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Does Currency Substitution Affect Exchange Rate Volatility?

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ABSTRACT: This study investigates the impacts of the degree of currency substitution on nominal exchange rate volatility in seven countries (Indonesia, the Philippines, the Czech Republic, Hungary, Poland, Argentina, and Peru). We use the Threshold ARCH model to consider the ratchet effect of currency substitution and sample periods in the 2000s, during which time the economies of the sample countries stabilized, while the U.S. dollar and euro depreciated against other major currencies following the recent global financial crisis. The presented empirical analyses show that the degree of currency substitution has significant positive effects on the conditional variance of the depreciation rate of the nominal exchange rate in most sample countries. Moreover, a shock to the depreciation rate of the nominal exchange rate has asymmetric effects on the conditional variance, depending on the sign. One possible explanation for these differential effects is the existence of the ratchet effect of currency substitution.

Keywords: Currency Substitution; Exchange Rate Volatility; TARCH model
JEL Classifications: E50; E52; F32; F41

1. Introduction

Currency substitution, the phenomenon of domestic residents preferring to use a foreign currency such as the U.S. dollar or euro as a means of payment, is a common feature of developing and transition countries that have previously experienced high inflation. One of the main issues investigated by the large body of theoretical and empirical research on currency substitution is its impact on exchange rate volatility. Under currency substitution, money demand for the domestic currency depends not only on the domestic nominal interest rate but also on the foreign nominal interest rate. Therefore, the money demand function becomes unstable and exchange rate volatility increases.

A volatile exchange rate has undesirable impacts on domestic economies. First, it increases inflation rate volatility through the effects on imported goods prices. Second, it increases exchange rate risk, negatively influencing international trade and capital flows (e.g., McKenzie, 1999). Third, since the exchange rate is used as a nominal anchor, especially in developing countries, a volatile exchange rate destabilizes inflation expectations (Amato and Gerlach, 2002). Thus, central banks in currency substitution countries should consider the existence of currency substitution and its impact on exchange rate volatility when formulating their monetary policies.

This study investigates how the degree of currency substitution affects exchange rate volatility in seven countries (Indonesia, the Philippines, the Czech Republic, Hungary, Poland, Argentina, and Peru). We follow the approach taken by Akçay et al. (1997) by using the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) family model to proxy for exchange rate volatility as a conditional variance of the depreciation rate of the nominal exchange rate and then to examine how the degree of currency substitution affects exchange rate volatility. However, while Akçay et al. (1997)

used the Exponential GARCH (E-GARCH) model, we employ the Threshold ARCH (TARCH) model proposed by Glosten et al. (1993) and Zakoïan (1994) to take into account the ratchet effect of currency substitution, which occurs when the degree of currency substitution increases rapidly with macroeconomic destabilization but decreases only slightly, or not at all, after stabilization[1].

Domestic residents determine whether they should use the domestic or the foreign currency by comparing their usefulness as a means of payment and as a store of value. The usefulness of a currency as a means of payment depends on its general acceptability. The greater the number of domestic residents using a currency, the more useful it becomes. Thus, the higher the degree of currency substitution in a country, the more useful is the foreign currency as a means of payment. Therefore, even if the inflation rate (and hence the nominal interest rate differential and depreciation rate of the nominal exchange rate) in the domestic country falls, domestic residents would continue to use the foreign currency if they consider it to be more useful as a means of payment than the domestic currency is as a store of value. Hence, the different signs of the shocks to the nominal exchange rate have different effects on the degree of currency substitution. Specifically, a depreciation shock to the nominal exchange rate increases the degree of currency substitution rapidly, thereby magnifying exchange rate volatility. On the contrary, currency substitution reacts only slightly to an appreciation shock, which does not affect exchange rate volatility. As demonstrated in this study, the TARCH model can take into account these differential effects.

Moreover, in contrast to other studies of this topic, we use sample periods in the 2000s, during which time the economies in currency substitution countries stabilized, while the U.S. dollar and euro depreciated against other major currencies following the recent global financial crisis. This depreciation has meant that the relative usefulness of the U.S. dollar and euro as a store of value has declined, leading to de-dollarization or de-euroization. Generally speaking, the volatility of any arbitrary variable increases as its level rises. In the situation of a lower inflation rate and lower depreciation rate of the nominal exchange rate, their volatilities also decrease. Therefore, using recent sample periods to conduct our estimation is expected to provide new insights into currency substitution.

The remainder of this paper is organized as follows. Section 2 reviews related studies, while Section 3 explains the method used. Section 4 presents the empirical results. Section 5 concludes.

2. Literature Review

The earliest study that examined theoretically the impact of currency substitution on nominal exchange rate volatility was Kareken and Wallace (1981). They used the overlapping generations model to argue that the nominal exchange rate becomes indeterminate when domestic and foreign currencies are perfect substitutes. However, they found that even a small degree of imperfect substitution is enough to specify the nominal exchange rate, highlighting the potential instabilities caused by currency substitution. Similarly, Girton and Roper (1981) showed that currency substitution produces instability in the sense that shifts in the anticipated rate of exchange rate change produce larger movements in the nominal exchange rate and these movements are unbounded as currency substitution increases.

Isaac (1989) used a portfolio balance model to show that as substitutability between the domestic and the foreign currency increases, the nominal exchange rate responds more to both asset market and commodity market shocks, while the extent of exchange rate overshooting and undershooting depends on the degree of currency substitution. Mahdavi and Kazemi (1996) used a cash-in-advance model to find that as substitutability increases, the exchange rate becomes more sensitive to changes in economic fundamentals, thus increasing its volatility. Moreover, they showed that even under imperfect currency substitution (i.e., a small degree of currency substitution), the nominal exchange rate becomes indeterminate in the sense that its behavior cannot explained by changes in economic fundamentals, and this indeterminacy is exacerbated if the central banks in the domestic and foreign countries adopt similar monetary policies. Finally, Canzoneri and Diba (1993)

[1] Uribe (1997) and Peiers and Wrase (1997) showed that because an economy's accumulated experience in using a foreign currency as a means of payment acts as a network externality, it reduces the marginal cost of buying goods with the foreign currency. This network externality produces the ratchet effect of currency substitution.

used the money-in-the-utility-function model to show that when the relative supply of the foreign currency (circulated in the domestic country) to the domestic currency follows an explosive process, more currency substitution leads to greater exchange rate volatility.

As for empirical analyses, as noted in the Introduction, Akçay et al. (1997) used an E-GARCH model to estimate exchange rate volatility as a conditional variance of the depreciation rate of the nominal exchange rate, finding that the degree of currency substitution affects exchange rate volatility for the Turkish Lira–U.S. dollar exchange. Later, the study by Saatçíoğlu et al. (2007) extended their sample period, while Yinusa (2008) estimated exchange rate volatility by using the GARCH model and then employed the bivariate VAR model to investigate Granger causality between the degree of currency substitution and exchange rate volatility, finding bidirectional causality in Nigeria[2].

3. Empirical Method

We employ the following TARCH model proposed by Glosten et al. (1993) and Zakoïan (1994) to estimate exchange rate volatility as a conditional variance of the depreciation rate of the nominal exchange rate in order to consider the ratchet effect of currency substitution:

$$\Delta s_t = \alpha + \beta(i_t - i_t^*) + \varepsilon_t, \tag{1}$$

$$E_{t-1}[\varepsilon_t] \sim N(0, \sigma_t^2), \tag{2}$$

$$\sigma_t^2 = \mu + \delta cs_t + \sum_{j=1}^{q} \kappa_j \sigma_{t-j}^2 + \sum_{i=1}^{p} \lambda_i \varepsilon_{t-i}^2 + \sum_{k=1}^{r} \eta_k \varepsilon_{t-k}^2 I_{t-k}^-, \tag{3}$$

where $I_t^- = 1$ if $\varepsilon_t < 0$ and 0 otherwise.

s_t is a natural logarithm of the nominal exchange rate defined by the price of the *domestic currency* in terms of the *foreign currency*; therefore, an increase in s_t means the *appreciation* of the domestic currency. i_t and i_t^* are the domestic and foreign nominal interest rates, respectively, and $cs_t \equiv m_{F,t} + s_t - m_{H,t}$ denotes the degree of currency substitution, where $m_{H,t}$ and $m_{H,t}$ are the natural logarithms of demand deposits denominated in the domestic and the foreign currency, respectively.

Equation (1) means that the depreciation rate of the nominal exchange rate is governed by the uncovered interest rate parity (UIP) condition, with the deviation from the UIP condition captured by the UIP shock ε_t. Equations (2) and (3) mean that the UIP shock ε_t follows the TARCH(p,q,r) process and its conditional variance (defined as the one-period ahead forecast variance based on past information) σ_t^2 is affected by the degree of currency substitution cs_t. The indicator variable I_t^- captures the differential effects of ε_t on the conditional variance σ_t^2.

In our model, a positive UIP shock $\varepsilon_t > 0$, which leads to an appreciation of the exchange rate, has an impact of λ_i, while a negative one $\varepsilon_t < 0$, leading to a depreciation, has an impact of $\lambda_i + \eta_i$. If $\eta_i > 0$, the positive UIP shock increases exchange rate volatility, and we say that there is a *leverage effect*. If $\eta_i \neq 0$, the impact of the UIP shock is asymmetric. As discussed in the Introduction, when the ratchet effect of currency substitution exists, domestic residents increase their degree of currency substitution following a negative UIP shock, which might magnify exchange rate volatility. On the contrary, the degree of currency substitution reacts only slightly to an appreciation shock, which does not affect exchange rate volatility. Therefore, we expect the sign of η_i to be positive if the ratchet effect of currency substitution exists.

The impact of the degree of currency substitution on exchange rate volatility is estimated by δ in Equation (2). A positive coefficient of cs_t indicates that the higher the degree of currency substitution, the higher is exchange rate volatility.

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[2] Neanidis and Savva (2006) used a bivariate VARMA, GARCH-in-Mean model to investigate the effects of both inflation and currency substitution volatilities on the average rates of inflation and currency substitution for 12 emerging economies. They found that for the majority of countries, inflation volatility has a positive influence on both the average rates of inflation and currency substitution. Similarly, higher uncertainty in currency substitution enhances both inflation and currency substitution. Yinusa and Akinlo (2008) estimated the demand function for the foreign currency deposits of Nigeria and found that real exchange rate volatility is a significant determinant of the stock of foreign currency deposits.

4. Data and Empirical Results

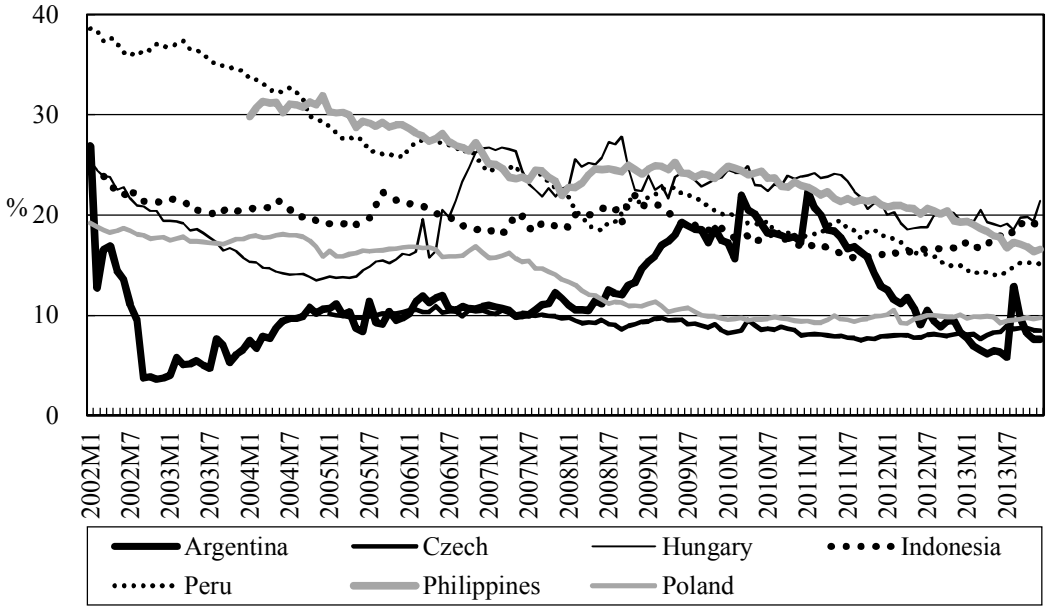
4.1 Data

Our seven-nation sample includes two Asian countries (Indonesia and the Philippines), three Central and Eastern European (CEE) countries (the Czech Republic, Hungary, and Poland), and two Latin American countries (Argentina and Peru)[3]. Owing to data availability, our sample period runs from 2002M1 to 2013M12 with monthly data, which covers the period when the economies in these sample countries were stable and when the U.S. dollar and euro were depreciating[4].

The nominal balance of a foreign currency is typically represented as the sum of the amount of the foreign currency in circulation and demand deposits denominated in the foreign currency. Unfortunately, it is difficult to collect data on the foreign currency in circulation. Therefore, as in the literature, we use data on demand deposits denominated in the foreign currency as a proxy of the nominal balance of the foreign currency. Consistently, we also use data on demand deposits denominated in the domestic currency as a proxy for the nominal balance of the domestic currency. Thus, these data are sourced from the central banks in each sample country.

The depreciation rate of the nominal exchange rate is calculated from the nominal exchange rate defined by the price of the *domestic currency* in terms of *the foreign currency*. Foreign currency is the U.S. dollar for Asian and Latin American countries and the euro for CEE countries. The nominal interest rate differential is calculated as the difference between the domestic interbank rate[5] and London Interbank Offered Rate (LIBOR) for Asian and Latin American countries, while the Euro Interbank Offered Rate (EURIBOR) is used for CEE countries. These data are sourced from the IMF's *International Financial Statistics*, *Economist Intelligence Unit,* and *DataStream*.

Figure 1. Degree of currency substitution in the sample countries



Note: Degree of currency substitution is defined as the proportion of foreign currency deposits relative to total deposits.

Figure 1 shows the degree of currency substitution for the seven sample countries throughout the study period, while Figure 2 shows the nominal interest rate differential. These figures show that in most countries, the degrees of currency substitution have fallen, as the nominal interest rate

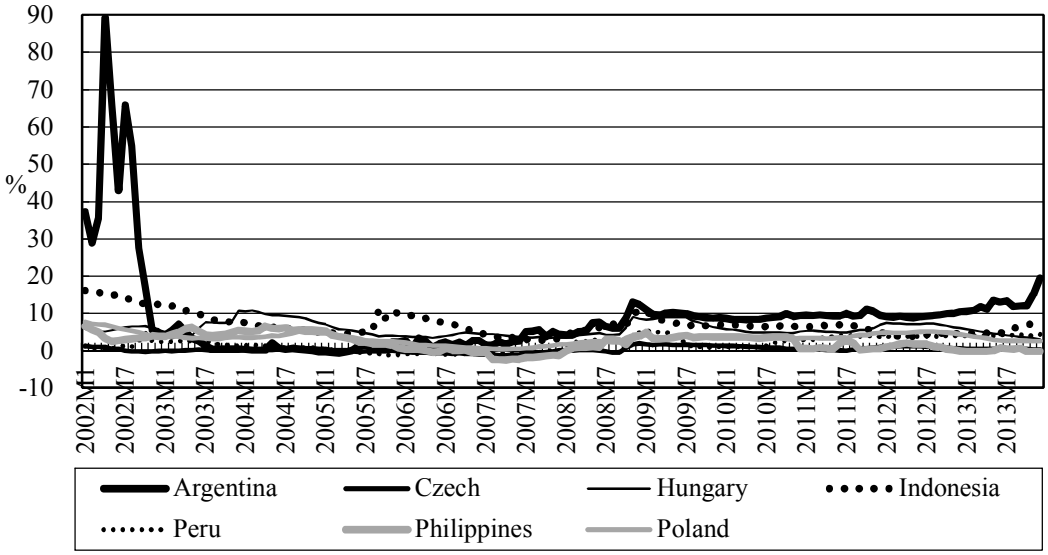
[3] It is known that the degree of currency substitution is high in other countries such as Cambodia, Laos, Vietnam, Bolivia, Mexico, Paraguay, and Uruguay. However, monthly data on these countries are not available. Therefore, expanding sample countries is one future research direction.

[4] Data unavailability restricted the sample periods to be from 2005M1 to 2013M12 for the Czech Republic and 2004M1 to 2013M12 for the Philippines.

[5] Owing to data availability, data on Argentina is the repo rate up to 15 days and data on the Philippines is the Treasury Bill rate with 91 days.

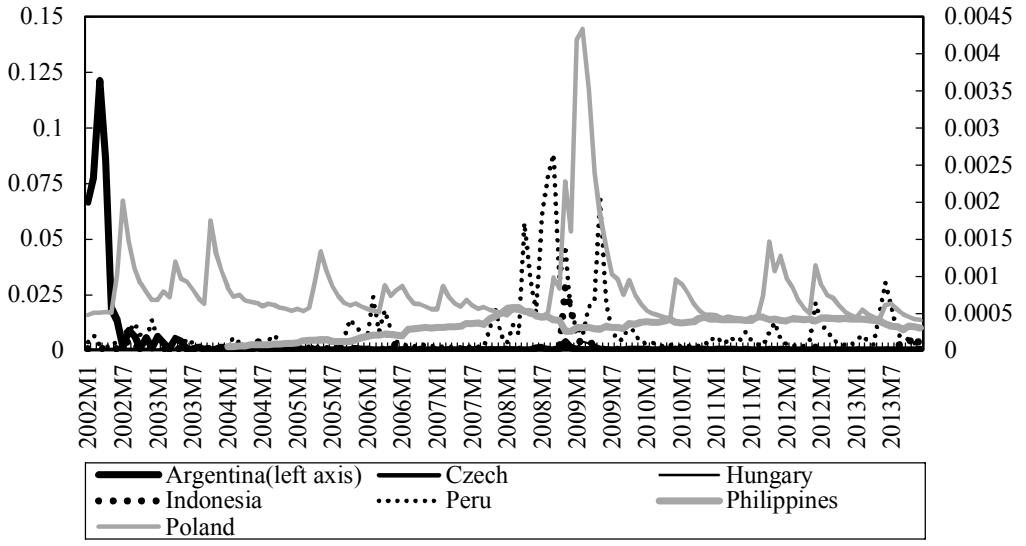
differentials have diminished (i.e., de-dollarization or de-euroization). In addition, Figure 3 shows the conditional variances of the depreciation rate of the nominal exchange rate estimated by the TARCH model, showing volatility clustering in some countries.

Figure 2. Nominal interest rate differential



Note: The nominal interest rate differential is defined as the average monthly difference between each country's three-month interbank offered rate and the three-month LIBOR or EURIBOR. The domestic nominal interest rate is the repo rate up to 15 days for Argentina and the Treasury Bill rate with 91 days for the Philippines.

Figure 3. Conditional variances of the depreciation rate of the nominal exchange rate



Note: Conditional variances of the depreciation rate of the nominal exchange rate are estimated from our TARCH(1,1,1) estimation. The left axis is for Argentina, while the right axis is for the other countries.

4.2 Empirical Results

The empirical results are shown in Table 1. In our estimation, we follow Bollerslev (1986) to set the order of the ARCH term to $p=1$ and that of the GARCH term to $q=1$. We also set the order of the TARCH term to $r=1$ to estimate the TARCH(1,1,1) model[6].

[6] For the conditional distribution of the error term, EViews prepares three alternatives: the normal (Gaussian), the Student's t-distribution, and the generalized error disturbance (GED).

Table 1. Empirical results

	Argentina	Czech	Hungary	Indonesia	Peru	Philippines	Poland
α	-0.003* (0.058)	0.001 (0.400)	-0.006 (0.295)	-0.016*** (0.000)	0.003*** (0.005)	0.003 (0.295)	0.005 (0.414)
β:i-i*	-0.440*** (0.000)	-1.051** (0.028)	0.400 (0.291)	1.014*** (0.000)	-0.162 (0.317)	-0.152 (0.539)	-0.695 (0.302)
μ	0.001*** (0.000)	1.3E-04*** (0.000)	4.6E-04** (0.011)	0.002*** (0.0009)	9.11E-06 (0.579)	1.41E-05** (0.013)	2.7E-04 (0.177)
κ :GARCH(-1)	0.106** (0.010)	1.015*** (0.000)	0.707*** (0.000)	0.193 (0.125)	0.300** (0.042)	0.996*** (0.000)	0.628*** (0.000)
λ :ARCH(-1)	0.832*** (0.006)	-0.102*** (0.000)	-0.133 (0.273)	0.026 (0.911)	0.602** (0.012)	0.071 (0.289)	0.032 (0.790)
η :TARCH(-1)	-0.014 (0.971)	0.145*** (0.000)	0.315* (0.073)	1.037*** (0.003)	0.167 (0.671)	-0.104 (0.249)	0.250* (0.093)
δ :cs	0.0002*** (0.000)	5.60E-05*** (0.000)	0.0002** (0.024)	0.0009** (0.014)	-1.68E-05 (0.321)	1.25E-05** (0.026)	6.24E-05 (0.522)

Note 1: Probability values are reported in parentheses.

Note 2: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 1 shows that the degree of currency substitution has significant positive effects on the conditional variance of the depreciation rate of the nominal exchange rate in Argentina and the Czech Republic at the 1% level, and in Hungary, Indonesia, and the Philippines at the 5% level, while we cannot find any significant effect for Peru and Poland. These results imply that a rise in the degree of currency substitution increases exchange rate volatility in most sample countries. Moreover, we find differential effects in the Czech Republic and Indonesia at the 1% level and in Hungary and Poland at the 10% level, suggesting that a UIP shock has asymmetric effects on the conditional variances, depending on the sign. As discussed in the Introduction, one possible explanation is the existence of the ratchet effect of currency substitution, under which domestic residents increase currency substitution following a depreciation shock, thus magnifying exchange rate volatility, whereas the degree of currency substitution reacts only slightly to an appreciation shock.

5. Conclusion

In this study, we investigated the impacts of the degree of currency substitution on nominal exchange rate volatility in seven countries (Indonesia, the Philippines, the Czech Republic, Hungary, Poland, Argentina, and Peru). We used the TARCH model to take into account the ratchet effect of currency substitution and sample periods in the 2000s, during which time the economies in currency substitution countries stabilized, while the U.S. dollar and euro depreciated against other major currencies following the recent global financial crisis.

The presented empirical analyses show that the degree of currency substitution has significant positive effects on the conditional variance of the depreciation rate of the nominal exchange rate in most of our sample countries (Argentina, the Czech Republic, Hungary, Indonesia, and the Philippines). These results mean that in most sample countries, a rise in the degree of currency substitution increases exchange rate volatility. Moreover, differential effects exist in some countries (the Czech Republic, Hungary, Indonesia, and Poland), suggesting that a UIP shock has asymmetric effects on the conditional variance, depending on the sign. One possible explanation is the existence of the ratchet effect of currency substitution, under which domestic residents increase their degree of currency substitution following a depreciation shock but this change is less marked after an appreciation shock.

Our findings have some implications for monetary policy. A volatile exchange rate has undesirable impacts on domestic economies such as increasing inflation rate volatility through the effects on imported goods prices, negatively affecting international trade and capital flows, and destabilizing inflation expectations. In general, the central banks in advanced countries argue that monetary policy should only respond to exchange rate movements if they threaten the inflation objective. However, in emerging countries, it is proposed that stability is achieved by responding to exchange rate movements proactively because of their shallow currency markets and short histories of stable inflation. Moreover, our results point out that the existence of currency substitution could be another source of exchange rate volatility, which should be considered by central banks in currency substitution countries when formulating their monetary policies.

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