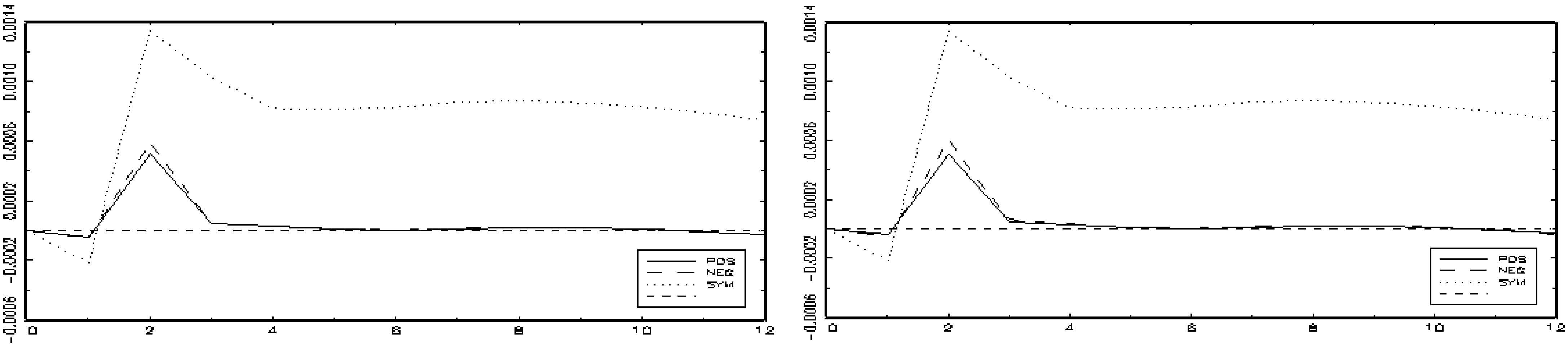



Figure 7: Effect of positive and negative (one-standard deviation) exchange rate shocks

**Serbia**

LOW REGIME | HIGH REGIME

Cumulative response of deposit euroization




Cumulative response of interest rate differential

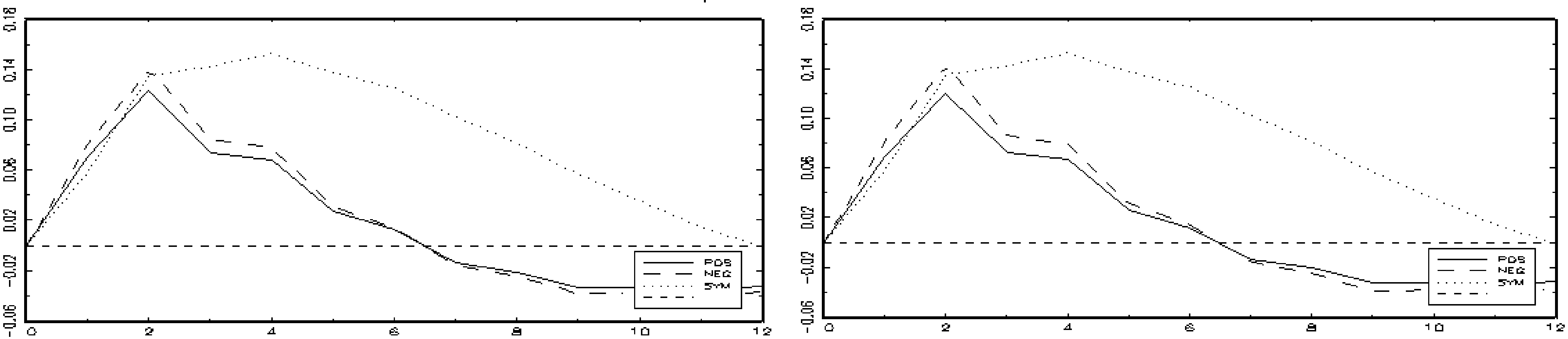
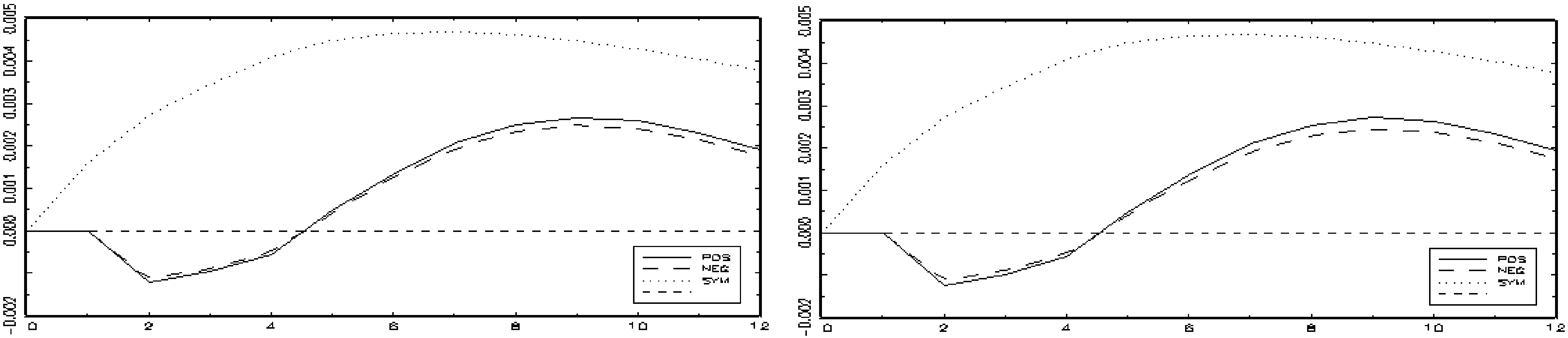


Figure 8: Effect of positive and negative (one-standard deviation) exchange rate shocks

**Turkey**

LOW REGIME HIGH REGIME

Cumulative response of deposit euroization




Cumulative response of interest rate differential

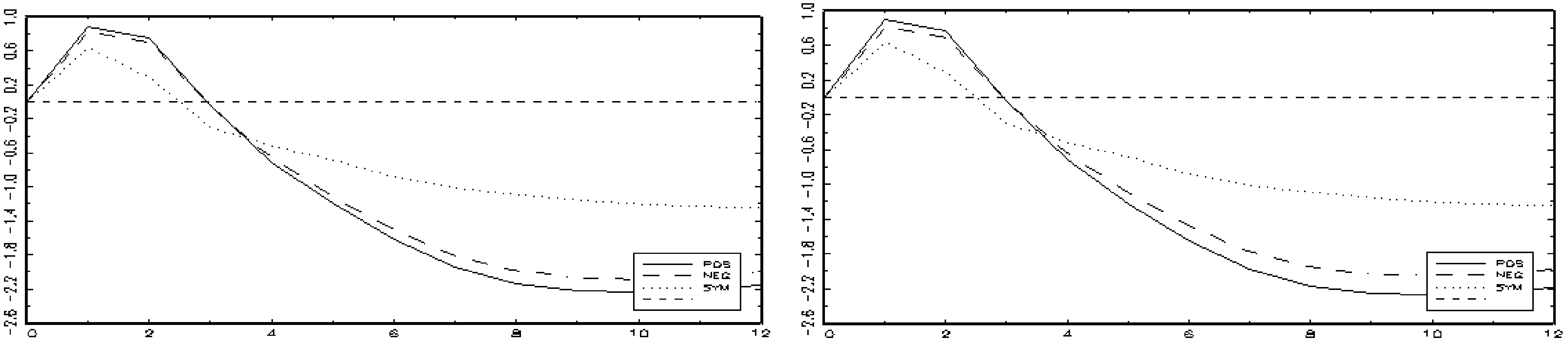
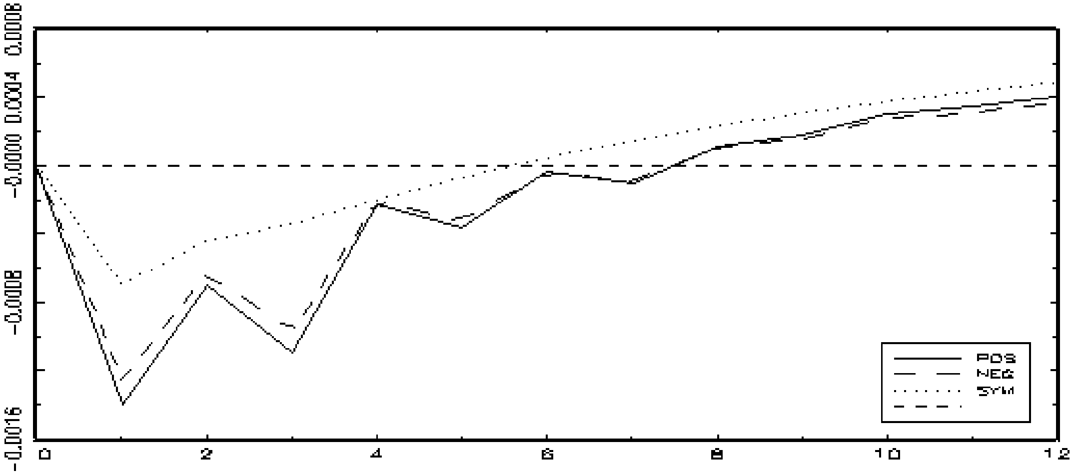


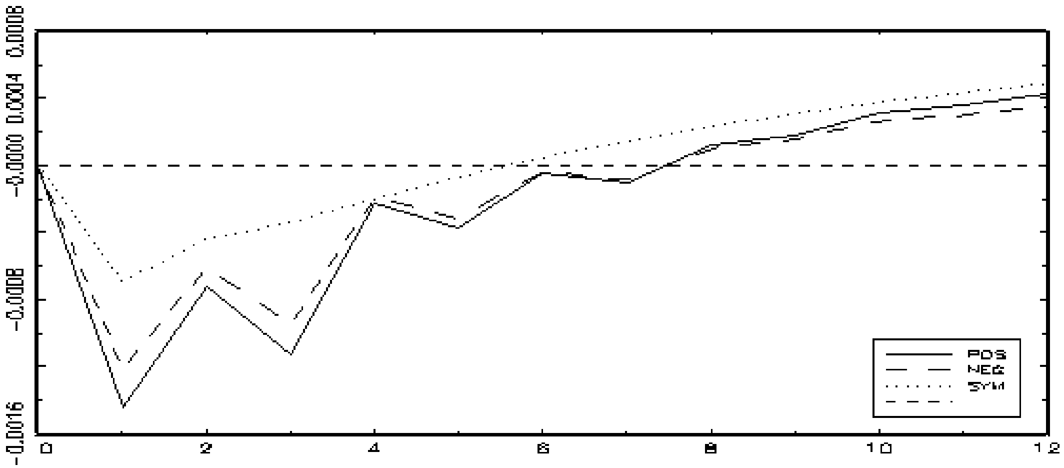
Figure 9: Effect of positive and negative (one-standard deviation) interest rate differential shocks

**Bulgaria**

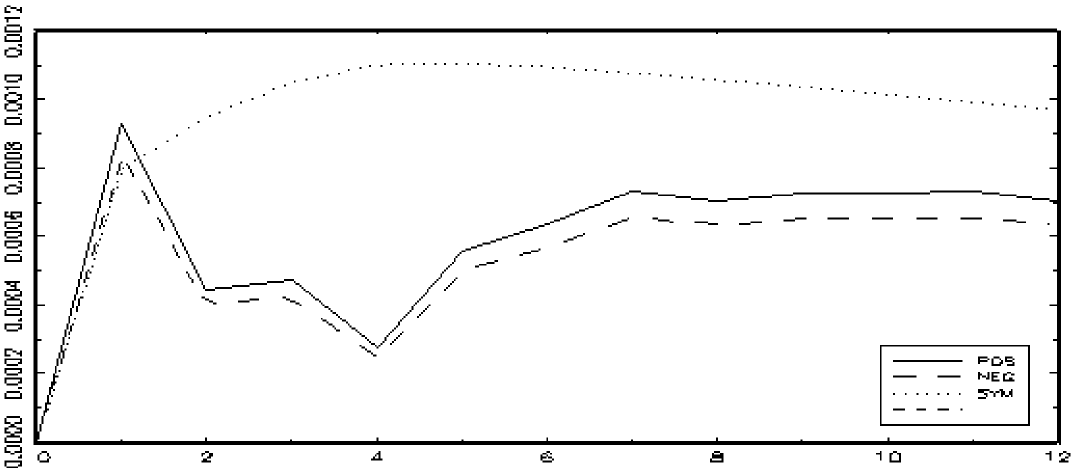
LOW REGIME | HIGH REGIME

Cumulative response of deposit euroization




Cumulative response of exchange rate



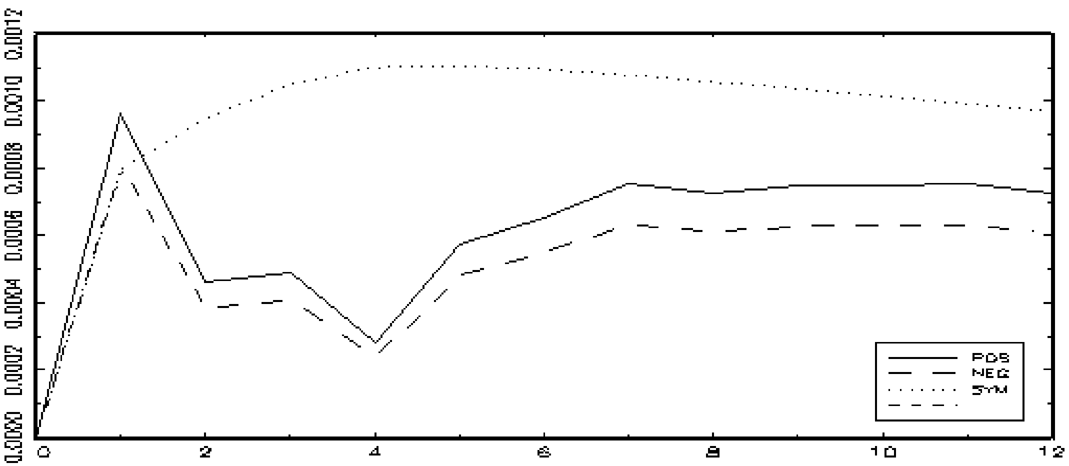
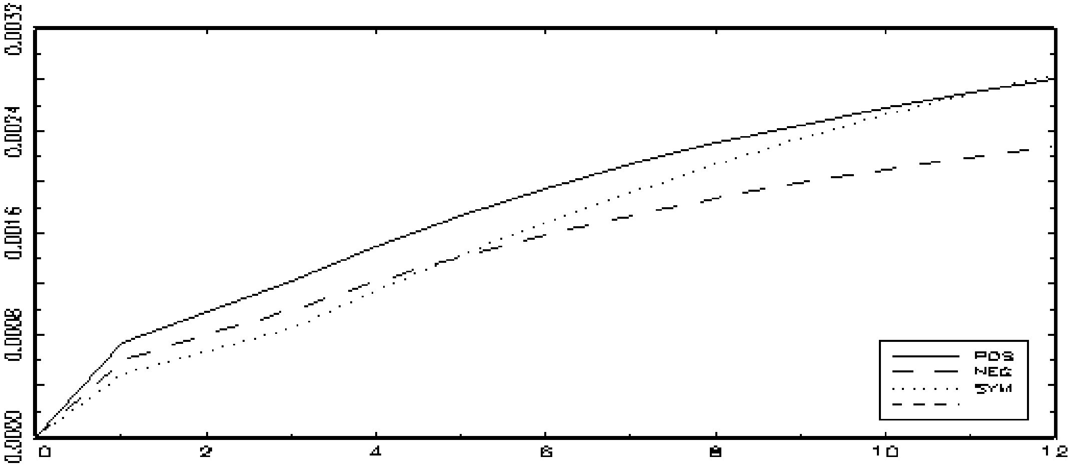



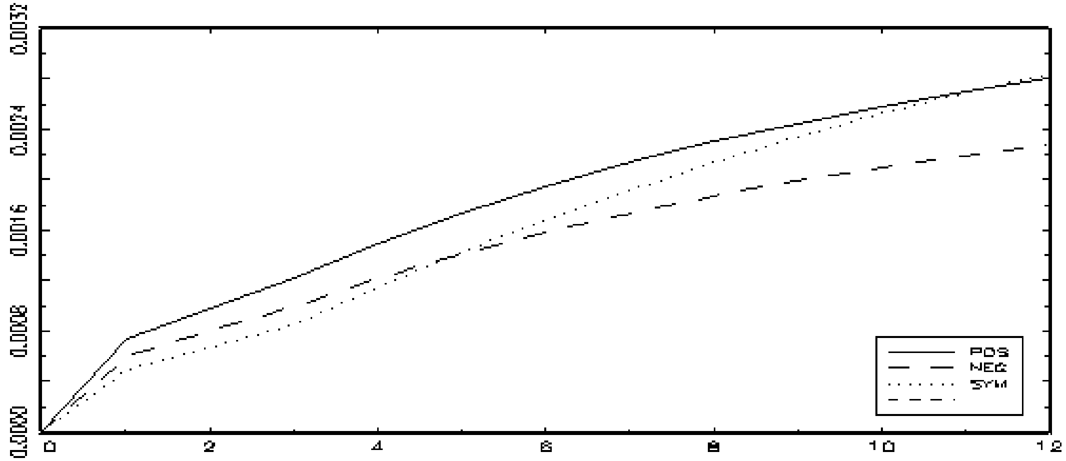
Figure 10: Effect of positive and negative (one-standard deviation) interest rate differential shocks

**Croatia**

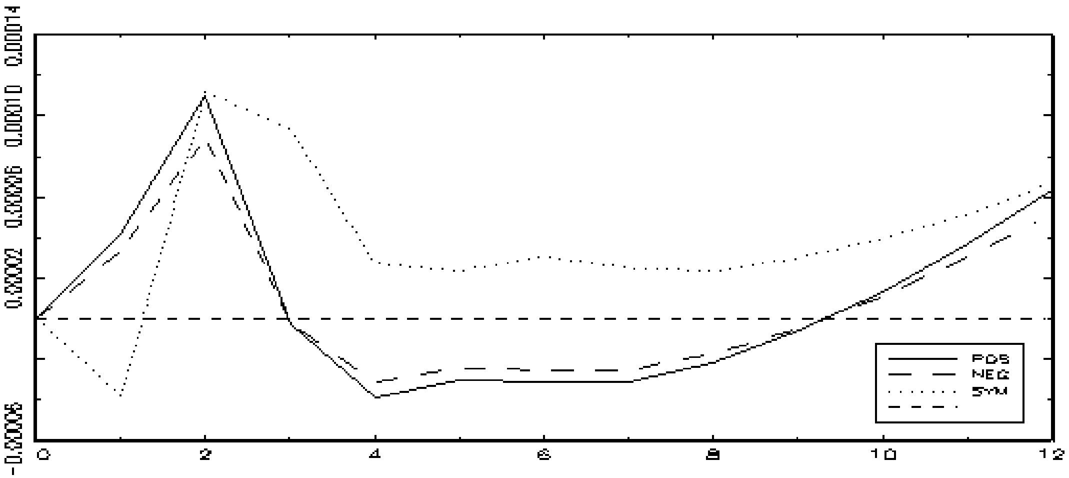
LOW REGIME | HIGH REGIME

Cumulative response of deposit euroization




Cumulative response of exchange rate



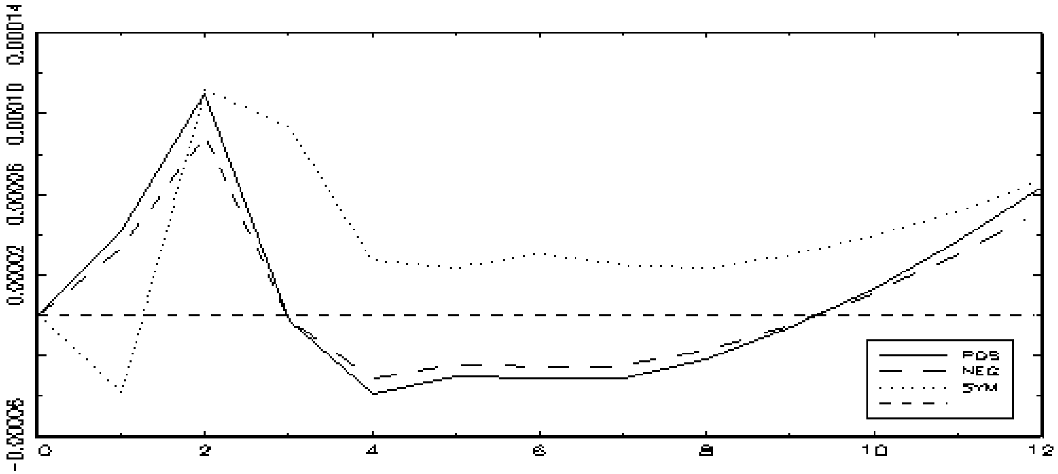



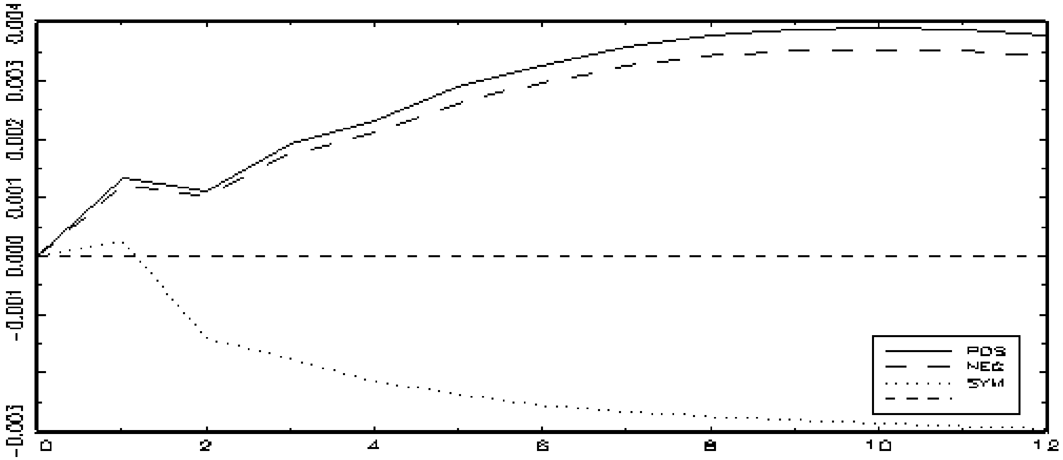
Figure 11: Effect of positive and negative (one-standard deviation) interest rate differential shocks

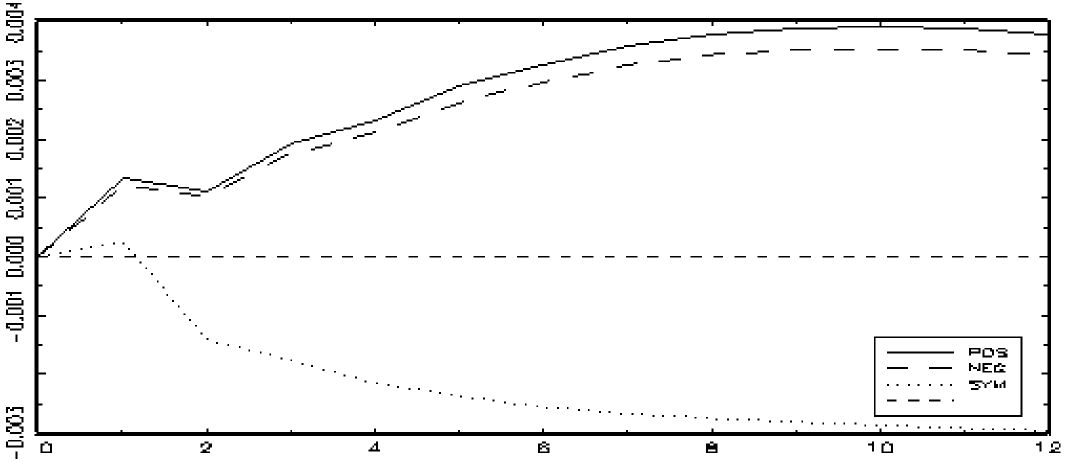
**Hungary**

LOW REGIME

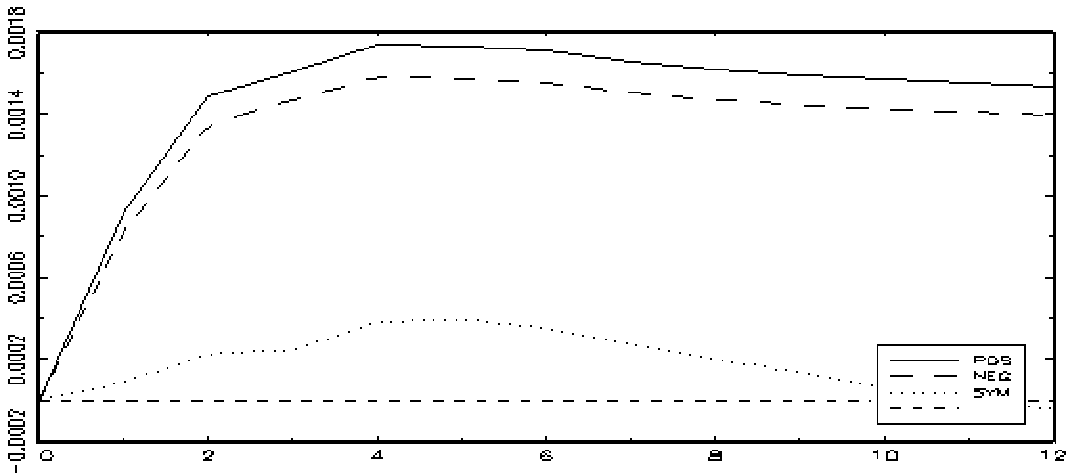
HIGH REGIME

Cumulative response of deposit euroization




Cumulative response of exchange rate



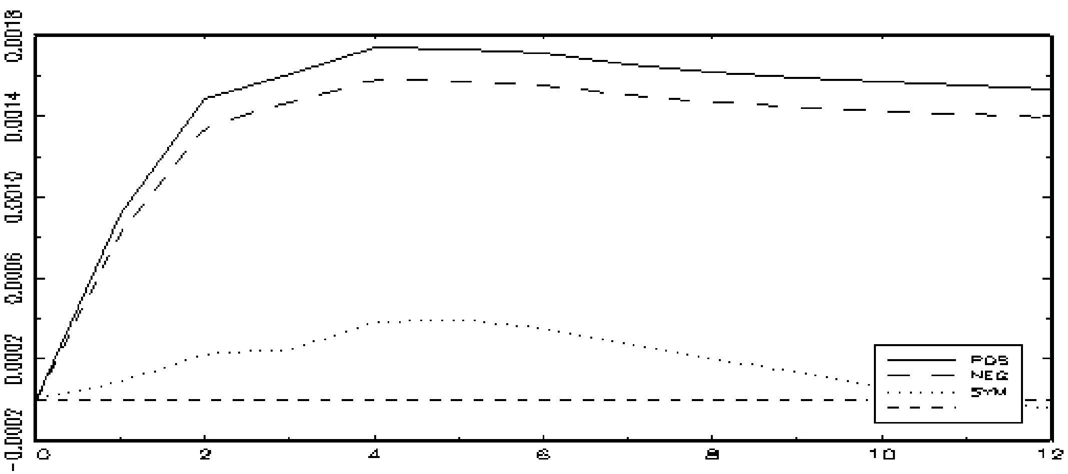
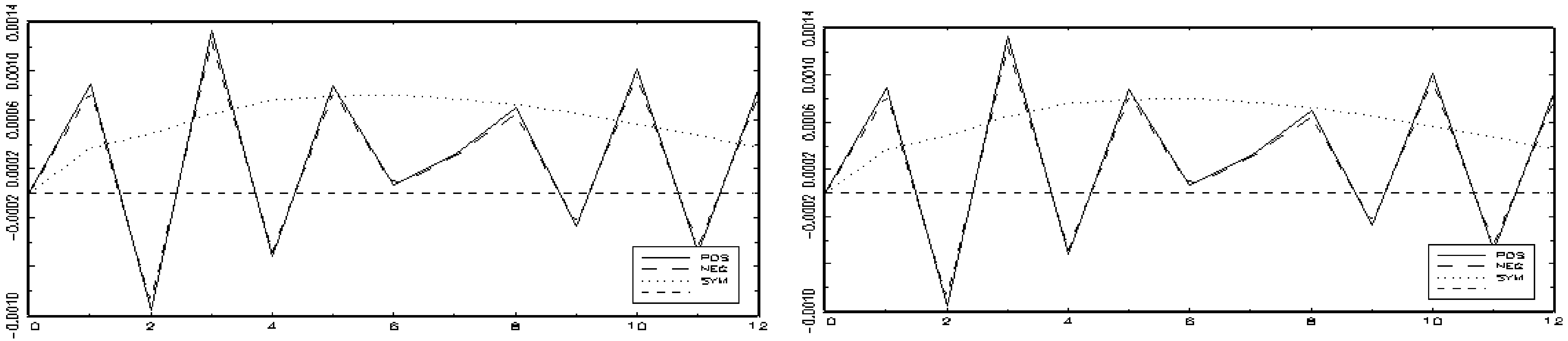



Figure 12: Effect of positive and negative (one-standard deviation) interest rate differential shocks

**Latvia**

LOW REGIME HIGH REGIME

Cumulative response of deposit euroization




Cumulative response of exchange rate

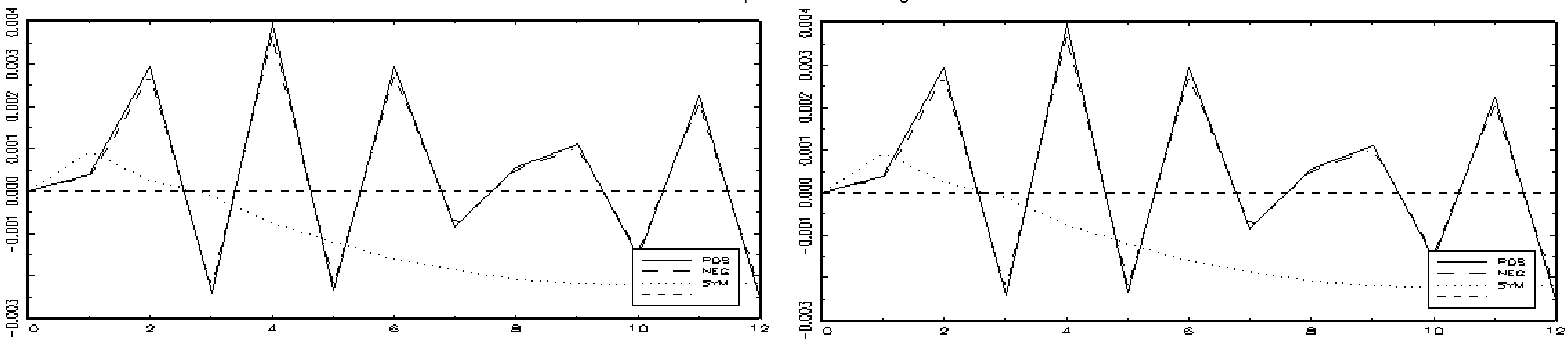
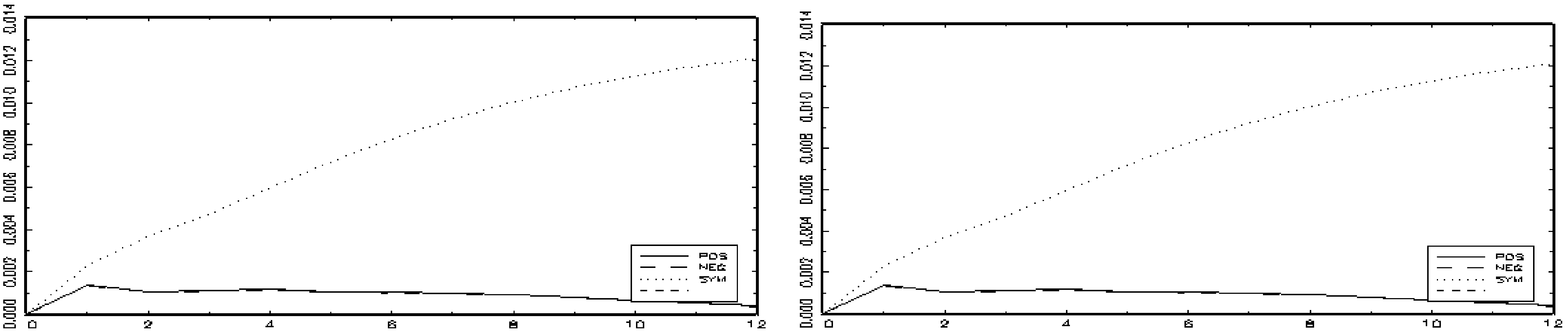


Figure 13: Effect of positive and negative (one-standard deviation) interest rate differential shocks

**Lithuania**

LOW REGIME | HIGH REGIME

Cumulative response of deposit euroization




Cumulative response of exchange rate

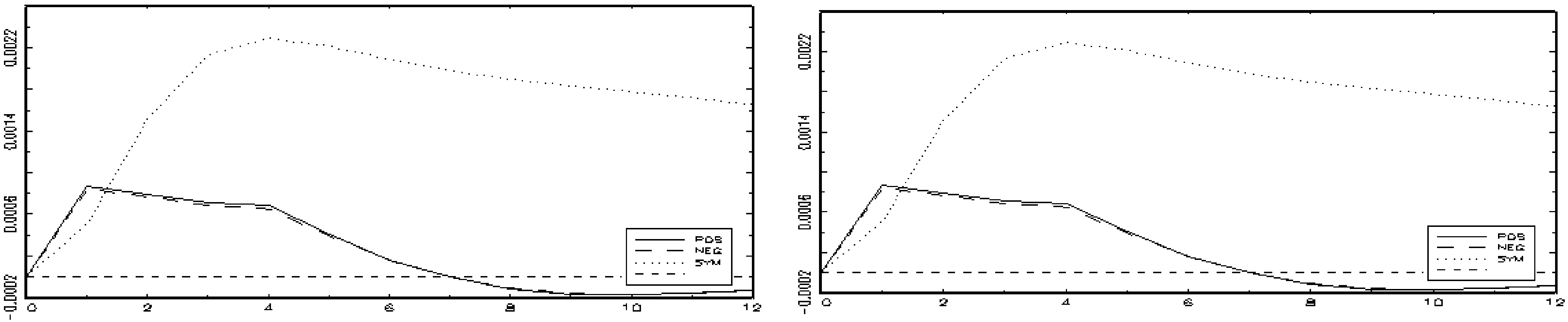
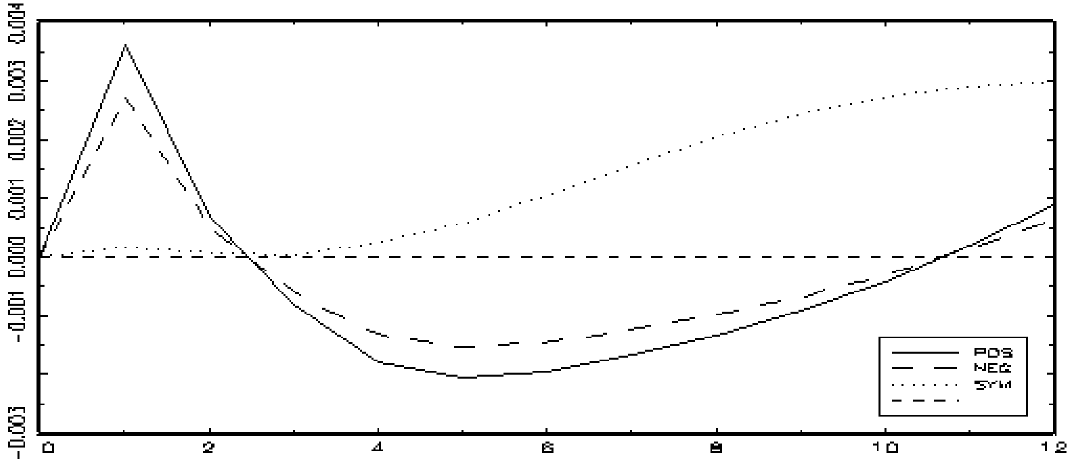


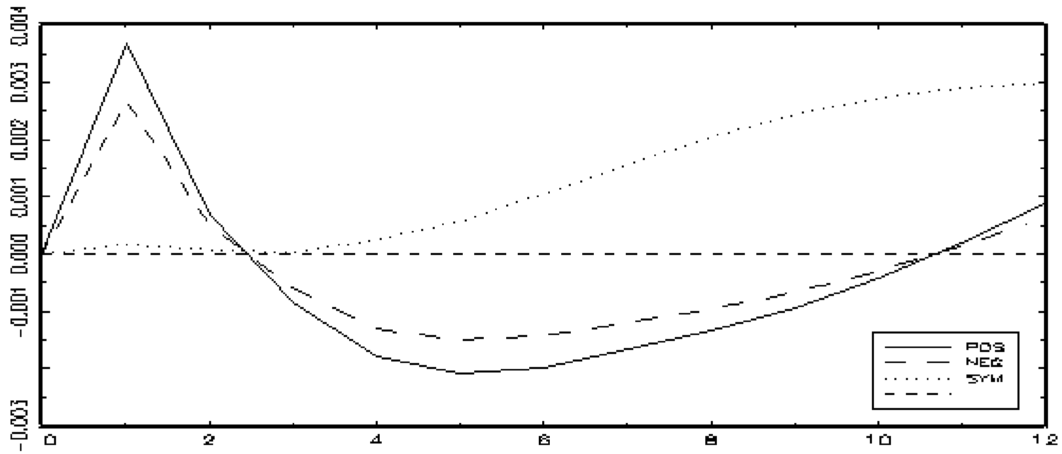
Figure 14: Effect of positive and negative (one-standard deviation) interest rate differential shocks

**Romania**

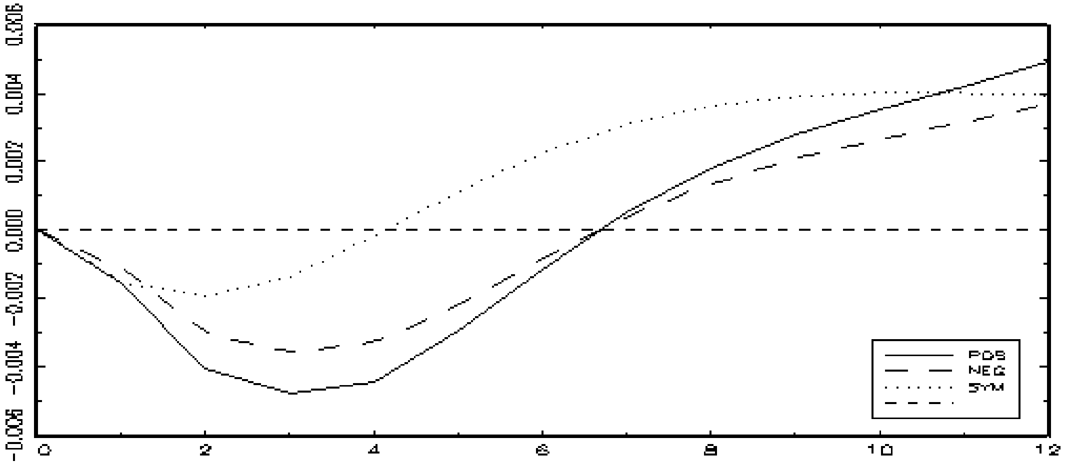
LOW REGIME | HIGH REGIME

Cumulative response of deposit euroization




Cumulative response of exchange rate



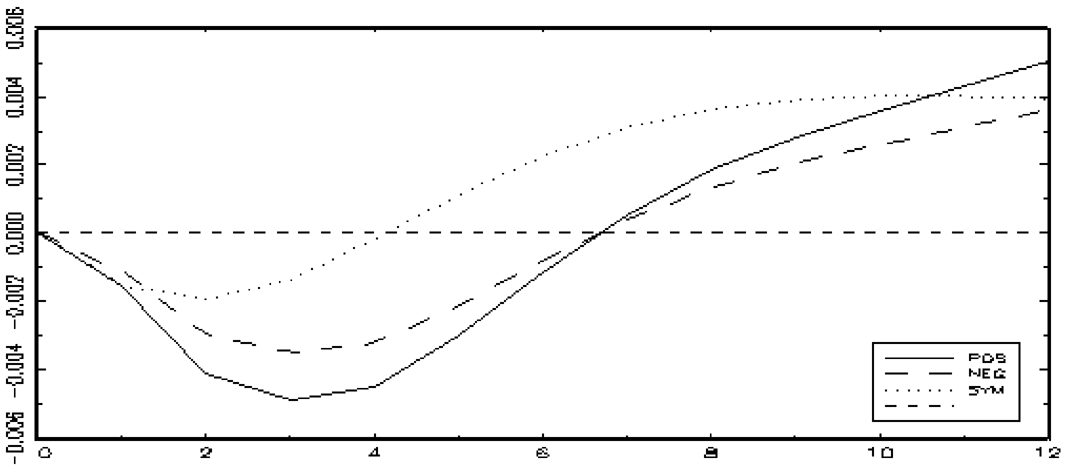
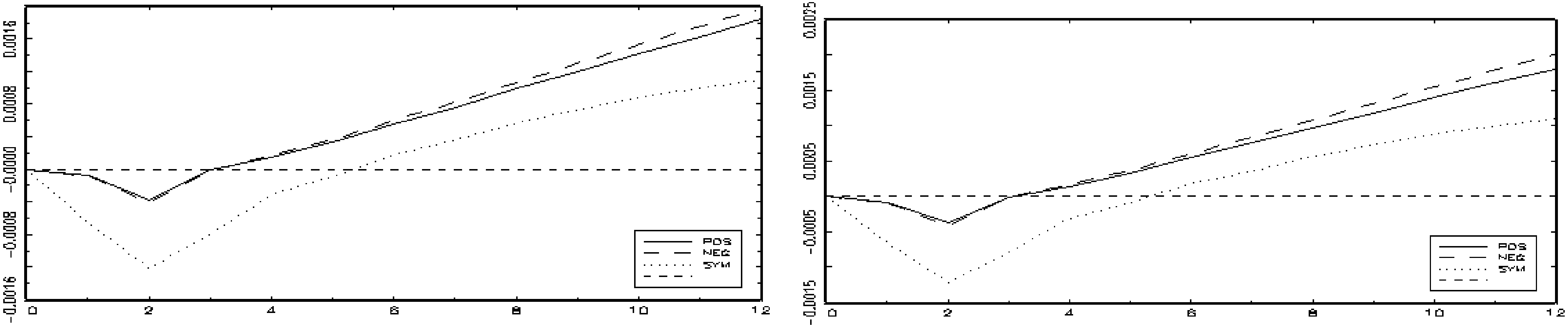



Figure 15: Effect of positive and negative (one-standard deviation) interest rate differential shocks

**Serbia**

LOW REGIME HIGH REGIME

Cumulative response of deposit euroization




Cumulative response of exchange rate

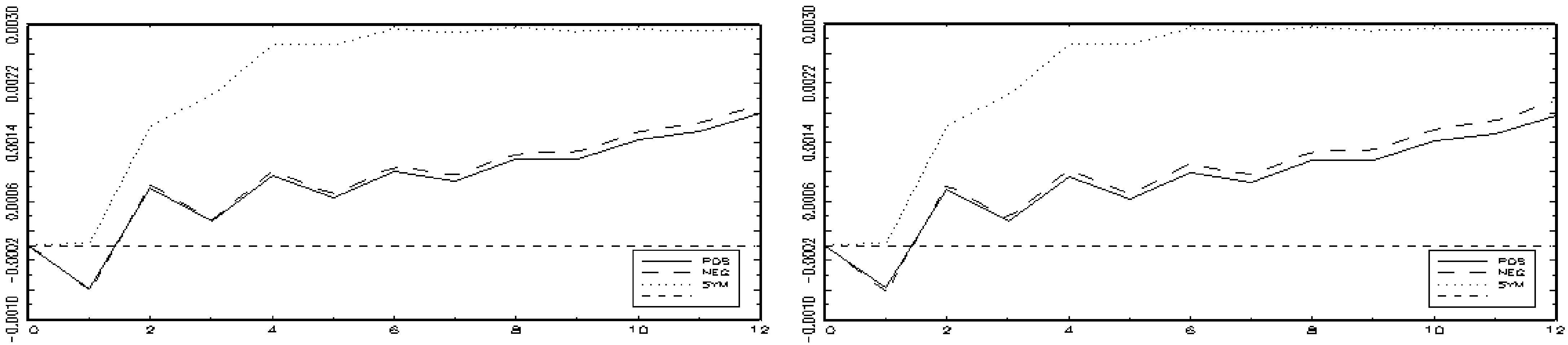
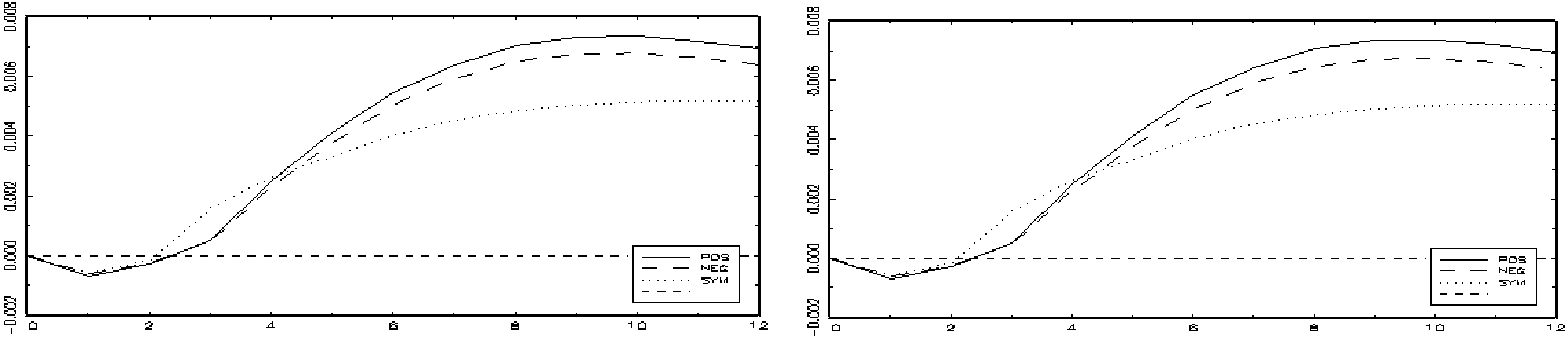


Figure 16: Effect of positive and negative (one-standard deviation) interest rate differential shocks

**Turkey**

LOW REGIME HIGH REGIME

Cumulative response of deposit euroization




Cumulative response of exchange rate