Dinamika depozitne eurizacije u europskim posttranzicijskim zemljama: slučaj VAR-a s uključenim pragom

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Contents

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Abstract:
This paper investigates determinants of deposit euroization (DE) in twelve European post-transition economies using both linear and threshold models. Results suggest that exchange rates and interest rate differentials are important for explaining DE. Results for the two countries with the highest macroeconomic and institutional credibility and flexible exchange rate regimes, the Czech Republic and Poland, suggest no evidence of threshold effects, while for other countries threshold behavior was found. Threshold VAR results indicate depreciations have a stronger effect on DE than appreciations, while interest rate spreads widen more after exchange rate depreciations than after appreciations. Moreover, we found evidence that DE changes more strongly after interest rate differentials increase than after they decrease.

Keywords: cointegration, deposit euroization, transition, threshold VAR
JEL classification: C32, E44, E58, F31, F41

Dinamika depozitne eurizacije u europskim posttranzicijskim zemljama: slučaj VAR-a s uključenim pragom

Sažetak:
U članku se koriste linearni modeli te modeli s uključenim pragom pomoću kojih se istražuju determinante depozitne eurizacije (DE) na uzorku 12 europskih posttranzicijskih zemalja. Rezultati pokazuju da su valutni tečajevi i kamatni diferencijali važni za objašnjavanje DE. Opaža se da Češka i Poljska, dvije zemlje s najvišom razinom makroekonomskog i institucionalnog kredibiliteta te plutajućim tečajnim režimom, ne pokazuju nelinearni obrazac ponašanja dok se kod ostalih zemalja ti obrasci pronalaze. VAR s uključenim pragom upućuje na to da tečajne deprecijacije imaju snažniji utjecaj na DE nego tečajne aprecijacije, dok se kamatni diferencijali više proširuju nakon tečajne deprecijacije nego nakon tečajne aprecijacije. Povrh toga, promjene DE mnogo su veće nakon širenja kamatnih diferencijala nego nakon njihova sužavanja.

Ključne riječi: kointegracija, depozitna eurizacija, tranzicija, VAR s uključenim pragom
JEL klasifikacija: C32, E44, E58, F31, F41

1 Introduction

In the 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, long after macroeconomic stability had been achieved, 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 the official currency (known as official euroization), unofficial euroization is a result of voluntarily using foreign currency for different money functions: either the medium-of-exchange function that leads to currency substitution or the 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 of 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 the 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 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 (2000) 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 the phenomenon, its determinants and influences on the economy. Especially now when an explosion of public debt in some CEE (Central and East European) countries like Hungary will make Maastricht criteria unreachable and therefore euro adoption impossible. That scenario leaves countries without the obvious exit strategy for dealing with FE – official

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

euro adoption. In order to ensure financial and economic stability, it is important to understand what drives FE and how exactly it affects the economy.

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. In addition, exchange rate depreciations seem to affect FE strongly and quickly, while the opposite exchange rate changes have a much more moderate impact. This sort of FE development mimics regime dynamics, in which a variable reacts in one way when above some threshold and in a different manner when below the threshold. One possible explanation for threshold effects is the presence of transaction costs, where changing the currency structure of deposits or loans is time-consuming and usually comes with an expense. For example, switching foreign currency deposits to domestic currency deposits might be protracted if those deposits are agreed not to be withdrawn before a certain period of time elapses unless a penalty is paid. Although threshold or nonlinear effects might describe FE dynamics 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 of deposit euroization. We investigate DE dynamics in twelve Central, Baltic and Southeastern European countries that record very high levels of financial euroization. Our model incorporates DE and two monetary variables recognized as DE drivers in the literature, the interest rate differential and the exchange rate. We would like to show how DE reacts to changes in those monetary variables and how those responses 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 apply TVAR (threshold vector autoregression) which is 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. The goal of this research is to answer two policy questions. Specifically, we aim to explore how exchange rate changes, more precisely, exchange rate depreciations affect DE in an economy with a high level of DE. We expect to show there are nonlinearities in the DE response to exchange rate changes – stronger DE responses to depreciations than to appreciations. If those nonlinearities exist, we will investigate how they differ with respect to the prevailing exchange rate regime. In line with that, we expect stronger DE reactions to exchange rate depreciations than to appreciations in countries with fixed or managed floating exchange rate regimes.

The analysis will contribute to the existing field of knowledge in several ways. Firstly, it will give new insights into the dynamics, characteristics and consequences of DE in European post-transition economies. In order to depict the relationships between euroization and the monetary system, we model monetary determinants of DE. We give special attention to the influence of the prevailing exchange rate regime on the level of DE since research shows there is a strong link between the two. As far as we know, there are no studies on FE determinants that use TVAR methodology. To the best of our knowledge, there is only one paper by Ivanov, Tkalec and Vizek (2011) that tests for nonlinear or threshold effects of FE in Croatia.

The remainder of the paper is organized as follows. The next section presents an overview of the existing empirical literature with an emphasis on the results for FE in European post-transition countries 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 conduct of monetary policy. In the eighties and early nineties, unofficial euroization was considered 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 (Kokenyne, 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 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 behavior is facilitated by central banks' commitment to maintaining a stable exchange rate that creates a 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 favor domestic currency. Such institutional imperfections

[2] This minimum variance theory is discussed also in De Nicoló, Honohan and Ize (2005).

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.

The literature typically deals with dollarization in Latin America and determinants characteristic for that region, but in the last few years one witnesses a growing body of research on euroization in European post-transition countries. Therefore, a number of more recent studies on post-transition economies identify exchange rates, especially exchange rate volatility, and interest rate differentials as determinants of FE. A growing area of research considers financial integration, foreign bank presence and the accumulation of foreign liabilities as important drivers of FE in transition economies. Most of the research studies a pool of countries using panel data analysis and interprets the results for the region as a whole, sometimes without considering country-specific features. For example, Kokenyne, Ley and Veyrune (2010) find a positive link between the real exchange rate and DE and a negative effect of increasing exchange rate volatility on both foreign exchange deposits and loans. 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. 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) contradict the findings of Basso, Calvo-Gonzales and Jurgilas (2011) since they empirically show a positive relationship between the interest rate differentials and DE and a negative relationship between exchange rate volatility and DE. Since their research is more focused on CE rather than DE, Luca and Petrova (2008) describe banks' "matching behavior" 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 effect on the pass-through coefficient, with the impact being higher the greater the level of euroization. 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 on the balance sheet. Besides those FE drivers, panel data analysis results add some other FE determinants, such as increased access to global capital markets (Reinhart, Rogoff and Savastano, 2003), closeness to the European Union (European Central Bank, 2010; Neanidis, 2010) and country size (Rosenberg and Tirpák, 2008).

[3] Confirmed in Basso, Calvo-Gonzales and Jurgilas (2011).

[4] A contrary view is expressed in Arteta (2005a, 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.

Research using time series methods country-by-country is scarce when compared to panel data analysis results summarized above. Feige (2003) and Levy Yeyati (2003) claim that underdeveloped domestic financial markets are in part responsible for high FE levels in some countries. 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 behavior is predetermined by the level of euroization. Lastly, only one study deals with micro data in European post-transition economies. Stix (2011) finds that remittances and income from tourism can have a significant impact on currency substitution in some post-transition economies and that underdevelopment of domestic financial markets drives FE.

Nevertheless, within the vast literature on euroization and related topics, these relationships are usually analyzed as part of a linear 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, to the best of our knowledge there are only two studies that model FE using a nonlinear framework, but neither of these studies models the responses of FE to exchange rate changes and FE feedback effects. These two studies are Heimonen (2001) and Ivanov, Tkalec and Vizek (2011). Heimonen (2001) analyzes 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 does it consider substitution between foreign and domestic currency. Ivanov, Tkalec and Vizek (2011) explore FE in Croatia using single equation threshold cointegration. They build different models using a great number of variables and find that nominal exchange rate changes have a strong effect on DE and that CE is affected by banks' foreign-currency-structure matching behavior. Moreover, they find threshold effects for both DE and CE. However, their research does not consider the possibility of diverse FE responses to exchange rate appreciations/depreciations nor do they consider interest rate differentials as a determinant of euroization.

Additionally, the importance of nonlinear FE behavior is clearly recognized by several studies applying a linear modelling framework, within which limited nonlinear FE features are incorporated. Thus both Rennhack and Nozaki (2006) and Neanidis and Savva (2009) use an index of asymmetry of exchange rate movements. The latter study finds positive short-run effects of depreciations decrease with the level of euroization because depreciations induce depositors to change their currency compositions in favor of foreign currencies.

3 The Data

We model DE with three variables using VAR and threshold VAR methodology with DE defined as the share of deposits in foreign currency (or indexed to foreign currency, where available) in total deposits. Although the most accurate way to measure DE 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 DE behavior across time, the alternative is to use banks' aggregate balance sheet data that provide only levels of time and savings' deposits in foreign currency. 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, 2011).

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. 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. The exchange rate influences deposits when confidence in the domestic currency is low. If investors expect the exchange rate to depreciate, they will save in foreign rather than in domestic currency. Therefore, it is justifiable to expect a change in investor behavior that 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 the euro calculated as a monthly average. However, for countries that have a fixed exchange rate regime, the real effective exchange rate was used instead. The interest rate differential is calculated as the difference between domestic and euro-area interest rates, where the domestic rate is either the 3-month money market interest rate or a short-run deposit rate and the euro-area rate is the 3-month money market interest rate. While 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. In addition to these two explanatory variables, we also need a threshold variable in order to distinguish between 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 order to control for the level of euroization.

We investigate twelve post-transition European countries with their samples varied across countries. Those countries are Belarus, Bulgaria, Croatia, the Czech Republic, Hungary, Latvia, Lithuania, Macedonia, Poland, Romania, Serbia and Turkey. The longest data span is for Croatia – 1995:07 to 2010:11 or 185 observations – and the shortest for Macedonia – 2005:01 to 2010:12 or 72 observations. A short description of prevailing exchange rate regimes, DE levels and figures for each country can be found in Appendix I. Data are compiled from central bank statistics and Eurostat with a detailed description presented in Appendix II. All data are seasonally adjusted, with both the deposit euroization and the exchange rate in logarithms. In order to achieve stationarity, we take the first differences and test the series with augmented Dickey-Fuller unit root methodology. Results presented in Table 1 show all series are stationary in first differences.

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	-11.020
	IRD	1	-3.163**	0.0951	-11.860		IRD	0	-6.439***	-	-2.055
Bulgaria	DE	2	-3.853***	0.0430	-10.520	**Macedonia**	DE	0	-4.408***	-	-10.520
	RER	4	-4.052**	0.0345	-2.915		RER	0	-6.704***	-	-11.580
	IRD	4	-4.073**	0.0334	-13.810		IRD	0	-3.372**	-	-2.438
Croatia	DE	3	-3.559***	0.0705	-11.690	**Poland**	DE	1	-9.438***	0.0942	-8.979
	NER	1	-9.669***	0.0379	-11.690		NER	0	-7.502***	-	-9.249
	IRD	2	-7.737***	0.0674	-0.511		IRD	0	-6.106***	-	-2.780
Czech R.	DE	1	-10.480***	0.0355	-8.244	**Romania**	DE	2	-3.000**	0.0389	-9.179
	NER	6	-4.710***	0.0013	-10.220		NER	0	-4.998***	-	-9.633
	IRD	1	-6.338***	0.0771	-3.990		IRD	4	-2.975**	0.5543	0.285
Hungary	DE	0	-13.730***	-	-8.342	**Serbia**	DE	0	-10.260***	-	-10.360
	NER	1	-7.747***	0.0422	-9.675		NER	0	-5.120**	-	-10.100
	IRD	0	-8.626***	-	-1.028		IRD	0	-7.997***	-	-2.230
Latvia	DE	8	-3.543***	0.0378	-11.350	**Turkey**	DE	0	-8.245***	-	-9.406
	RER	2	-3.134**	0.0283	-10.970		NER	1	-6.359***	0.1119	-8.570
	IRD	11	-3.557***	0.5275	0.919		IRD	1	-7.444***	0.0007	-0.672

Notes: 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 is 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 at the 1 percent level of significance; ** hypothesis about existence of unit root rejected at the 5 percent level of significance.*

4 Methodology

Baseline Linear Model

Before conducting any kind of nonlinear modelling, we first 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:

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

where $y_t = (y_{1t,\ldots,}y_{kt})'$ is a vector of k endogenous variables. Γ_0 is a k-dimensional vector including deterministic terms like a constant, a linear trend or even dummy variables, while the Γ_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. If the variables are nonstationary, we can rewrite the VAR model in vector error-correction form:

$$\Delta y_t = b_0 + b_1 t + \Pi y_{t-1} + \sum_{i=1}^{j-1} \delta \Delta y_{t-i} + u_t \tag{2}$$

where $\Pi = \alpha\beta'$ is a matrix representing cointegrating equations with β referring to cointegrating coefficients and α 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 β and if $\beta' y_t$ is a stationary process. If there is a cointegrating relationship, α and β will be ($k \times r$) matrices of rank r (Engle and Granger, 1987).

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:

$$y_t = \Gamma_1 X_t + \Gamma_2 X_t I\left[z_{t-d} \geq z^*\right] + u_t \tag{3}$$

where $X_t = (1, y_{t-1}, \dots, y_{t-j})'$. Similarly, the vector error-correction model (VECM) is described by the following equation:

$$\Delta y_t = \Gamma_1^v X_t^v + \Gamma_2^v X_t^v I\left[z_{t-d} \geq z^*\right] + u_t \tag{4}$$

with $X_t^v = (1, \beta' y_{t-1}, \Delta y_{t-1} \dots, \Delta y_{t-j+1})'$. 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

[5] The 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 use TVAR methodology, including Balke (2000), Atanasova (2003), Calza and Sousa (2006) and Jääskelä (2007).

together with other parameters. According to Hansen (1996, 1997), the transition variable can be either an endogenous or an exogenous variable.

Before the 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. The 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 $-\infty = z_0 < z_1 < \ldots < z_{s-1} < \infty$ 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 ensures 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.

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

$$y_t = X_t(z)'\delta + u_t \tag{5}$$

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 the method of least squares (LS) with the relevant estimation of δ equal to:

$$\hat{\delta}(z) = (\sum_{t=1}^{T} X_t(z) X_t(z)')^{-1} (\sum_{t=1}^{T} X_t(z)) y_t \,. \tag{6}$$

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 δ that minimizes 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:

$$F_T = \sup_{z \in Z} F_T(z)$$
$$F_T = T\left(\frac{\tilde{\sigma}_T^2 - \hat{\sigma}_T^2(z)}{\hat{\sigma}_T^2(z)}\right) \tag{7}$$

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

A 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:

$$F_T^* = \sup_{z \in Z} F_T^*(z)$$
$$F_T^* = T\left(\frac{\tilde{\sigma}_T^{*2} - \hat{\sigma}_T^{*2}(z)}{\hat{\sigma}_T^{*2}(z)}\right). \tag{8}$$

It is then possible to approximate the asymptotic null distribution of F_T. Keeping 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. The 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 realizations of the F-statistics for each grid point and construct the empirical distribution to account for Hansen (1996).

Generalized Impulse Response

The 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, the 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. The TVAR equation reveals Γ_1 and Γ_2 as "structural" contemporaneous relationships in the two regimes.

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

Relying on Christiano, Eichenbaum and Evans (1999), we also assume Γ_1 and Γ_2 have a recursive structure with a causal ordering of DE, the exchange rate and the 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 use this recursive identification because of its simplicity; using more complicated identification schemes would protract the estimation considerably.

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 the nonlinearity of the system. First, the shock must depend on the entire history of the system before the point at 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 ε_t:

$$\begin{aligned} GIRF = {} & E\left[X_{t+m} | \varepsilon_t, \varepsilon_{t+1} = 0, \ldots, \varepsilon_{t+m} = 0, \Omega_{t-1}\right] - \\ & E\left[X_{t+m} | \varepsilon_t = 0, \varepsilon_{t+1} = 0, \ldots, \varepsilon_{t+m} = 0, \Omega_{t-1}\right] \end{aligned} \tag{9}$$

where m is the forecasting horizon and Ω_{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 from shocks in a high euroization regime. Since the computation of GIRF is not trivial, we describe the algorithm step-by-step in Appendix III.

5 Estimation Results

The three variables, deposit euroization (*DE*), the exchange rate (*ER*) and the interest rate differential (*IRD*), make the linear baseline reduced-form VAR model:

$$y_t = \Gamma X_t + u_t \tag{10}$$

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

where $y_t = (DE, ER, IRD)$, $\Gamma = (\Gamma_0, \Gamma_1, ..., \Gamma_j)$ and $X_t = (1, y_{t-1}, ..., y_{t-j})'$. 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 to use three lags for the estimation of the nonlinear model. This structure still gives us good estimation power and better autocorrelation properties.

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 β is conducted using Johansen's likelihood ratio procedure (Johansen, 1991, 1995). The deterministic term appears significant for all countries except for Poland and the Czech Republic, while in the case of Lithuania we also needed to include a linear trend term. The results for trace and maximum eigenvalue tests are presented in Table 3. For Belarus, Macedonia, Romania and Serbia both tests reject cointegration 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] However, linearity is misspecified in countries for which we confirm nonlinearity in the second step, so we present results for the Czech Republic and Poland only. Namely, those two countries are the only ones that confirm cointegration and at the same time do not witness threshold effects. Resulting cointegrating vectors for all countries can be found in Table 4.

Table 2 **Lag Length Selection Criteria**

Lag	LR	FPE	AIC	SIC	HQ	Lag	LR	FPE	AIC	SIC	HQ
Belarus						**Lithuania**					
0	-	0.000	-13.412	-13.320	-13.375	0	-	0.000	-1.853	-1.788	-1.827
1	575.188	0.000	-21.164	-20.796	-21.017	1	1253.95	0.000	-11.220	-10.963	-11.116
2	68.033	0.000	-21.913	-21.269*	-21.656*	2	50.554	0.000	-11.480	-11.030*	-11.297*
3	18.342*	0.000	-21.954	-21.034	-21.587	3	6.585	0.000	-11.399	-10.757	-11.138
4	16.842	0.000*	-21.985*	-20.789	-21.507	4	21.785	0.000	-11.444	-10.609	-11.105
Bulgaria						5	11.259	0.000	-11.406	-10.378	-10.988
0	-	0.000	-7.397	-7.312	-7.363	6	19.321	0.000	-11.438	-10.218	-10.942
1	698.151	0.000	-15.50	-15.166*	-15.367*	7	36.693*	0.000*	-11.628*	-10.215	-11.054
2	17.860	0.000	-15.519	-14.928	-15.281	8	7.623	0.000	-11.564	-9.958	-10.912

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

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					
0	-	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 Republic					
0	-	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					
0	-	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					
0	-	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
Macedonia					
0	-	0.000	-15.038	-14.936	-14.998
1	36.935*	0.000*	-15.378*	-14.970*	-15.218*
2	10.374	0.000	-15.278	-14.563	-14.997
3	7.564	0.000	-15.135	-14.114	-14.733
4	12.384	0.000	-15.097	-13.770	-14.575
5	13.717	0.000	-15.103	-13.470	-14.461
6	13.307	0.000	-15.120	-13.181	-14.357
7	5.618	0.000	-14.971	-12.726	-14.088
8	4.901	0.000	-14.814	-12.263	-13.811
Poland					
0	-	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					
0	-	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					
0	-	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					
0	-	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

*Notes: * 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	*p*-value[#]		Eigenvalue	Test statistic	*p*-value[#]
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.				Note: Unrestricted constant and 2 lags.			
Trace test	None	**Bulgaria**	0.248	38.63	0.019*	**Macedonia**	0.271	29.04	0.200
	At most 1		0.095	12.41	0.421		0.071	7.24	0.876
	At most 2		0.035	3.27	0.541		0.031	2.17	0.743
Maximum eigenvalue test	None		0.248	26.22	0.011*		0.271	21.80	0.057
	At most 1		0.095	9.14	0.431		0.071	5.06	0.873
	At most 2		0.035	3.27	0.540		0.031	2.17	0.742
		Note: Restricted constant and 1 lag.				Note: Restricted constant and 3 lags.			
Trace test	None	**Croatia**	0.137	36.54	0.034*	**Poland**	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.				Note: No constant and 2 lags.			
Trace test	None	**Czech R.**	0.133	25.74	0.031*	**Romania**	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.				Note: Unrestricted constant and 2 lags.			
Trace test	None	**Hungary**	0.195	38.08	0.004**	**Serbia**	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.				Note: Unrestricted constant and 4 lags.			
Trace test	None	**Latvia**	0.417	45.96	0.002**	**Turkey**	0.248	46.27	0.000**
	At most 1		0.157	13.61	0.208		0.067	12.40	0.140
	At most 2		0.055	3.38	0.066		0.034	4.16	0.042*
Maximum eigenvalue test	None		0.417	32.35	0.002**		0.248	33.87	0.000**
	At most 1		0.157	10.24	0.383		0.067	8.25	0.362
	At most 2		0.055	3.38	0.066		0.034	4.16	0.042*
		Note: Restricted constant, unrestricted trend and 9 lags.				Note: Restricted constant and 6 lags.			

*Notes: ** 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).

The Czech Republic has a very high interest rate differential coefficient that we restricted to -1. Therefore, an increase of 1 percent in the interest rate differential leads to a 1 percent decrease in DE. As explained in Basso, Calvo-Gonzales and Jurgilas (2011), a rise in domestic interest rates stimulates domestic currency savings which eventually decreases DE. The nominal exchange rate coefficient for the Czech Republic implies the same relationship, a moderation in DE after exchange rate depreciation.

Table 4 **Cointegrating Vectors**

Country	**Variable**	**Cointegration vector**	**Cointegrating vector with restrictions**	**Country**	**Variable**	**Cointegration vector**	**Cointegrating vector with restrictions**
Bulgaria	DE	1	1	**Latvia**	DE	1	1
	RER	1.335	0.107		RER	0.136	0.105
	IRD	-0.199	-0.073		IRD	-0.001	-0.001
	Const.	-2.716	0		Const.	-0.058	0
Note: Chi square = 2.5601 [0.1096]				Note: Chi square = 0.254 [0.614]			
Croatia	DE	1	1	**Lithuania**	DE	1	1
	NER	-1.371	-1		NER	-3.250	-1
	IRD	-0.055	-1		IRD	-0.086	-0.080
	Const.	1.431	3.397	Note: Chi square = 0.7642 [0.3820]			
Note: Chi square = 3.4030 [0.1824]				**Poland**	DE	1	
Czech R.	DE	1	1		NER	1.132	
	NER	0.911	1		IRD	-0.001	
	IRD	0.955	1	Note: No restrictions accepted.			
Note: Chi square = 0.0777 [0.9619]				**Turkey**	DE	1	1
Hungary	DE	1			NER	-0.454	-1
	NER	-6.936			IRD	-0.014	-0.026
	IRD	0.018		Note: Chi square = 2.475 [0.116]			
Note: No restrictions accepted.							

Notes: All coefficients are in vector notation; DE – *deposit euroization;* NER – *nominal exchange rate;* RER – *real exchange rate;* IRD – *interest rate differential.*

This result is not in accordance with our assumptions about post-transition economies in general, but since this is a country with a flexible exchange rate regime, one does not expect exchange rate changes exhibiting a strong impact 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 1 percent. The interest rate differential coefficient is very small and positive, leading to the conclusion that a larger increase in local interest rates relative to interest rates in EMU does increase DE, but very mildly.

The Threshold Model

Recall that our threshold adjusted VAR model is specified as:

$$y_t = \Gamma_1 X_t + \Gamma_2 X_t I\left[z_{t-d} \geq z^*\right] + u_t \tag{11}$$

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

$$y_t = \Gamma_1^1 y_t + \Gamma_2^1 (L) y_{t-1} + (\Gamma_1^2 y_t + \Gamma_2^2 (L) y_{t-1}) I\left[z_{t-d} \geq z^*\right] + u_t \,. \tag{12}$$

In this specification, Γ_1^1 and Γ_1^2 reflect the "structural" relationship in the two regimes. Using Cholesky decomposition and the relevant recursive structure with the causal ordering of DE, the exchange rate and the interest rate differential, we are able to identify structural errors. Bearing 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 form of identification 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 to closely 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 $z_{k,t-d}(d,k) = \frac{1}{k-d+1} \sum_{i=d}^{k} DE_{t-i}$ for different values of d and k. Based on a minimum residual variance and maximum likelihood, we choose d equal to 1 and k equal to 3.[9]

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.[10] For Bulgaria, Croatia, Lithuania and Turkey linearity is rejected at the 1 percent level, and for the other countries at the 5 percent level. It is interesting that both the Czech Republic and Poland show no sign of nonlinearity. Among post-transition countries in our sample, 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.

[9] However, the deposit euroization variable enters the VAR in its original form.

[10] For the Czech Republic and Macedonia, the linearity is rejected at the 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.

Table 5 **Estimation of TVAR and Test of Nonlinearity**

Country	Estimated threshold	Sup F test	Bootstrapped *p*-value	Chi-square *p*-value	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
Macedonia	-0.266	37.2685	0.335	0.000	-
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

*Notes: *** null hypothesis about linearity rejected at the 1 percent level of significance; ** hypothesis about linearity rejected at the 5 percent level of significance.*

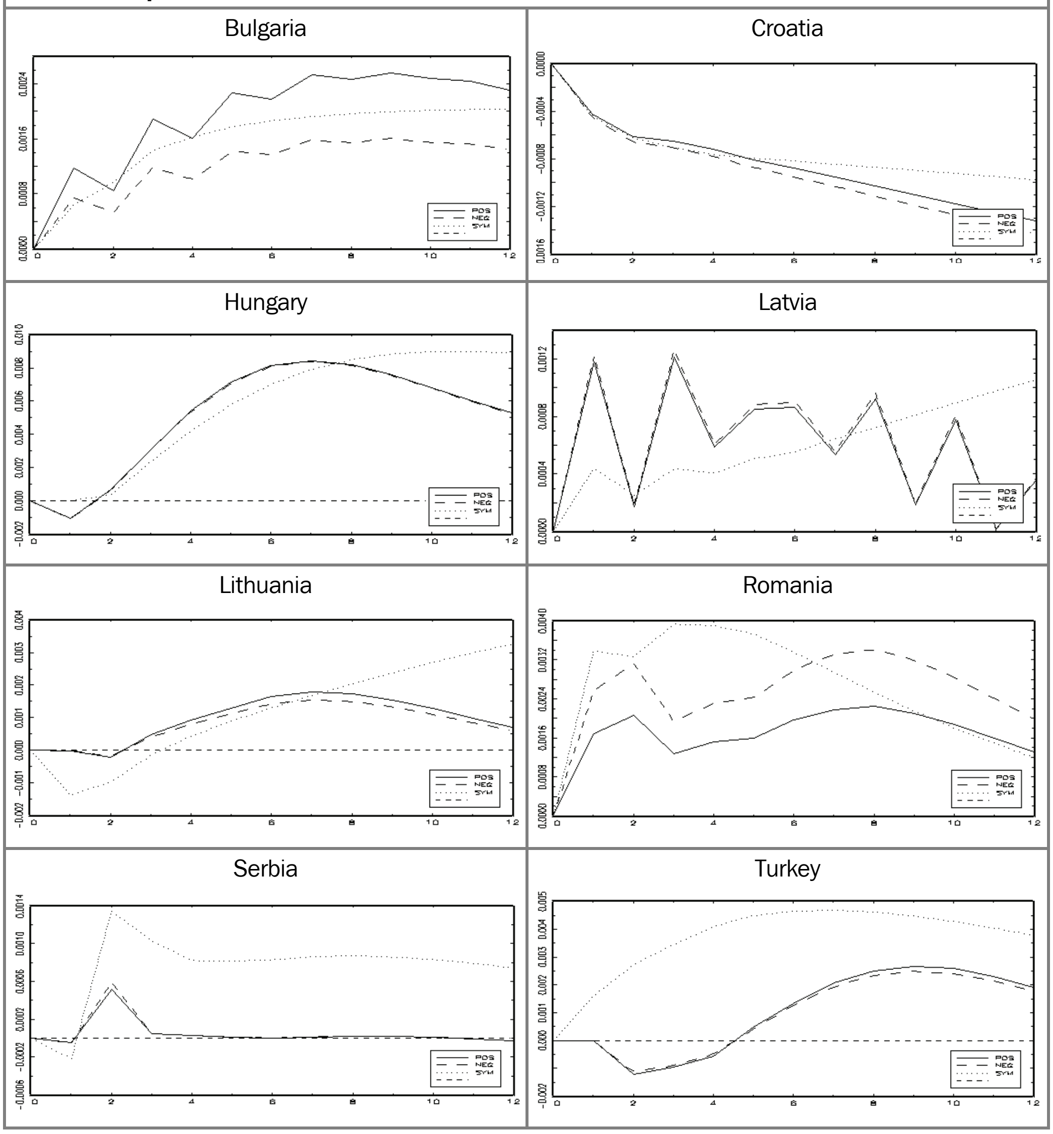
Figures 1 to 3 directly compare positive and negative shocks with the linear impulse response functions. For easier comparison of positive and negative shocks, we transform the sign in front of the simulated impulse response after a negative shock.[11] Although linear responses are misspecified when tests confirm nonlinearity, we leave them as a reference. We find clear differences between linear and nonlinear GIRFs and between positive and negative shocks in all countries. Further, since differences between regimes are almost negligible, due to space considerations, we present GIRFs for low regime only. It is important to note that regime differences are observable when there is a natural explanation for two states of the endogenous variable. If the endogenous variable is the output gap or perhaps credit growth rate, there is reasoning for the existence of a low (negative or contractionary) and a high (positive or expansionary) regime. Since DE does not have a negative and a positive state (DE is always positive), we simply use it as a threshold variable.

Before discussing the results for all countries and all shocks explored in this study, we discuss results for one country and one specific shock in order to explain this rather complicated technique. Firstly, the x-axis measures periods, in this case months, while the y-axis measures the value of the response to the shock that is set to one standard deviation. In cases where the responses to positive and negative shocks differ, this difference is

[11] We do not present confidence intervals around impulse responses since there is no consensus on how to compute them for nonlinear models that allow regimes to switch (Kilian, 1998).

measured on the y-axis. The first graph of Figure 1 presents the cumulative response of DE, both positive and negative, to a one-standard-deviation shock in the exchange rate. The graph provides evidence of nonlinearities between the effects of positive and negative exchange rate shocks on DE in Bulgaria. The response of DE to exchange rate depreciation is around 0.0009 after two months and around 0.0022 after six months. However, responses to negative exchange rate shocks differ and are around 0.0006 after two months and around 0.0014 after six months. These findings show that after two months, positive exchange rate changes (depreciations) have a 50 percent stronger impact on DE in Bulgaria than do negative exchange rate changes (appreciations). After six months, the difference becomes more pronounced since DE has 57 percent stronger responses to positive exchange rate changes than to negative ones. The remaining graphs should be interpreted in the same manner, but due to space considerations we provide an overall summary of results.

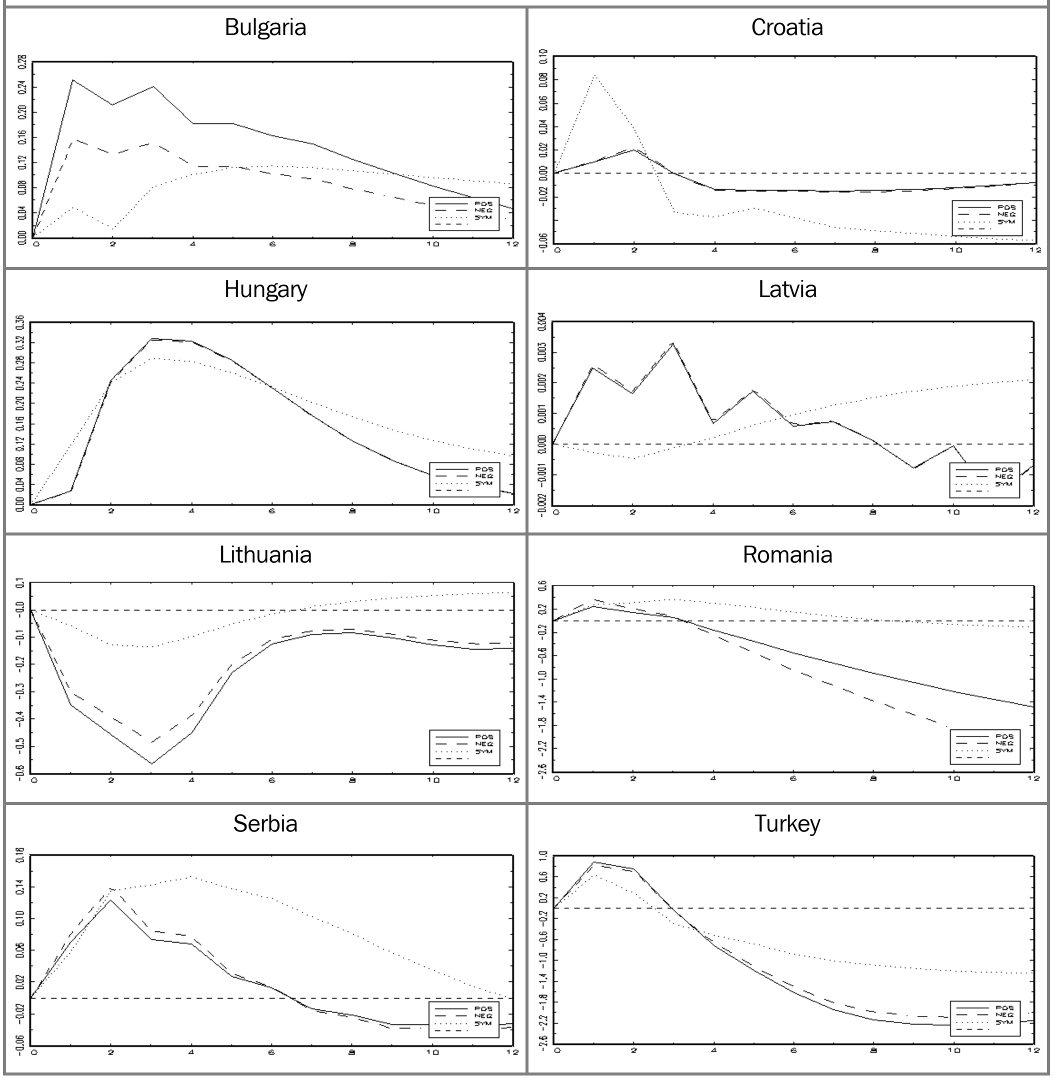
Figure 1 **Effect of Positive and Negative (One-Standard Deviation) Exchange Rate Shocks on Deposit Euroization**



Note: Full line represents a positive shock, broken line a negative shock and dotted line a linear response.

Figure 1 presents the reaction of DE to exchange rate shocks. Results for Bulgaria, Latvia and Romania are in line with economic intuition 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 reacts as one would expect, with a hike preceded by exchange rate depreciation. To summarize, from the countries witnessing nonlinear behavior, only Croatia does not corroborate our hypothesis that depreciation drives up DE.

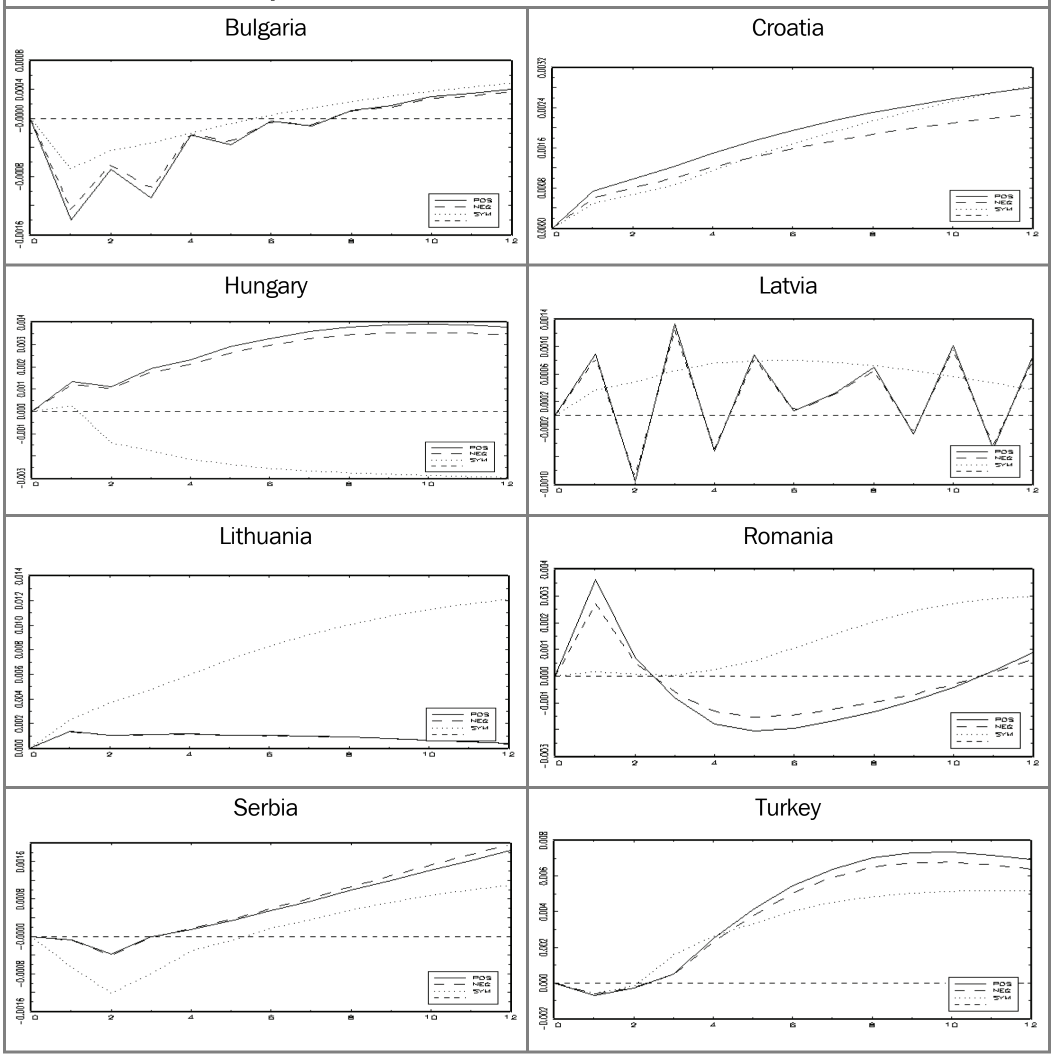
Figure 2 **Effect of Positive and Negative (One-Standard Deviation) Exchange Rate Shocks on Interest Rate Differential**



Note: Full line represents a positive shock, broken line a negative shock and dotted line a linear response.

When depreciation pressures arise, central banks that experience "fear of floating" usually react with a liquidity squeeze that eventually manifests itself in a domestic interest rate increase. If this theory holds, we would observe a positive response of the interest rate differential to a positive exchange rate shock or depreciation. Interest rate differential responses to exchange rate shocks are displayed in Figure 2. We find evidence of the described effect in all countries, except in Lithuania. 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 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.

Figure 3 **Effect of Positive and Negative (One-Standard Deviation) Interest Rate Differential Shocks on Deposit Euroization**



Note: Full line represents a positive shock, broken line a negative shock and dotted line a linear response.

Figure 3 displays DE responses to shocks in the interest rate differential. Although these shocks are not our primary goal of research, a few interesting findings can be noted. As in Luca and Petrova (2008), we show that DE increases after a positive shock in the interest rate differential in six out of eight countries and in five countries positive shocks have stronger effects on DE than negative ones. Only Bulgaria manifests an opposite response, while for Latvia it is impossible to detect the direction of the responses.[12]

The above results imply that exchange rate and interest rate shocks affect deposit euroization and play an important role in DE dynamics. Differences in positive and negative shocks are evident and in line with the observed deposit euroization behavior in our post-transition economies sample.

6 Conclusion

Financial euroization in the European post-transition region has multiple causes, of which policy credibility, high inflation, low exchange rate volatility and closeness to the EU are the most important ones. In addition, a number of authors stress the influence of foreign bank financing and capital inflows as being in large part responsible for FE persistence in emerging Europe. Nevertheless, FE is not just a temporary consequence of macroeconomic instability experienced in the first period of transition, but a long-lasting phenomenon in almost all European post-transition countries.

The latest economic crisis, aggravated by large currency depreciations in some countries and massive defending of hard pegs in others, 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 by detecting its determinants. Results of this study show what the monetary determinants of deposit euroization are in European post-transition economies and describe the nonlinear relationships between them.

Cointegration analysis results suggest that monetary variables influence DE considerably 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., the Czech Republic and Poland, show just the opposite and speak in favor of flexible exchange rate regimes. Since TVAR methodology implies that linear results are not misspecified only for the Czech Republic and Poland, for other countries one should interpret only nonlinear analysis results. Although regime switching is significant in a small number of cases, the differences in the sign of shocks are obvious and in line with the observed DE behavior. In seven out of eight countries, depreciations have a stronger effect on DE than appreciations, showing clear signs of nonlinear behavior. That interest rate differentials widen by a greater amount after depreciations is also confirmed in seven out of eight countries. Both results indicate foreign currency deposits react unfavorably to exchange rate depreciations since they increase when compared to domestic currency deposits. Although one would expect that a rise in domestic interest rates relative to euro

[12] We find no evidence of threshold behavior for Belarus, the Czech Republic, Macedonia and Poland.

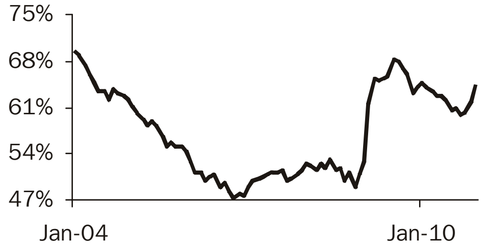
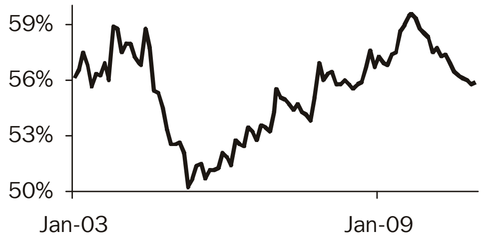
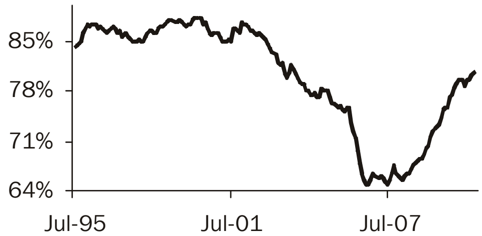
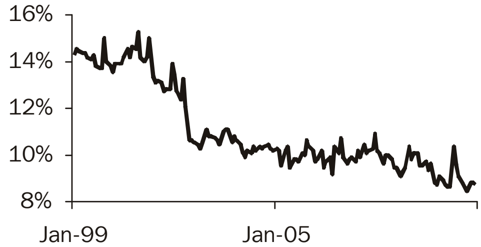
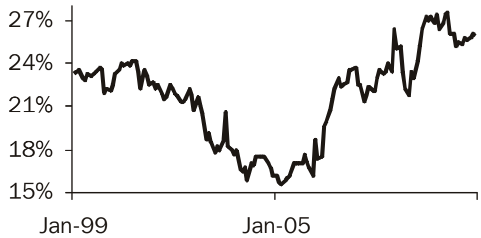
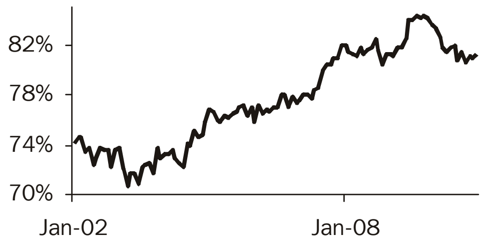
rates would decrease DE levels, it does just the opposite. In six out of eight countries, we find evidence that DE changes more strongly after interest rate spread widening than interest rate spread narrowing.

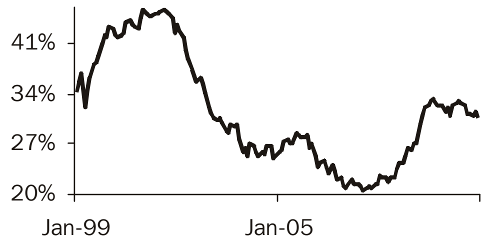
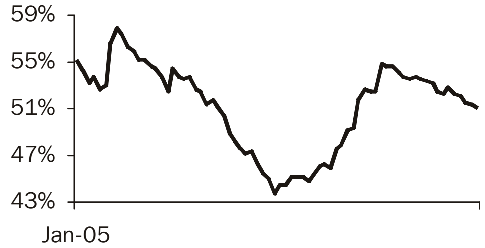
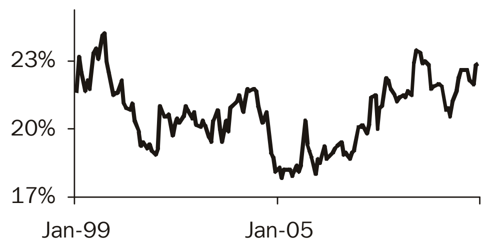
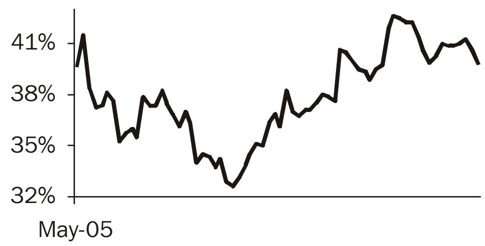
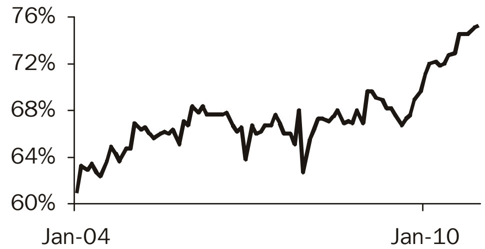
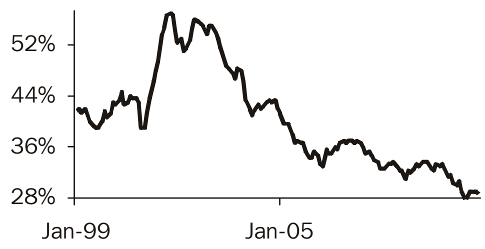
These results form suggestions for an optimal set of policy recommendations aimed at curbing DE in post-transition Europe. The most simple exit strategy would be to adopt the euro, but that scenario is becoming less and less likely for some countries due to difficulties in reaching the Maastricht criteria. For countries that have already fixed their exchange rate 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 their official currency. Countries that are too far from adopting the euro and have already exhausted a great deal of regulatory measures in fighting DE like Croatia, Hungary and Romania, but to some extent also Serbia and Turkey, will probably have to rely on measures other than in the regulatory sphere 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 the Czech Republic and Poland that already have a tradition of such policies and as a result exhibit the lowest DE levels.

Our study shows that exchange rates and interest rate differentials 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 keep in mind that these market development measures are plausible only in countries with strong institutional frameworks. This indicates that country-specific characteristics should be taken into account when designing deeuroization strategies.

Appendix I

DE Levels and Exchange Rate Regimes

Country	Exchange rate regime	Average DE level in the sample period	DE development
Belarus	Pegged within horizontal bands	57.20%	
Bulgaria	Currency board	55.45%	
Croatia	Stabilized arrangement	80.00%	
Czech Republic	Free float	11.06%	
Hungary	Managed float	21.65%	
Latvia	Pegged to euro	77.63%	

Lithuania	Currency board	31.00%	
Macedonia	Stabilized arrangement	51.21%	
Poland	Free float	20.48%	
Romania	Managed float	37.42%	
Serbia	Managed float	67.41%	
Turkey	Free float	40.39%	

Source: See Appendix II.

Appendix II

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 add deposits indexed 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 the 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 are used. Where not possible, average short-term interest rates on deposits are used. The unit of measure is a percentage point.

Appendix III

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:

$$GIRF_y(m, \varepsilon_t, \Omega_{t-1}) = E\left[y_{t+m} | \varepsilon_t, \Omega_{t-1}\right] - E\left[y_{t+m} | \Omega_{t-1}\right] \tag{A1}$$

with m the forecast horizon, ε_t the shock and Ω_{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 Ω_{t-1}^r (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 regimes.

2. Pick a sequence of k-dimensional shocks ε_{t+m}^b 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 Ω_{t-1}^{r} and ε_{t+m}^{b} simulate the evolution of y_{t+m} over $p+1$ periods. The resulting baseline path is given by $y_{t+m}(\Omega_{t-1}^{r}, \varepsilon_{t+m}^{b})$.

4. Substitute ε_{i0} for the i_0 element of ε_{t+m}^{b} 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 $y_{t+m}(\Omega_{t-1}^{r}, \varepsilon_{t+m}^{b})$ 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 Ω_{t-1}^{r}.

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:

$$y_{t+m}(\varepsilon_{i0}) = \frac{\left[y_{t+m}(\varepsilon_{i0}, \Omega_{t-1}^{r}, \varepsilon_{t+m}^{b}) - y_{t+m}(\Omega_{t-1}^{r}, \varepsilon_{t+m}^{b}) \right]}{BR} \tag{A2}$$

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

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