Recent Experiences with Currency Substitution

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Abstract

We empirically investigate recent experiences with currency substitution. We focus especially on the determinants of currency substitution, namely, the factors representing the usefulness of a foreign currency both as a medium of exchange and a store of value. This paper has three key distinguishing features. First, our sample includes eight developing and/or emerging countries from different regions to permit direct cross-country comparison, unlike in many previous studies. Second, this study covers a recent sample period. The U.S. dollar and the euro have been depreciating against other currencies since the 2007 financial crisis, and have therefore become less useful as a store of value. Therefore, it is important that we investigate whether the determinants of currency substitution have changed in recent periods. Third, we derive an estimated equation from the agent's utility maximization problem. In particular, we introduce the exchange rate risk premium as an alternative determinant, considering its relevance to the forward premium puzzle—the failure of the interest rate differential to correctly represent expected changes in the nominal exchange rate and hence the usefulness of foreign currency as a store of value. The empirical results indicate that the variables representing the usefulness of foreign currency both as a medium of exchange and a store of value are significant determinants of currency substitution. The results show that currency substitution has important monetary policy implications.

Keywords: currency substitution, network externalities, ratchet effects, foreign currency, domestic currency, euro

1. Introduction

Currency substitution is a phenomenon in which domestic residents use foreign currency in their economic transactions. It is observed especially in high-inflation economies such as Latin American countries, some Asian countries, and Central and Eastern European transition countries.

Domestic residents would determine whether they should use domestic or foreign currency by comparing their usefulness as a medium of exchange and a store of value. With high inflation, domestic residents fear that the domestic currency would be less useful as a store of value. Therefore, they would look for alternatives such as the U.S. dollar or euro. (Note 1)

On the other hand, the usefulness of a currency as a medium of exchange depends on its general acceptability. That is, the greater the number of domestic residents using a currency, the more useful it becomes. That is, the higher the degree of currency substitution in a country, the more useful is foreign currency as a medium of exchange. Therefore, even if the inflation rate (and hence the nominal interest rate and the expected change in the nominal exchange rate) in the domestic country falls, domestic residents would continue to use foreign currency if they consider it more useful as a medium of exchange than is the domestic currency as a store of value. This phenomenon is typically referred to as the *ratchet effect,* or hysteresis, of currency substitution. That is to say, currency substitution increases rapidly with macroeconomic destabilization but decreases only slightly, or not at all, after stabilization. Uribe (1997) and Peiers and Wrase (1997) show that as the economy's accumulated experience in using foreign currency as a medium of exchange acts as a network externality, it reduces the marginal cost of buying goods with foreign currency. This network externality produces ratchet effects of currency substitution. (Note 2)

Many previous studies have investigated currency substitution. (Note 3) However, most of them considered a single country or a few countries within the same region, making comparative studies among countries and regions impossible. Furthermore, they focused on sample periods characterized by macroeconomic destabilization (high inflation, expansion of the interest rate differential, and depreciation of the domestic currency vis-à-vis the U.S.

dollar or euro). However, more recent years, especially the period after the 2007 financial crisis, have witnessed relative macroeconomic stabilization (lower inflation, reduction of the interest rate differential, and depreciation of the U.S. dollar and euro against other currencies). Therefore, investigating currency substitution in that era would be a meaningful exercise.

The purpose of this paper is to empirically investigate recent currency substitution experiences of eight developing and/or emerging countries located in different regions: Indonesia, the Philippines, Tajikistan, the Czech Republic, Hungary, Poland, Argentina, and Peru. In particular, we focus on the determinants of currency substitution, that is, the factors representing the usefulness of foreign currency both as a medium of exchange and a store of value. This paper has three key distinguishing features.

First, our sample comprises eight countries from different regions—Asia, Eastern Europe, and Latin America. This geographical spread allowed a direct cross-country comparison unlike in previous studies.

Second, this study covers a recent sample, focusing on the period after the 2007 financial crisis. Since the financial crisis, the U.S. dollar and euro have been depreciating against other currencies. That is, the usefulness of the U.S. dollar and euro has diminished over the years. Therefore, we need to investigate whether the determinants of currency substitution have changed recently.

Third, we derive an estimated equation from the agent's utility maximization problem, which is represented by a currency substitution-type money-in-the-utility-function model with network externalities. In particular, we introduce the exchange rate risk premium as an alternative determinant. This is important in the context of the so-called *forward premium puzzle*. (Note 4) When covered interest parity holds, uncovered interest parity indicates that the forward premium (and hence the interest rate differential) should be an unbiased predictor of the ex-post movement in the spot exchange rate (and hence the expected change of nominal exchange rate) under the assumption of rational expectations. However, several previous works claim that forward premium is a biased predictor of the actual movement in the exchange rate. This means the interest rate differential could not correctly represent the expected change of nominal exchange rate, namely, the usefulness of foreign currency as a store of value.

Our analysis can be expected to have some monetary policy implications. Previous theoretical and empirical studies show that currency substitution could have significant effects on the independence of monetary policy and exchange rate stability under a flexible exchange rate system (e.g., Girton and Roper, 1981; Kareken and Wallace, 1981; Rogers 1990; Akçay, Alper, & Karasulu, 1997; Kumamoto & Kumamoto, 2004). For example, a high degree of currency substitution has been shown to cause the nominal interest rate to react strongly to even small monetary policy changes. This makes the nominal exchange rate more volatile. Moreover, currency substitution would restrict the ability of monetary policy to isolate domestic economy from foreign shocks. On the other hand, under a fixed exchange rate system, currency substitution could significantly affect sustainability of currencies in a fixed exchange rate system (e.g., Giovannini, 1991; Sawada & Yotopoulos, 2002). For example, it is shown that a higher degree currency substitution can lead to greater variability of foreign exchange reserves. Moreover, even if the central bank does not expand domestic credit excessively, the more pronounced currency substitution is in a country, the earlier a currency crisis tends to occur, and the stronger it is.

From the above arguments, even when the central bank decides to reduce currency substitution through macroeconomic stabilization in order to restore the domestic currency as a useful store of value, currency substitution will not decrease rapidly if the ratchet effect is strong.

This paper is organized as follows. Section 2 derives the estimation equation and describes the econometric methodology. Section 3 presents the data and illustrates the recent status of currency substitution in the sample countries. Section 4 discusses the econometric results and provides their monetary policy implications. Finally, Section 5 concludes the study.

2. Empirical Methodology

First, we derive an estimated equation following Kumamoto and Kumamoto (2008), who introduce currency substitution through the money-in-the-utility-function framework with network externalities in currency substitution.

We consider a small open economy where the price level is flexible and capital mobility is perfect. We assume many identical infinitely living households obtaining utility from real consumption and real balances of domestic and foreign money. We also assume that the utility obtained from holding foreign currency depends on *knowing* how to use it as a medium of exchange. Therefore, at time t, a typical household maximizes the following expected value of a discounted stream of period utility:

$$\max_{\{B_t, B_t^*, M_t, M_t^*\}} U_t = \sum_{s=t}^{\infty} \beta^{s-t} E_t[u(C_s, M_s/P_s, M_s^*/P_s^*)], \quad (1)$$

where

$$u_t = C_t + \gamma X_t, \quad X_t = [\{1-\delta(K_t)\}(M_t/P_t)^{-\varepsilon} + \delta(K_t)(M_t^*/P_t^*)^{-\varepsilon}]^{-(1/\varepsilon)},$$

$$s.t. \quad (B_t/P_t)+(B_t^*/P_t^*)+(M_t/P_t)+(M_t^*/P_t^*) = Y_t+(1+i_{t-1})(B_{t-1}/P_t)+(1+i_{t-1}^*)(B_{t-1}^*/P_t^*)+(M_{t-1}/P_t)+(M_{t-1}^*/P_t^*)-C_t, \quad (2)$$

$\gamma>0$, $0<\delta(\cdot)<1$, $\delta(1)=1/2$, $\delta'(\cdot)>0$, $\varepsilon>-1$, C_t is real consumption, M_t and M_t^* are nominal balances of domestic and foreign currencies, respectively, and P_t and P_t^* are the domestic and foreign price levels, respectively. K_t is the domestic residents' average accumulated knowledge and experience of using foreign currency, which is a proxy for the general acceptability of foreign currency as a medium of exchange. We suppose that households take K_t as given, but at an aggregate level, K_t is endogenously determined. β is a subjective discount factor. B_t and B_t^* are nominal bonds denominated in domestic and foreign currencies, respectively. i_{t-1} and i_{t-1}^* are nominal interest rates on bonds issued at the end of period $t-1$ to the end of period t. Y_t is real income determined exogenously. Our utility function is specified as follows: (1) a household's preference can be represented by an additive separable function with respect to real consumption C_t and currency index X_t, (2) the currency index X_t is a constant elasticity of substitution (CES) technology in which elasticity of substitution is equal to $1/(1+\varepsilon)$, and (3) the share of foreign currency in the utility function, δ, is an increasing function of K_t, because foreign currency become more attractive as a medium of exchange as K_t increases.

With these specifications and the assumption of purchasing power parity condition, Kumamoto and Kumamoto (2008) show the log-linearized relative money demand function as

$$cs_t = (\overline{cs} + \bar{k}) + [\eta/(1+\varepsilon)]k_t + [1/(1+\varepsilon)][\bar{i}/(1+\bar{i})](i_t - i_t^*), \quad (3)$$

where $\eta \equiv [\delta'(\bar{K})/\{\delta(\bar{K})(1-\delta(\bar{K}))\}]\bar{K}$ .The lowercase letters denote natural logarithms except for nominal interest rates, and the upper bar denotes the steady-state value. $cs_t (\equiv m_t^* + s_t - m_t)$ denotes relative money demand, which can be regarded as the degree of currency substitution, and s_t is the natural logarithm of the nominal exchange rate in terms of the domestic currency. The interest rate differential $i_t - i_t^*$ represents the usefulness of foreign currency as a store of value. If the interest rate differential increases, currency substitution increases as well because the domestic currency is expected to depreciate through the uncovered interest rate parity condition. Therefore, the cost of holding domestic currency increases. The knowledge of using foreign currency as a medium of exchange, k_t, proxies for its general acceptability and hence usefulness as a medium of exchange, capturing the ratchet effects of currency substitution. The implication is that domestic residents determine whether they should use domestic or foreign currency by comparing its usefulness as a store of value and a medium of exchange.

Moreover, Kumamoto and Kumamoto (2008) show that uncovered interest parity can be derived as

$$i_t - i_t^* = E_t[s_{t+1}] - s_t + v_t - v_t^*, \quad (4)$$

where $v_t = -(1/2)\sigma^2_{p,t}$, $\sigma^2_{p,t} \equiv Var_t[p_{t+1}]$, and $v_t^* = -(1/2)\sigma^2_{p^*,t}$, $\sigma^2_{p^*,t} \equiv Var_t[p_{t+1}^*]$ and $Var_t[\cdot]$ is a conditional variance operator based on information available at period t. (Note 5) The term $v_t - v_t^*$ can be regarded as the risk premium. Note that if we insert equation (4) into (3), nominal exchange rate terms appear on both sides, which would cause endogenous bias. Therefore, we use the purchasing power parity condition in equation (4) to obtain

$$i_t - i_t^* = E_t[p_{t+1}] - p_t - (E_t[p_{t+1}^*] - p_t^*) + v_t - v_t^*. \quad (5)$$

Considering the possibility that currency substitution would react to the change in interest rate differential or the expected change in the nominal exchange rate (inflation rate differential) with some lags, we specify the following ARDL (p, q_1, q_2) model consisting of two equations:

$$cs_t = \mu + \sum_{i=1}^{p} \alpha_i cs_{t-i} + \sum_{j=0}^{q_1} \beta_{1j}(i_{t-j} - i_{t-j}^*) + \sum_{j=0}^{q_2} \beta_{2j} k_{t-j} + \varepsilon_t, \quad (6)$$

$$cs_t = \mu + \sum_{i=1}^{p} \alpha_i cs_{t-i} + \sum_{j=0}^{q_1} \beta_{1j}\{(E_{t-j}[p_{t-j+1}] - p_{t-j}) - (E_{t-j}[p_{t-j+1}^*] - p_{t-j}^*)\} + \sum_{j=0}^{q_2} \beta_{2j}(v_{t-j} - v_{t-j}^*) + \sum_{j=0}^{q_3} \beta_{3j} k_{t-j} + \varepsilon_t, \quad (7)$$

where μ is a constant term and ε is a disturbance term at t. (Note 6)

In this paper, we suppose that the maximum degree of currency substitution for the past one year represents the knowledge of using foreign currency as a medium of exchange at period t.

$$k_t = \max_j \ cs_j, \ j = t-12, \ \cdots, \ t-1. \quad (8)$$

This assumption means that the knowledge of using foreign currency is proportional to the largest amount of the currency substitution in the past. However, the economy as a whole forgets how to use foreign currency in order to purchase goods as time passes.

To calculate v_t and v_t^*, we need to obtain the values of $\sigma^2_{p,t}$ and $\sigma^2_{p^*,t}$. In this paper, we estimate the series of $\sigma^2_{p,t}$ and

$\sigma^2_{p^*,t}$ using the generalized autoregressive conditional heteroscedasticity (GARCH) model.

Assuming that p_t follows the autoregressive integrated moving average (ARIMA) $(p,1,q)$ process, $\Phi(L,p)\Delta p_t=\xi+\Psi(L,p)\varepsilon_{p,t}$, $E_{t-1}[\Delta p_t]\sim N(0,h_t)$, we estimate the GARCH (s_1,s_2) model, $h_{p,t}=\delta_0+\sum_{j=1}^{s_1}\delta_j\varepsilon^2_{p,t-j}+\sum_{j=1}^{s_2}\eta_j h_{p,t-j}$, for the residuals from the ARIMA model. The orders p and q of the ARIMA models are determined according to the Schwartz Bayesian information criterion (SBIC). We use the GARCH (1,1) model as the lag length of the GARCH model. (Note 7) We adopt the same techniques for p_t^*.

We rewrite equation (6) more compactly as

$$A(L,p)cs_t=\mu+B_1(L,q_1)(i_t-i_t^*)+B_2(L,q_2)k_t+\varepsilon_t, \tag{9}$$

where L is a lag operator and $A(L,p)=1-\alpha_1L-\cdots-\alpha_pL^p$ and $B_i(L,q_i)=\beta_{i0}+\beta_{i1}L+\cdots+\beta_{iq}L^{qi}$, $(i=1,2)$ are polynomials in the lag operator L. The distributed lag form of the ARDL model is

$$\begin{aligned} cs_t&=\{1/A(L,p)\}\mu+\{B_1(L,q_1)/A(L,p)\}(i_t-i_t^*)+\{B_2(L,q_2)/A(L,p)\}k_t+\{1/A(L,p)\}\varepsilon_t \\ &=\{1/A(L,p)\}\mu+\sum_{k=0}^{\infty}\iota_k(i_{t-k}-i_{t-k}^*)+\sum_{l=0}^{\infty}\nu_l k_{t-l}+\sum_{n=0}^{\infty}\xi_n\varepsilon_{t-n}. \end{aligned} \tag{10}$$

The long-run effects for the response of cs_t to a unit change in $i_t-i_t^*$ and k_t are $\sum_{k=0}^{\infty}\iota_k=B_1(L,q_1)/A(1,p)$ and $\sum_{l=0}^{\infty}\nu_l=B_2(L,q_2)/A(1,p)$, respectively.

After some rearrangements, we get the error correction model (ECM) associated with the ARDL (p,q_1,q_2):

$$\Delta cs_t=\beta_{10}\Delta(i_t-i_t^*)+\beta_{20}\Delta k_t-\sum_{j=1}^{p-1}\alpha_i^*\Delta cs_{t-j}-\sum_{j=1}^{q_1-1}\beta_{1i}^*\Delta(i_{t-j}-i_{t-j}^*)-\sum_{j=1}^{q_2-1}\beta_{2i}^*\Delta(k_{t-j})-A(1,p)EC_{t-1}+\varepsilon_t, \tag{11}$$

where EC_t is the error correction term, defined by $EC_t=cs_t-\{1/A(1,p)\}\mu-\{B_1(1,q_1)/A(1,p)\}(i_t-i_t^*)-B_2(1,q_2)/A(1,p)\}k_t$. α_i^* and β_{ij}^* are given by $\alpha_1^*=\alpha_p+\alpha_{p-1}+\cdots+\alpha_3+\alpha_2$, $\alpha_2^*=\alpha_p+\cdots+\alpha_3$, $\cdots$, $\alpha_{p-1}^*=\alpha_p$ and $\beta_{i1}^*=\beta_{iqi}+\beta_{iqi-1}+\cdots+\beta_{i3}+\beta_{i2}$, $\beta_{i2}^*=\beta_{iqi}+\beta_{iqt-1}+\cdots+\beta_{i3}$, $\cdots$, $\beta_{iqt-1}^*=\beta_{iqi}$ $(i=1,2)$.

The main advantage of the ARDL model is that, as shown in Pesaran and Shin (1999), it can be applied irrespective of whether the underlying regressors are *I(0)* or *I(1)*. This avoids the pretesting problems associated with standard cointegration analysis, which requires the classification of the variables into *I(0)* and *I(1)*. (Note 8)

The analytical procedure is as follows: First, we determine the lag length of equation (9) based on the Akaike information criterion (AIC) and estimate equation (6). Next, we estimate the long-run coefficients based on the above results. Finally, we obtain the short-run coefficients by estimating ECM (11).

The same argument can be applied for the transformation of equation (7).

3. Data

The appropriate data on the nominal balances of foreign currency represent the amount of foreign currency in circulation (holdings of nominal balances of foreign currency) plus demand deposits denominated in foreign currency. (Note 9) Unfortunately, data on foreign currency in circulation are difficult to collect. Therefore, we use the amount of demand deposits denominated in foreign currency as a proxy for nominal foreign currency balances. (Note 10) For consistency, we use data on demand deposits denominated in the domestic currency as a proxy for nominal domestic currency balances. The above data are collected from the respective central banks.

For the nominal interest rate, different authors use different data. For example, Mizen and Pentecost (1994) and Mongardini and Mueller (2000) use the treasury bill rate, and Akçay et al. (1997) use the interbank offered rate. Clements and Schwartz (1993), Bahmni-Oskooee and Karacal (2006), and Kumamoto and Kumamoto (2008) use the deposit rate for the nominal interest rate. Hence, this paper uses three measures of the nominal interest rate to confirm the robustness of the empirical result: (i) TB, defined as the average yield difference between each country's and the U.S.'s three-month treasury bills; (ii) IBOR, defined as the average monthly yield difference between each country's three-month interbank offered rate and the three-month London Interbank Offered Rate (LIBOR); and (iii) DR, defined as the three-month deposit rate difference between domestic and foreign currency deposits. (Note 11) For Poland, DR is defined as the three-month deposit rate difference between domestic and euro deposits. The above data are sourced from the IMF's *International Financial Statistics* (April 2014, CD- ROM) and the respective central banks.

To avoid endogenous bias as mentioned above, the expected change in the nominal exchange rate is proxied by monthly inflation rate differences, measured by the consumer price index differences between the respective countries (except for the Czech Republic, Hungary, and Poland) and the United States. For the three Eastern European countries, the monthly inflation rate differences are measured by the consumer price index difference between each country and the Euro area. Data shown above are sourced from the IMF's *International Financial*

Statistics (April 2014, CD- ROM). The monthly-frequency data are seasonally adjusted.

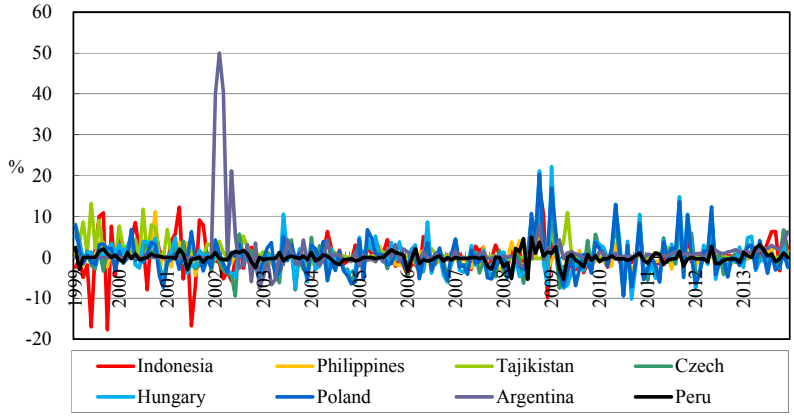

Figure 1. Depreciation rate of domestic currency vis-à-vis the U.S.

Data from IMF, *International Financial Statistics*, April 2014 (CD- ROM).

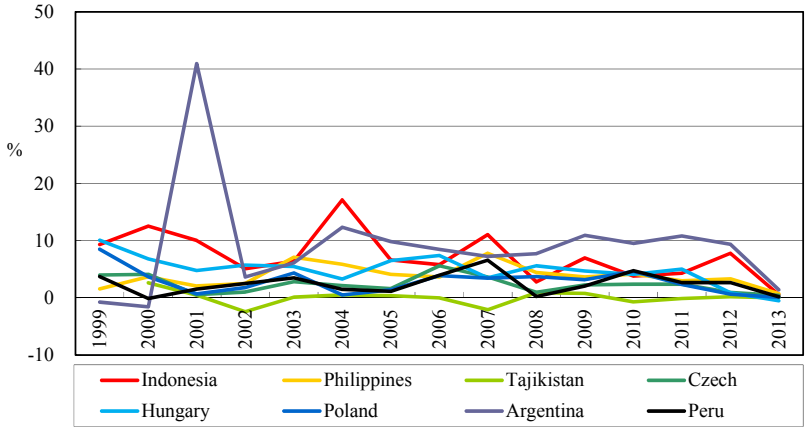

Figure 2. Inflation rate differential

Data from IMF, *International Financial Statistics*, April 2014 (CD- ROM).

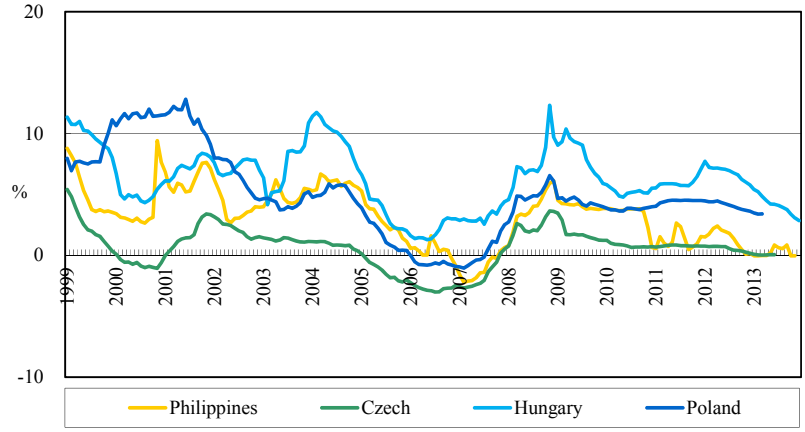

Figure 3. Nominal interest rate differential (TB)

TB = average yield difference between each country's and the U.S.'s three-month treasury bills. Data from IMF, *International Financial Statistics*, April 2014 (CD- ROM).

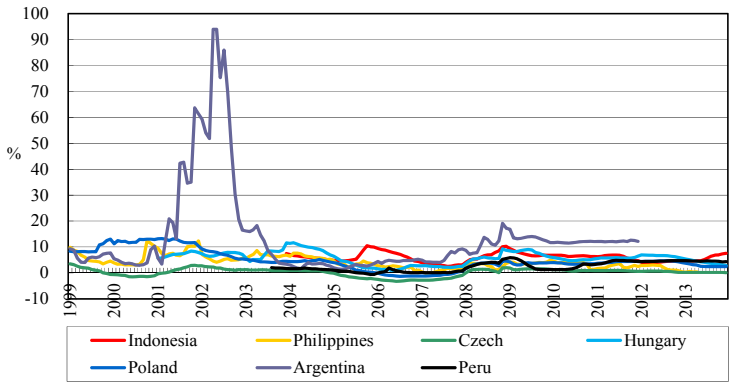

Figure 4. Nominal interest rate differential (IBOR)

IBOR = average monthly yield difference between each country's three-month interbank offered rate and the three-month London Interbank Offered Rate. Data from IMF, *International Financial Statistics*, April 2014 (CD-ROM), Bank of Indonesia, Bangko Sentral ng Pilipinas, Czech National Bank, The Central Bank of Hungary, Polski Portal Finansowy, Banco Central de la República Argentina, Asociación de Bancos del Perú.

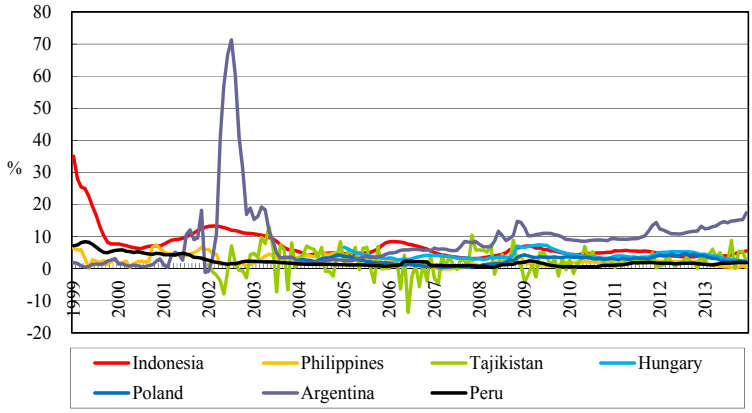

Figure 5. Nominal interest rate differential (DR)

DR = three-month deposit rate difference between domestic and foreign currency deposits. Data from IMF, *International Financial Statistics*, April 2014 (CD- ROM), National Bank of Tajikistan, The Central Bank of Hungary, Noradowy Bank Polski.

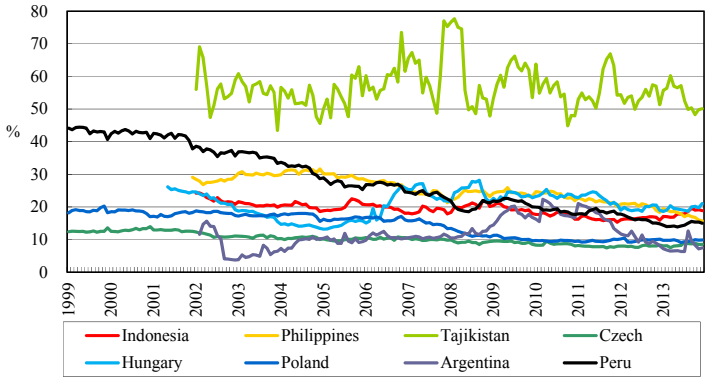

Figure 6. Degree of currency substitution

Degree of currency substitution is defined as the ratio of foreign currency deposits to total deposits. Data from Bank of Indonesia, Bangko Sentral ng Pilipinas, National Bank of Tajikistan, Czech National Bank, The Central Bank of Hungary, Noradowy Bank Polski, Banco Central de la República Argentina, Banco Central de Reserva del Peru.

The data mentioned above are illustrated in Figures 1 to 6. As shown in Figure 6, the degree of currency substitution varies across countries. For example, it is below 15% in the Czech Republic and Poland, and above 40% in Tajikistan.

4. Empirical Findings

4.1 Empirical Results

The empirical results are shown in Tables 1 and 2. (Note 12) The results in the tables are based on equation (6) (interest rate differential) and equation (7) (expected nominal exchange rate), respectively. They present the ECM representation of the short-run and implied long-run estimates. The optimal lag length for each variable is determined by AIC.

From Table 1, we see that the short-run coefficients of the interest rate differential, *dIntdiff*, have the expected sign and are statistically significant at the 10% level in the Philippines (TB and IBOR), the Czech Republic (TB and IBOR), Hungary (TB), Poland (IBOR), Argentina (IBOR and DR), and Peru (DR). These results imply that the interest rate differential is a significant determinant of currency substitution in the short run. The ECM coefficient, *EC(-1)*, is negative and highly significant in all countries, reflecting the joint significance of the long-run coefficients. Consider a case in which the error correction term is positive. This occurs when the interest rate differential is lower than the degree of currency substitution implied by the long-run cointegration relationship. In this case, the negative coefficient of *EC(-1)* indicates that currency substitution decreases in the next period. Hence, this implies that currency substitution decreases in response to a reduction in the interest rate differential. The F-statistic is highly significant, and the Durbin-Watson statistic does not indicate any sign of residual serial correlation.

The long-run coefficients of the interest rate differential, *Intdiff*, have the expected sign in all countries and are significant at the 10% level in the Philippines (TB and IBOR), the Czech Republic (TB and IBOR), Hungary (TB, IBOR, and DR), Poland (IBOR and DR), Argentina (IBOR and DR), and Peru (DR). Hence, these findings indicate that the interest rate differential is a significant determinant of currency substitution in all countries except Indonesia and Tajikistan. (Note 13) For Indonesia and Tajikistan, both the short- and long-run coefficients of the interest rate differential have the expected sign, but are insignificant.

More important, all short- and long-run coefficients of the ratchet variables, *dk* and *k*, have the expected sign and are significant at the 1% level. This implies that as the past one-year peak value of currency substitution increases, both short- and long-run currency substitution increases as well. Therefore, currency substitution has a ratchet effect in all countries.

From Table 2, we see that *EC(-1)* is negative and highly significant in Indonesia and Tajikistan, where the interest rate differentials are not significant. These results imply that the degree of currency substitution decreases in response to a reduction in the expected change in the nominal exchange rate and/or risk premium.

The long-run coefficients of the expected change in the nominal exchange rate, *Exch*, have the expected sign and are significant at the 10% level in both countries. The long-run coefficients of the risk premium *rp* have the expected sign but are not significant in both countries. Thus, these findings indicate that the expected change in the nominal exchange rate is a significant currency substitution determinant.

Furthermore, we also see that both the short- and long-run coefficients of the ratchet variable have the expected sign and are significant at the 5% level.

4.2 Discussion

These empirical results indicate that variables representing the usefulness of a foreign currency, both as a medium of exchange and a store of value, are significant determinants of currency substitution. That is, the decline in the interest rate differential or the expected changes in the nominal exchange rate could reduce the degree of currency substitution. Thus, the central bank could have some impact on the degree of currency substitution by pursuing a monetary policy aimed at macroeconomic stabilization. However, all countries evidence strong ratchet effects. Therefore, even when the central bank decides to reduce currency substitution through macroeconomic stabilization in order to restore the usefulness of domestic currency as a store of value, currency substitution will not decrease rapidly. In other words, more powerful policies (i.e., de-dollarization or de-euroization) will need to be pursued over an extended period of time for further reduction of currency substitution.

Table 1. Regression results

Estimated Long-run Coefficients

Variables	Indonesia			Philippines			Tajikistan			Czech		
	TB	IBOR	DR	TB	IBOR	DR	TB	IBOR	DR	TB	IBOR	DR
Intdiff	—	3.154	7.371	10.185 ***	14.827 ***	6.976	—	—	6.888	1.132 *	1.513 *	—
		(2.276)	(5.343)	(1.262)	(2.354)	(15.076)			(7.751)	(0.674)	(0.849)	
Const.	—	-0.100	-0.105	-0.204 ***	-0.385 ***	-0.065	—	—	-0.076	0.060	0.053 *	—
		(0.082)	(0.086)	(0.040)	(0.069)	(0.057)			(0.062)	(0.027)	(0.031)	
k	—	1.049 ***	1.074 ***	0.945 ***	0.829 ***	1.127 ***	—	—	0.591 ***	0.953 ***	0.923 ***	—
		(0.126)	(0.126)	(0.036)	(0.054)	(0.108)			(0.097)	(0.029)	(0.034)	

Short-run Coefficients: Error Correction Representation

Variables	Indonesia			Philippines			Tajikistan			Czech		
	TB	IBOR	DR	TB	IBOR	DR	TB	IBOR	DR	TB	IBOR	DR
dCS(-1)	—	-0.235	0.179 *	—	—	—	—		0.248 **	—	—	—
		(0.115)	(0.104)						(0.103)			
dCS(-2)	—	-0.281 **	-0.174 *	—	—	—	—	—	0.244 **	—	—	—
		(0.112)	(0.091)						(0.097)			
dCS(-3)	—		0.152 *	—	—	—	—	—	0.125	—	—	—
			(0.092)						(0.087)			
dIntdiff	—	-3.549 *	-0.393	3.717 ***	3.351 **	-9.472 **	—	—	4.211	0.458 *	0.523 *	—
		(1.932)	(9.147)	(0.673)	(1.542)	(4.748)			(4.669)	(0.272)	(0.289)	
dIntdiff(-1)	—	-4.939 **	-20.343 **	—	-3.585 **	-2.870	—	—	—	—	—	—
		(2.282)	(8.910)		(1.597)	(5.054)						
dIntdiff(-2)	—	-0.292	—	—	—	-8.488 *	—	—	—	—	—	—
		(2.109)				(4.719)						
dIntdiff(-3)	—	-1.549	—	—	—	-3.795	—	—	—	—	—	—
		(2.062)				(4.880)						
Const.	—	-0.028	-0.027	-0.074 ***	-0.110 ***	-0.011	—	—	-0.046	0.011	0.018 *	—
		(0.024)	(0.022)	(0.019)	(0.025)	(0.011)			(0.039)	(0.011)	(0.011)	
dk	—	0.291 **	0.280 ***	0.345 ***	0.238 ***	0.198 **	—	—	0.362 ***	0.385 ***	0.319 ***	—
		(0.123)	(0.094)	(0.069)	(0.057)	(0.078)			(0.093)	(0.066)	(0.060)	
EC(-1)	—	-0.277 **	-0.261 ***	-0.365 ***	-0.286 ***	-0.176 **	—	—	-0.611 ***	-0.404 ***	-0.345 ***	—
		(0.106)	(0.085)	(0.071)	(0.062)	(0.070)			(0.109)	(0.068)	(0.062)	
SEE	—	0.016	0.017	0.024	0.025	0.025	—	—	0.175	0.014	0.014	—
R-squared	—	0.292	0.218	0.305	0.211	0.211	—	—	0.228	0.253	0.217	—
DW-statistics	—	2.005	1.951	1.966	2.042	1.981	—	—	1.963	1.878	1.890	—
F-statistic	—	6.745	3.926	6.460	8.284	8.284	—	—	6.556	6.690	5.713	—
sample period	—	2003M12	2002M1	2001M12	2001M12	2001M12	—	—	2002M1	1999M1	1999M1	—
		-2013M12	-2013M12	-2013M11	-2013M4	-2013M12			-2013M12	-2013M6	-2013M12	

Estimated Long-run Coefficients

Variables	Hungary			Poland			Argentina			Peru		
	TB	IBOR	DR	TB	IBOR	DR	TB	IBOR	DR	TB	IBOR	DR
Intdiff	16.609 **	15.524 ***	26.238 ***	0.022	0.382 *	2.198 ***	—	2.255 **	11.591 ***	—	3.258	120.010 *
	(6.494)	(4.926)	(9.786)	(0.695)	(0.204)	(0.878)		(1.093)	(4.185)		(9.981)	(71.753)
Const.	-0.171	-0.129	-0.206 **	-0.126	-0.007	-0.008	—	0.066	0.034	—	-0.120	-0.537 *
	(0.128)	(0.099)	(0.091)	(0.119)	(0.103)	(0.012)		(0.111)	(0.100)		(0.185)	(0.290)
k	0.731 ***	0.698 ***	0.841 ***	1.192 ***	0.991 ***	1.011 ***	—	0.716 ***	0.748 ***	—	1.027 ***	0.888 ***
	(0.218)	(0.181)	(0.069)	(0.189)	(0.012)	(0.017)		(0.119)	(0.104)		(0.190)	(0.130)

Short-run Coefficients: Error Correction Representation

Variables	Hungary			Poland			Argentina			Peru		
	TB	IBOR	DR	TB	IBOR	DR	TB	IBOR	DR	TB	IBOR	DR
dCS(-1)	-0.063	-0.012	0.057	—	0.267 ***	0.230 **	—	-0.174 *	-0.125	—	0.336 ***	0.209 ***
	(0.092)	(0.094)	(0.100)		(0.080)	(0.0890)		(0.098)	(0.086)		(0.107)	(0.079)
dCS(-2)	0.103	0.076	0.155	—	0.083	—	—	—	—	—	0.110	—
	(0.093)	(0.092)	(0.098)		(0.078)						(0.113)	
dCS(-3)	0.242 ***	0.228 **	0.316 ***	—	0.186 **	—	—	—	—	—	0.232 *	—
	(0.090)	(0.090)	(0.094)		(0.073)						(0.113)	
dIntdiff	3.152 *	2.700	-12.105 **	0.006	1.551 *	0.408	—	1.631 *	5.335 ***	—	-4.793	36.456 ***
	(1.821)	(2.147)	(4.735)	(0.179)	(0.885)	(1.742)		(0.856)	(2.459)		(3.300)	(10.928)
dIntdiff(-1)	2.466	-0.456	—	—	—	1.019	—	-0.982 **	—	—	—	8.515
	(1.830)	(2.202)				(1.706)		(0.473)				(11.458)
dIntdiff(-2)	-4.359 **	-5.833 ***	—	—	—	0.944	—	—	—	—	—	-14.207
	(1.811)	(2.193)				(1.708)						(11.052)
dIntdiff(-3)	-2.194	—	—	—	—	4.282 **	—	—	—	—	—	27.510 ***
	(1.835)					(1.765)						(10.178)
Const.	-0.020	-0.019	-0.095 **	-0.033	-0.003	-0.005	—	0.015	0.009	—	-0.013	-0.024 **
	(0.016)	(0.016)	(0.044)	(0.029)	(0.005)	(0.007)		(0.026)	(0.026)		(0.051)	(0.009)
dk	0.086 *	0.102 *	0.388 ***	0.307 ***	0.515 ***	0.587 ***	—	0.167 **	0.196 ***	—	0.115 *	0.199 ***
	(0.050)	(0.052)	(0.088)	(0.090)	(0.082)	(0.095)		(0.068)	(0.067)		(0.051)	(0.051)
EC(-1)	-0.117 **	-0.146 ***	-0.461 ***	-0.258 ***	-0.519 ***	-0.580 ***	—	-0.234 ***	-0.263 ***	—	-0.112 **	-0.209 ***
	(0.046)	(0.050)	(0.089)	(0.080)	(0.082)	(0.093)		(0.072)	(0.069)		(0.050)	(0.052)
SEE	0.053	0.054	0.060	0.013	0.012	0.012	—	0.063	0.069	—	0.016	0.017
R-squared	0.278	0.224	0.285	0.222	0.247	0.313	—	0.318	0.286	—	0.223	0.293
DW-statistics	1.913	2.030	1.951	1.892	1.903	2.027	—	1.918	1.935	—	1.945	1.999
F-statistic	4.661	4.323	4.643	5.529	6.711	6.963	—	10.142	13.423	—	4.507	8.682
sample period	2001M5	2001M5	2005M1	1999M1	1999M1	2004M1	—	2002M1	2002M1	—	2003M8	1999M1
	-2013M12	-2013M12	-2013M12	-2013M3	-2013M12	-2013M12		-2011M12	-2013M12		-2013M12	-2013M12

Notes: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. Standard errors are in parentheses.

Table 2. Extended regression results

Estimated Long-run Coefficients

Variables	Indonesia	Philippines	Tajikistan	Czech	Hungary	Poland	Argentina	Peru
Exch	2.150 **	5.342 **	8.179 **	4.002 **	0.275	-0.065	0.232	0.157
	(1.048)	(2.254)	(3.292)	(1.825)	(1.711)	(0.057)	(2.209)	(0.151)
rp	832.785	-3100.9	56.374	1631.0	1870.5	339.040	593.709 **	3862.8 ***
	(763.466)	(2785.8)	(421.633)	(1252.5)	(5866.4)	(691.071)	(252.529)	(435.867)
Const.	-0.733 **	0.032	-0.082	-0.112	-0.364 *	-0.020 *	0.342 *	-0.020 ***
	(0.305)	(0.188)	(0.064)	(0.203)	(0.210)	(0.011)	(0.194)	(0.003)
k	0.557 ***	1.104 ***	0.569 ***	1.025 ***	0.824 ***	1.005 ***	0.577 ***	1.008 ***
	(0.210)	(0.116)	(0.095)	(0.280)	(0.171)	(0.015)	(0.172)	(0.006)

Short-run Coefficients: Error Correction Representation

Variables	Indonesia	Philippines	Tajikistan	Czech	Hungary	Poland	Argentina	Peru
dCS(-1)	0.020	-0.163 *	0.132	-0.212 ***	0.108	0.215 *	-0.258 ***	0.313 ***
	(0.090)	(0.091)	(0.105)	(0.079)	(0.092)	(0.082)	(0.095)	(0.066)
dCS(-2)	-0.229 **	—	0.284 ***	—	0.122	0.089	-0.133	0.166 **
	(0.091)		(0.099)		(0.091)	(0.078)	(0.086)	(0.068)
dCS(-3)	—	—	0.152 *	—	0.284 ***	0.144 *	—	0.333 ***
			(0.091)		(0.086)	(0.075)		(0.066)
dExch	0.350 ***	0.629 ***	0.709	0.004	0.112	0.095 *	0.095	0.097
	(0.086)	(0.134)	(1.293)	(0.061)	(0.097)	(0.050)	(0.289)	(0.092)
dExch(-1)	-0.320 **	—	—	-0.693 ***	-0.187	0.048	—	—
	(0.113)			(0.135)	(0.176)	(0.042)		
dExch(-2)	-0.171 *	—	—	-0.505 ***	-0.304 **	0.540	—	—
	(0.088)			(0.119)	(0.145)	(0.033)		
dExch(-3)	-0.108	—	—	-0.343 ***	-0.205 **	0.070 ***	—	—
	(0.153)			(0.094)	(0.101)	(0.024)		
drp	96.376	-364.849	22.793	285.804 *	244.672	150.283	17.531	526.687
	(79.805)	(341.343)	(170.293)	(161.355)	(743.941)	(308.786)	(20.221)	(406.696)
drp(-1)	132.696 *	—	—	—	—	—	-100.054 ***	-1503.3 ***
	(76.390)						(19.386)	(425.056)
drp(-2)	—	—	—	—	—	—	-85.096 ***	-1902.6 ***
							(17.894)	(424.810)
drp(-3)	—	—	—	—	—	—	-80.910 ***	—
							(16.342)	
Const.	-0.080 **	0.002	-0.044	-0.015	-0.048 *	-0.009 *	0.052 **	-0.012 ***
	(0.033)	(0.013)	(0.043)	(0.028)	(0.026)	(0.005)	(0.025)	(0.003)4
dk	0.183 **	0.130 **	0.358 ***	0.135 **	0.191 ***	0.440 ***	0.149 **	0.622 ***
	(0.075)	(0.052)	(0.061)	(0.053)	(0.068)	(0.083)	(0.059)	(0.068)
EC(-1)	-0.245 ***	-0.118 **	-0.629 ***	-0.136 **	-0.215 ***	-0.438 ***	-0.245 ***	-0.617 ***
	(0.082)	(0.049)	(0.112)	(0.053)	(0.067)	(0.082)	(0.060)	(0.067)
SEE	0.028	0.025	0.166	0.029	0.055	0.013	0.066	0.171
R-squared	0.271	0.185	0.316	0.231	0.192	0.228	0.357	0.280
DW-statistics	1.938	2.059	1.982	1.961	1.978	1.889	1.908	2.055
F-statistic	6.048	5.576	6.573	3.921	3.238	5.289	9.030	7.237
sample period	2002M1 -2013M12	2001M12 -2013M12	2002M1 -2013M12	1999M1 -2013M12	2001M5 -2013M12	1999M1 -2013M12	2002M1 -2013M12	1999M1 -2013M12

Notes: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. Standard errors are in parentheses.

5. Conclusion

In this paper, we empirically investigated recent currency substitution experiences. In particular, we focused on the determinants of currency substitution, namely, the factors representing the usefulness of foreign currency, both as a medium of exchange and a store of value.

In the analysis, we estimated an equation from the agent's utility maximization problem and introduced the exchange rate risk premium as an alternative determinant, considering the forward premium puzzle.

Empirical results show that the variables representing the usefulness of foreign currency, both as a medium of exchange and a store of value, are significant determinants of currency substitution. They indicated that the central bank could have some impact on the degree of currency substitution by pursuing a monetary policy aimed at macroeconomic stabilization. However, all countries evidence strong ratchet effects. Therefore, even when the central bank decides to reduce currency substitution through macroeconomic stabilization in order to restore the usefulness of the domestic currency as a store of value, currency substitution will not decrease rapidly. In other words, more powerful policies (i.e., de-dollarization or de-euroization) will need to be pursued over an extended period of time for further reduction of currency substitution.

Note that these results should be treated with caution for the following reasons. First, as shown by the R-squared statistics, the currency substitution model used here can only explain about 19 to 36% of the currency substitution phenomenon. Second, the currency substitution measure should include foreign currency in circulation. However, such data are not available, so the currency substitution measure used in this paper is incomplete. Other factors, too, explain the currency substitution phenomenon, and a more accurate measure of currency substitution will therefore need to be incorporated in the model to conclude that monetary policy or exchange rate policy could indeed be effective in reducing currency substitution. These tasks are our future research direction.

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Notes

Note 1. See Giovannini and Turtelboom (1994) and Végh (2013) for surveys on currency substitution.

Note 2. Two other factors explain the ratchet effects of currency substitution. One is based on the fixed costs of switching the currency denomination of transactions. Once the economy has reached an equilibrium in which foreign currency is used for many transactions, it would be costly to switch back to an equilibrium in which only the domestic currency is used. In other words, there is an inaction band within which the currency substitution ratio will not change even if domestic inflation falls (Guidotti & Rodriguez, 1992). The other is based on the volatility of real exchange depreciation and inflation. Ize and Levy-Yeyati (2003) use a portfolio model in which the equilibrium level of currency substitution depends on the relative price and real exchange rate volatility, and show that if real exchange depreciation is less volatile than inflation, then residents would prefer to hold foreign currency as it is less risky.

Note 3. Examples of previous studies for Latin America countries: Rodríguez and Turner (2003) study on Mexico; Ramirez-Rojas (1985) on Argentina, Mexico, and Uruguay; Clements and Schwartz (1993) on Bolivia; and Kumamoto and Kumamoto (2003a) on Argentina, Bolivia, Chile, Paraguay, Peru, and Uruguay. For Asian countries: Adam, Goujon, and Guillaumont (2004) on Vietnam; Sharma, Kandil, and Chaisrisawatsuk (2005) on Indonesia, Japan, Korea, Malaysia, Singapore, and Thailand; and Kumamoto and Kumamoto (2008) on Indonesia. For Central and Eastern European countries: Neanidis and Savva (2009) on Armenia, Bulgaria, the Czech Republic, Estonia, Georgia, the Kyrgyz Republic, Latvia, Poland, Romania, Russia, and Ukraine; and Stix (2011) on Croatia, Slovenia, and Slovakia.

Note 4. For a discussion on the puzzle and a review of the related literature, see Sarno (2005), Chakraborty, and Evans (2008).

Note 5. The derivation of uncovered interest parity is as follows. Domestic and foreign real interest rates can be defined via Fisher's consumption-based equation as $1+r_t=\{P_t(1+i_t)\}E_t[u_C(t+1)/P_{t+1}]\}/E_t[u_C(t+1)]= P_t(1+i_t)/E_t[P_{t+1}]$ and $1+r_t^*=\{P_t^*(1+i_t^*)\}E_t[u_C(t+1)/P_{t+1}^*]\}/E_t[u_C(t+1)]=P_t^*(1+i_t^*)/E_t[P_{t+1}^*]$, where P_t and P_t^* denote the currency prices of the consumption good at period t. Taking the natural logarithms of the two above equations and using the relationship $r_t=r_t^*$ (note that real interest rates are determined by world investment-saving balances; therefore, real interest rates must equalize across countries) and the purchasing power parity, we obtain a desirable result.

Note 6. The ratchet effects in currency substitution are investigated by Mongardini and Mueller (2000) for the Kyrgyz Republic; Kumamoto and Kumamoto (2003b) for Argentina, Bolivia, Mexico, Paraguay, Peru, and Uruguay; and Us (2003) for Turkey with an ARDL approach. Although Mongardini and Mueller (2000) and Us (2003) introduce the expected change in the nominal exchange rate as one of the determinants of currency substitution, they do not consider the forward premium puzzle.

Note 7. The simple GARCH(1,1) model has been found to provide a good representation of a wide variety of volatility processes (Bolleslev, 1986).

Note 8. Pesaran and Shin (1999) show that the OLS estimators of the short-run parameters are $\sqrt{T}$ -consistent with the asymptotically singular covariance matrix and the long-run parameters are T-consistent (super consistent), and that valid inferences on the long-run parameters can be made according to the standard normal asymptotic theory.

Note 9. Residents include non-financial incorporated enterprises and households, excluding private banks, the central bank, and the government.

Note 10. With the available data, we cannot determine whether residents hold deposits denominated in foreign currency as a medium of exchange for domestic or foreign transactions. Therefore, we might overestimate the degree of currency substitution.

Note 11. Data are not available for the treasury bill rate in Indonesia, Tajikistan, Argentina, and Peru; the interbank offered rate in Tajikistan; and the deposit rate on foreign currency deposits in the Czech Republic.

Note 12. All econometric results were computed with the *Microfit 4.1* software package for Windows, designed by Pesaran and Pesaran (1997).

Note 13. We confirm the robustness of the empirical result for Eastern European countries using IBOR, defined as the average monthly yield difference between the three-month interbank offered rate of the respective countries and the three-month Euro Interbank Offered Rate (EURIBOR).