JEL Classification: C32; E44; E58; F31; F41
Keywords: deposit euroization, exchange rate, transition, threshold

The Dynamics of Deposit Euroization in European Post-transition Countries: Evidence from Threshold VAR*

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Abstract

This paper investigates the determinants and dynamics of deposit euroization (DE) in twelve European post-transition economies using threshold models. The results suggest that exchange rates and interest rate differentials are important for explaining DE. The 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. The threshold VAR results indicate that depreciations have a stronger effect on DE than appreciations, while interest rate spreads widen more after home currency depreciations than after appreciations. Moreover, we found evidence that DE changes more strongly after interest rate differentials increase than after they decrease.

1. Introduction

Long after macroeconomic stability had been achieved, due to significant "fear of floating" exchange-rate-based monetary regimes persisted as an optimal policy choice for many European post-transition countries still pursuing currency boards, pegs, or 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 adoption of the euro as the official currency (known as official euroization), unofficial euroization is a result of voluntarily using foreign currency as either a medium of exchange or a store of value. The latter case, in which residents hold a significant share of assets or liabilities in foreign currency, is defined as financial euroization (FE) (Ize and Levy Yeyati, 2003). The liability side of FE is known as deposit euroization (DE) and reflects the propensity of the private and public sector to hold deposits in foreign currency.

It is argued that a high level of FE limits the choices for monetary policy makers, since large home currency depreciations increase the cost of servicing foreign currency denominated debt and severely affect probabilities of default (Reinhart et al., 2003). As a result, central banks respond with a myriad of managed exchange rate regimes biased toward depreciation. In line with that, FE indirectly affects the performance of all sectors of the economy, not just monetary policy. Although FE is a relevant economic policy issue, we still lack knowledge about the phenomenon,

[1] Throughout the text, the term euroization will be used instead of dollarization.

its determinants, and its influences on the economy. Since an explosion of public debt in some CEE (Central and Eastern European) countries, such as Hungary, precludes euro adoption as an exit strategy for unofficial euroization, 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. Besides, home currency depreciations seem to affect FE strongly and quickly, while opposite exchange rate changes have a much more moderate impact. This sort of FE development mimics threshold 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 at an expense. For example, switching foreign currency deposits to domestic currency deposits might be protracted if it has been agreed that those deposits will not 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 in countries that record high levels of FE. Our model incorporates DE and two monetary variables recognized in the literature as DE drivers—the interest rate differential and the exchange rate.[2] 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. We explore the monetary system due to its strong connection to the financial system and therefore financial euroization, implying that monetary policy is the first to react to increasing FE. For each of these cases and countries we will apply TVAR (threshold vector autoregression) and 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. What kind of threshold effects characterize an economy with a high level of DE? And if they exist, 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 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 the monetary determinants of DE. We give special attention to the influence of the prevailing exchange rate regime on the level of DE, since we feel there is a strong link between the two. Secondly, there are no studies on FE determinants that use TVAR methodology. To the best of our knowledge, there is only one paper—by Ivanov et al. (2011)—that tests for nonlinear or threshold effects of FE in Croatia. And finally, unlike

[2] In general, we use nominal exchange rates, but for countries that have a fixed exchange rate regime we use real effective exchange rates. The reason for that can be found in Ize and Levy Yeyati (2005), who claim that high inflation rates, which cause real exchange rate instability, encourage investors to save in foreign currency. In that case, saving in foreign currency provides more stable purchasing power. Therefore, higher inflation differentials followed by more real exchange rate volatility lead to higher FE.

the existing literature, in this paper we allow for diverse DE responses depending on the direction of the exchange rate changes. We directly model the responses of DE boosted by either home currency depreciations or appreciations and allow for diverse DE feedback effects. This property enables us to test the hypothesis that home currency depreciations have an adverse impact on DE and that DE reacts more strongly to home currency depreciations than to appreciations.

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 3 and 4 describe the methodology and data. The results of the empirical analysis are given in section 5, while the last section concludes the paper.

2. Literature

In the 1980s and early 1990s, 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 (Kokenyne et al., 2010). 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. The existing literature offers several explanations for the observed FE persistence phenomenon, with the most common ones being the market failure view and the institutional view (Levy Yeyati, 2006). 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 exchange rate risks. This behavior is facilitated by central banks' commitment to maintain a stable exchange rate, which creates a lower risk of borrowing and lending in foreign currency and hence increases moral hazard and asymmetric information in the system. 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 the domestic currency. Such institutional imperfections increase not only FE, but also the cost of home currency depreciation, which in turn leads to an even stronger commitment by policy makers (Reinhart et al., 2003; De Nicoló, Honohan, and Ize, 2005).

The literature typically deals with dollarization in Latin America and determinants characteristic of that region, but in the last few years we have witnessed 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. 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 et al. (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 et al. (2011) show that the interest rate differential has a negative effect on DE, contradicting Luca and Petrova's (2008) findings, since they empirically show a positive relationship between interest rate differentials and DE and a negative relationship between exchange rate volatility and DE. In a panel of more than a hundred countries, Carranza et al. (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. Moreover, they argue that large home currency depreciations can trigger a nonlinear effect on the balance sheet.

Nevertheless, within the vast literature on euroization and related topics, these relationships are usually analyzed as part of a linear model. Although the persistence of FE and the "fear of floating" observed 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 them models the responses of FE to exchange rate changes and FE feedback effects. These two studies are Heimonen (2001) and Ivanov et al. (2011). Heimonen (2001) 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 does it consider substitution between foreign and domestic currency. Ivanov et al. (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. They find threshold effects for DE but do not consider the possibility of diverse FE responses to home currency 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 modeling 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 that the positive short-run effects of home currency 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 threshold VAR methodology, with DE defined as the share of deposits in foreign currency (or linked to foreign currency, where available) in total deposits (Levy Yeyati, 2003; Neanidis and Savva, 2009).[3] We include only three variables simply for pragmatic reasons. As the number of coefficients in 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 which capture the influence of monetary policy on DE. Monetary policy is the first to fight against rising FE, since it is closest to the financial system and as such to unofficial euroization. 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

[3] It would be more appropriate to use a variable constructed as the share of euro deposits in total deposits, but due to data limitations that was not possible. However, OeNB Euro Survey data show that for most countries in our sample the share of euro deposits in total foreign currency deposits is well above 80 percent. The lowest share of euro deposits in foreign currency deposits is observed in Poland and amounts to two thirds of total foreign currency deposits.

in the domestic currency is low. If investors expect the home currency to depreciate, they will save in foreign rather than in domestic currency. On the other hand, 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.[4] In addition to these two explanatory variables, we 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. The data are compiled from central bank statistics and Eurostat, with a detailed description presented in the *Appendix*.

We investigate 12 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 is for Macedonia (2005:01 to 2010:12, or 72 observations). To indicate how important a role DE plays among the countries explored, the DE levels and figures together with a short description of the prevailing exchange rate regimes can be found for each country 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 using the Augmented Dickey-Fuller unit root test. The results (*Table 1*) show that all the series are stationary in first differences.

4. Methodology

4.1 The Threshold VAR Model

Although STAR (Smooth Transition AutoRegression) models are usually applied in the context of exchange rates, in some cases a threshold is more appropriate than a smooth transition because a smooth transition (when there actually is no smooth transition) would lead to misspecification of the model. Observing the variables from our sample, it is obvious they show threshold behavior, with two distinct states easily to notice. Deposit euroization in the period before the financial crisis decreased very steadily and gradually in the majority of the countries we explore. After Lehman Brothers went bankrupt, home currencies depreciated and interest rate differentials widened in many European transition countries, while deposit euroization swiftly increased.[5] Therefore, we observe one state in which the exchange rate is stable and deposit euroization decreases steadily and another state in which the home currency depreciates or there is perceived risk of a possible home currency depreciation combined with a rise in deposit euroization. TVAR is a simple way of capturing the nonlinearities suggested in a number of economic and monetary policy models, such as Teräsvirta and Anderson (1992), Holmes and Wang

[4] We tested for multicollinearity between the exchange rate and the interest rate differential using a number of methods. In the case of no multicollinearity between the variables, the Klein criterion suggests that the correlation coefficients should be smaller than R (root of R^2). For all twelve countries that we explore, that is the case. We checked for multicollinearity using alternative indicators as well. We found that all twelve variance inflation factors are smaller than five, and that the indicators of tolerance are larger than 0.2, suggesting there is no multicollinearity between the exchange rate and the interest rate differential.

[5] For example, it took more than 12 years to decrease deposit euroization in Croatia by 21 percentage points (from 87 to 66 percent) and only two years (2008 and 2009) to increase it back to 80 percent.

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
	DE	0	-6.053***	-	-9.005		DE	2	-4.491***	0.0019	-8.765
Belarus	NER	1	-5.965***	0.0089	-8.637	Lithuania	RER	1	-7.503***	0.0078	-11.02
	IRD	1	-3.163**	0.0951	-11.86		IRD	0	-6.439***	-	-2.055
	DE	2	-3.853***	0.0430	-10.52		DE	0	-4.408***	-	-10.52
Bulgaria	RER	4	-4.052**	0.0345	-2.915	Macedonia	RER	0	-6.704***	-	-11.58
	IRD	4	-4.073**	0.0334	-13.81		IRD	0	-3.372**	-	-2.438
	DE	3	-3.559***	0.0705	-11.69		DE	1	-9.438***	0.0942	-8.979
Croatia	NER	1	-9.669***	0.0379	-11.69	Poland	NER	0	-7.502***	-	-9.249
	IRD	2	-7.737***	0.0674	-0.511		IRD	0	-6.106***	-	-2.780
	DE	1	-10.48***	0.0355	-8.244		DE	2	-3.000**	0.0389	-9.179
Czech R.	NER	6	-4.710***	0.0013	-10.22	Romania	NER	0	-4.998***	-	-9.633
	IRD	1	-6.338***	0.0771	-3.990		IRD	4	-2.975**	0.5543	0.285
	DE	0	-13.73***	-	-8.342		DE	0	-10.26***	-	-10.36
Hungary	NER	1	-7.747***	0.0422	-9.675	Serbia	NER	0	-5.120**	-	-10.10
	IRD	0	-8.626***	-	-1.028		IRD	0	-7.997***	-	-2.230
	DE	8	-3.543***	0.0378	-11.35		DE	0	-8.245***	-	-9.406
Latvia	RER	2	-3.134**	0.0283	-10.97	Turkey	NER	1	-6.359***	0.1119	-8.570
	IRD	11	-3.557***	0.5275	0.9193		IRD	1	-7.444***	0.0007	-0.6721

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 = 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.

(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. The VAR model adjusted for the threshold specification then becomes:

$$y_t = \mathbf{\Gamma}_1 X_t + \mathbf{\Gamma}_2 X_t I\left[z_{t-d} \geq z^*\right] + \mathbf{u_t}$$

where $X_t = \left(1, y_{t-1}, \ldots, y_{t-j}\right)'$. As usual, gamma matrices are coefficient matrices and $\mathbf{u_t}$ 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.

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. 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 $Z = \left[\underline{z}, \overline{z}\right]$, with Z being an interval on the full sample range of the transition variable. The 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 the threshold can be tested, 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:

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

with $X_t(z) = (X_t' X_t' I)'$ and $\delta = (\mathbf{\Gamma}_1' \mathbf{\Gamma}_2')'$. 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 relevant estimation of δ equal to:

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

The related residuals are then defined as $\hat{\mathbf{u}}_\mathbf{t} = y_t - X_t(z)'\hat{\delta}(z)$ and the residual variance as $\hat{\sigma}_T^2 = 1/t \sum_{t=1}^{T} \hat{u}_t^2$. 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:

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

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

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, which 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 the bootstrap F-statistics F_T^*, we need the 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 $X_t(z)$. 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. The percentage of bootstrap samples for which $F_T^* > F_T$ gives the bootstrap p-value.

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 1,000 realizations of the F-statistics for each grid point and construct the empirical distribution for the Hansen test (Hansen, 1996).

4.2 Generalized Impulse Response

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. Relying on Christiano et al. (1999), we also assume that $\mathbf{\Gamma}_1$ and $\mathbf{\Gamma}_2$ have a recursive structure with 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 et al., 1996; Bernanke et al., 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 nonlinear model, we can construct impulse responses (IR) 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 et al., 1993; Koop et al., 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 fulfill these three conditions, we use generalized impulse response functions (GIRFs).[6]

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

Koop et al. (1996) define the GIRF as the difference between two conditional expectations with a single exogenous shock ε_t:

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

where m is the forecasting horizon and Ω_{t-1} the history at time $t-1$. In our case, the GIRF allows the shocks in the low euroization regime to differ from shocks in a high euroization regime. Since the computation of the GIRF is not trivial, we describe the algorithm step by step in the *Appendix*.

5. Estimation Results

According to the theory developed in section two, we use three variables to make the linear baseline reduced-form VAR model. Those variables are deposit euroization, the exchange rate (*ER*), and the interest rate differential (*IRD*). The most important DE determinant, the exchange rate, is recognized in Levy Yeyati (2006) and explained under the theory of market failure. Another significant and empirically tested DE driver is the interest rate differential, theoretically modeled in Basso et al. (2011). Using this baseline model, we determine the optimal lag length using different criteria and choose the number of lags for the estimation of the nonlinear model equal to three.[7] As in Galbraith and Tkacz (2000), we set the threshold variable z_{t-d} to be a moving average of its past values, or $z_{k,t-d}\left(d,k\right) = \frac{1}{k-d+1}\sum_{i=d}^{k} DE_{t-i}$ for different values of *d* and *k*. Based on the minimum residual variance and maximum likelihood, we choose *d* equal to one and *k* equal to three.

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 the fourth and fifth columns of *Table 2*. The trimming percentage for the threshold variable is 30% and the number of bootstrap replications is 1,000. It turns out that the chi-square test statistic is significant for all countries at the 1% level. However, the bootstrap test rejects linearity for Bulgaria, Croatia, Lithuania, and Turkey at the 1% level, and for Hungary, Latvia, Romania, and Serbia at the 5% level. It is interesting that both the Czech Republic and Poland show no sign of nonlinearity. Among the post-transition countries in our sample, those two have the lowest level of unofficial euroization, both have flexible exchange rates and inflation targeting regimes, and both implement policy measures to curtail FE.

The estimated threshold values are given in the second column of *Table 2*. As these values are in logarithms and moving averages, we report the corresponding original DE values in the last column. We observe that the threshold values are country specific and vary between 18.8% in Hungary and 81.5% in Latvia.

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 transformed the sign in front of the simulated impulse response after a negative

[7] Optimal lag length results are not presented in the paper to save space, but can be obtained upon request from the authors.

Table 2 Estimation of TVAR and Test of Nonlinearity

Country	Estimated threshold	Sup *F*	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 Rep.	-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% level of significance; ** hypothesis about linearity rejected at the 5% level of significance.

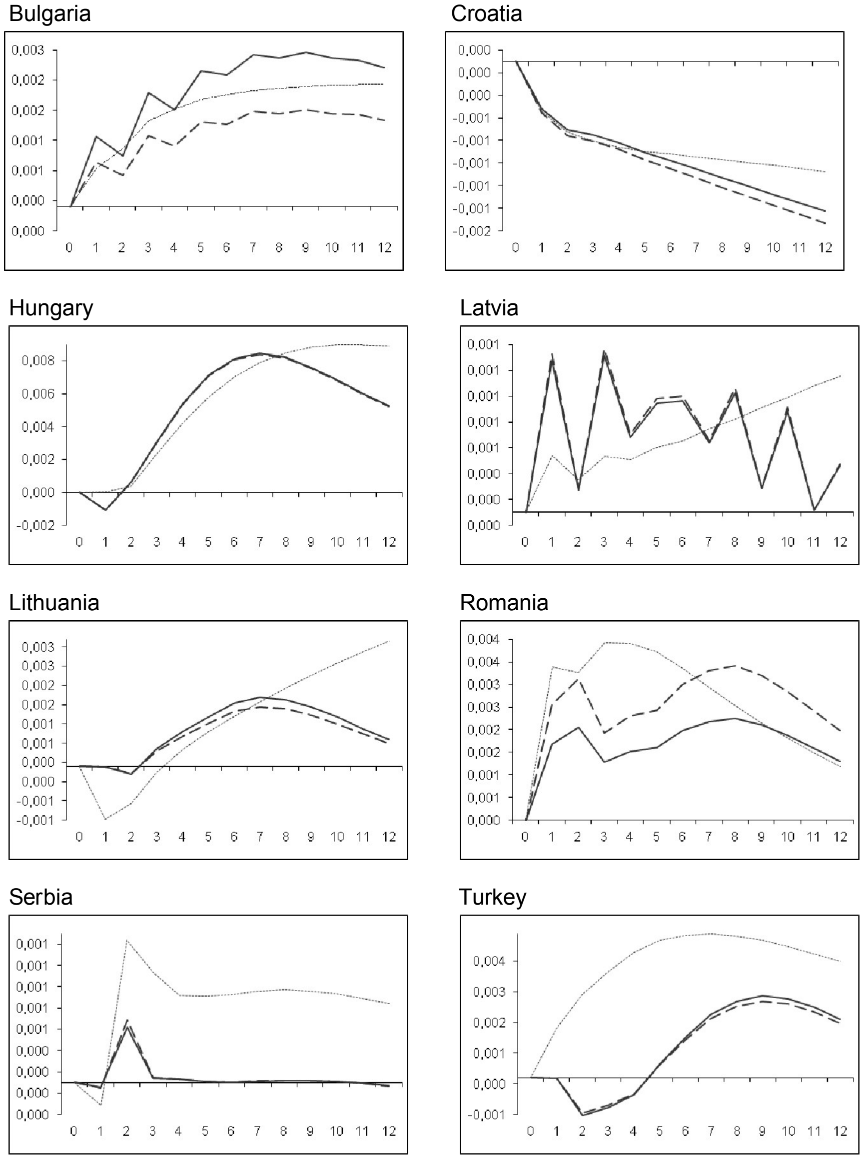
shock.[8] Although linear responses are misspecified when the tests confirm nonlinearity, we leave them as a reference. We find clear differences between linear and nonlinear GIRFs and between positive and negative shocks in all countries. Furthermore, since the differences between regimes are almost negligible, due to space considerations we present the GIRFs for the 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. Where the endogenous variable is the output gap or perhaps the 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.

Figure 1 presents the reaction of DE to exchange rate shocks. The results for Bulgaria, Latvia, and Romania are in line with economic intuition and indicate DE rises with home currency 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 home currency depreciation. To summarize, from the countries witnessing nonlinear behavior, only Croatia does not corroborate our hypothesis that home currency depreciation drives DE.

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 home currency 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 Lithuania. The linear and nonlinear responses are very similar in shape, but

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

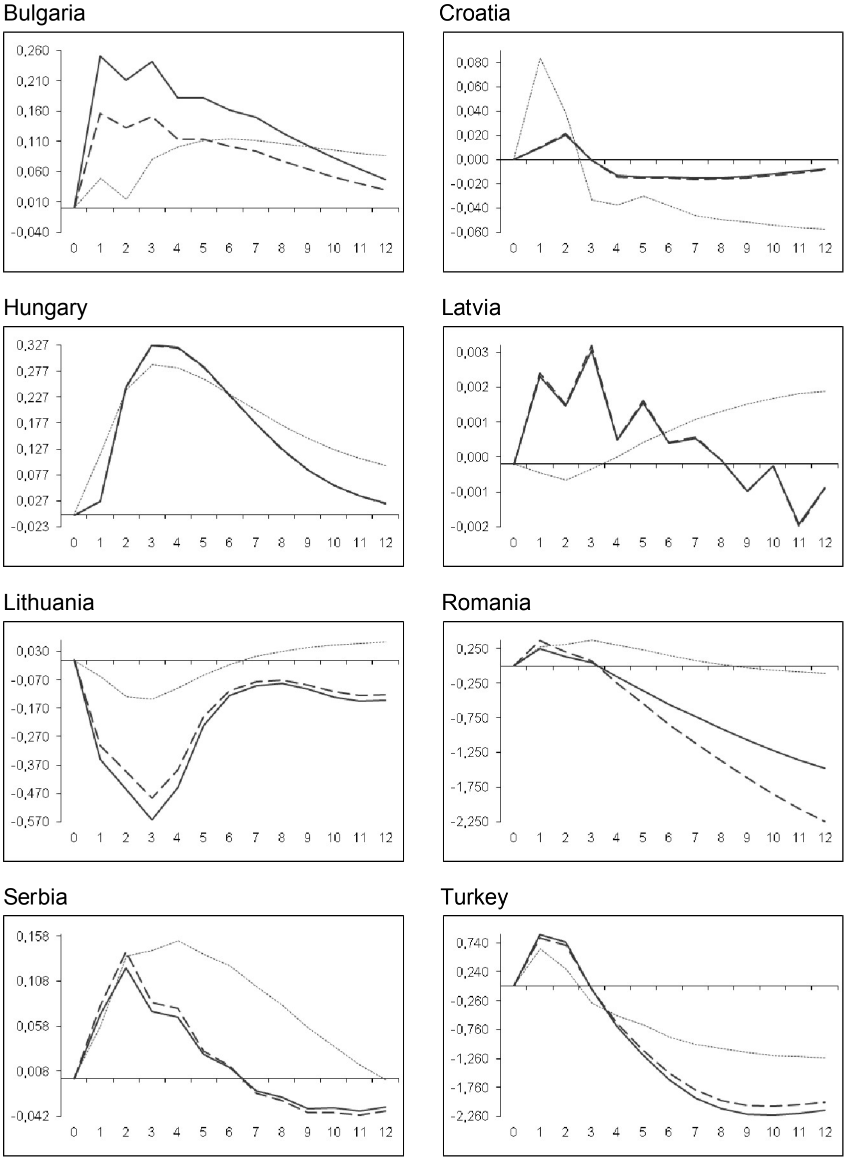
Figure 1 Effect of Positive and Negative (One-Standard Deviation) Exchange Rate Shocks on Deposit Euroization



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

in six out of the eight countries the 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.

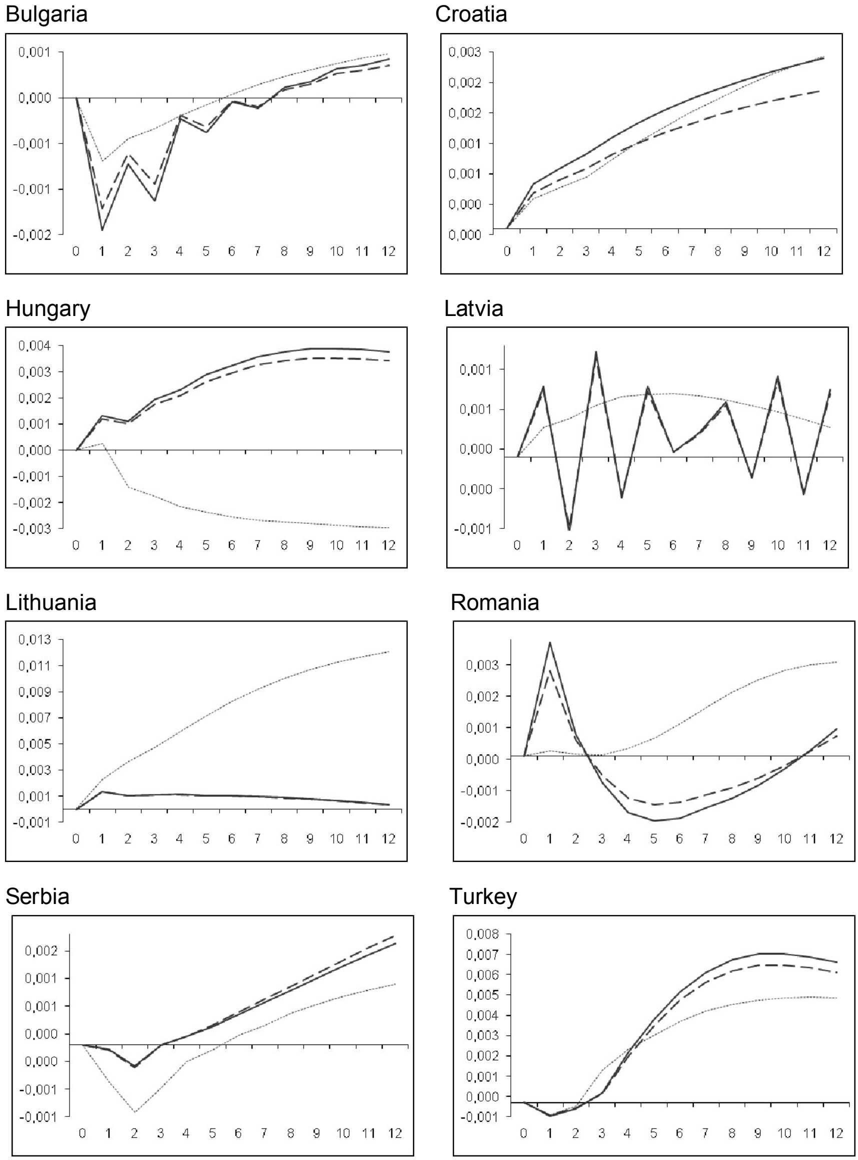
Figure 2 Effect of Positive and Negative (One-Standard Deviation) Exchange Rate Shocks on Interest Rate Differential



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

Figure 3 displays the DE responses to shocks in the interest rate differential. Although these shocks are not the primary goal of our 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 the eight countries, and in five countries positive shocks have stronger effects on DE than negative ones.

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.

Only Bulgaria manifests an opposite response, while for Latvia it is impossible to detect the direction of the responses.[9] These results are corroborated by Rosenberg and Tirpák (2009), who find that the level of euroization in new EU member states increases as interest rate differentials rise.

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

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 were evident and in line with the observed deposit euroization behavior in our post-transition economies sample.

6. Conclusion

This study gives new insights into the relationship between DE and the monetary system and shows that exchange rates and interest rate differentials have an important influence on DE in emerging Europe. The results explain the nonlinear dynamics of DE and show that home currency depreciations have a stronger effect on DE than appreciations. In order to tackle DE and possible adverse effects after home currency depreciations, it would be justifiable to introduce insurance measures for investors saving in the 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 frameworks. This indicates that country-specific characteristics should be taken into account when designing de-euroization strategies.

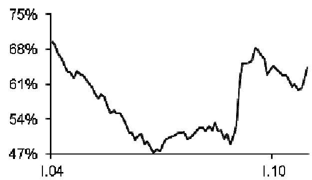
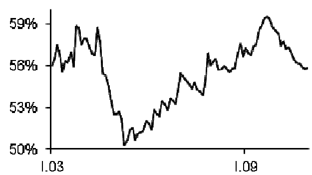
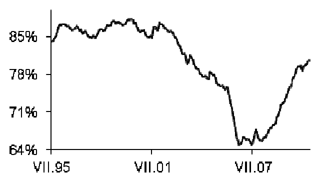
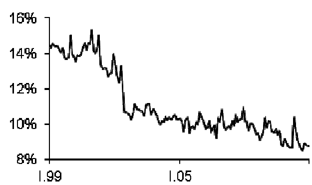
The results of this study offer suggestions for an optimal set of policy recommendations aimed at curbing DE in post-transition Europe. The most simple exit strategy would be to adopt the euro, but that scenario is becoming less and less likely for some countries due to difficulties in fulfilling the Maastricht criteria. For countries that have already fixed their exchange rate, such as Latvia, Lithuania, and Bulgaria, this seems to be the most possible scenario. The path these countries are supposed to follow is to achieve convergence (by fiscal consolidation and structural reforms) and eventually adopt 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, such as Croatia, Hungary, and Romania, but to some extent also Serbia and Turkey, will probably have to rely on non-regulatory measures because managing euroization risks is already becoming unsustainable. Their only alternative is to decrease DE by using different types of measures. Zettelmeyer et al. (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.

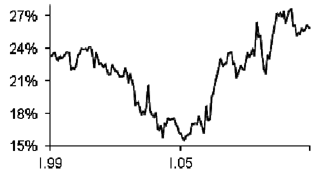
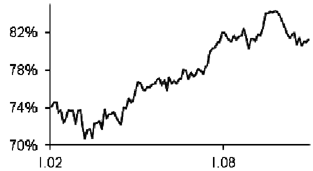
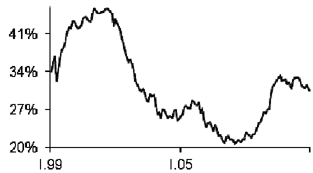
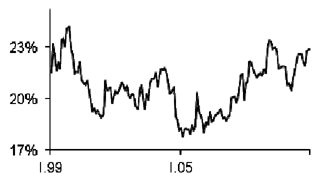
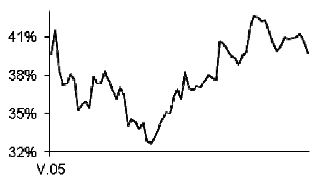
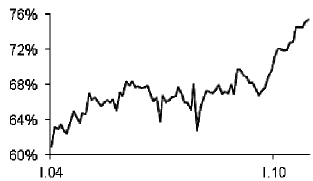
APPENDIX

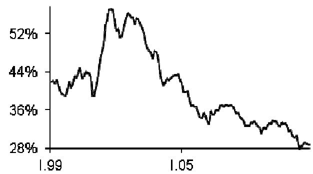
Data Sources and Transformations

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 the difference between interest rates for the 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. Measured in percentage points.

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 Rep.	free floating	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 floating	37.42%	
Serbia	managed float	67.41%	

Turkey	free float	40.39%	

Note: * As defined in Habermeier *et al.* (2009), stabilized arrangement is a non-floating exchange rate regime in which the exchange rate is kept stable by official central bank action but without policy commitment.

GIRF Algorithm

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

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

with m the forecast horizon, 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 the GIRF to be computed by simulating the model. A shock of one standard deviation occurs to the i-th variable ($i=1,...,k$) of y_t (defined earlier as $y_t=\left(y_{1t,...,}y_{kt}\right)'$ in period 0, with responses calculated for p periods thereafter. The algorithm is as follows:

1. Pick a history Ω^r_{t-1} (where $r=1,...,R$ denotes the number of iterations) that refers to an actual value of the lagged endogenous variable at a particular date. Since the values correspond to only one of the regimes, the algorithm has to be carried out twice, for both lower and upper regimes. The number of these histories is equal to the number of observations in the regime for which we calculate the impulse responses. The regimes are identified using the results of the TVAR estimation. We draw B times from the distribution of shocks at each history to produce B realizations of the shock for each Ω_t .
2. Pick a sequence of k-dimensional shocks ε^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 Ω^r_{t-1} and ε^b_{t+m} simulate the evolution of y_{t+m} over $p+1$ periods. The resulting baseline path is given by $y_{t+m}\left(\Omega^r_{t-1},\varepsilon^b_{t+m}\right)$.
4. Substitute ε_{i0} for the i_0 element of ε^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 $y_{t+m}\left(\Omega^r_{t-1},\varepsilon^b_{t+m}\right)$ 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.
8. Calculate the average GIRF for a given regime with R observations using the following equation:

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

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

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