Short-run determinants of the USD/PLN exchange rate and policy implications

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Abstract. *This paper examines short-run determinants of the U.S. dollar/Polish zloty (USD/PLN) exchange rate based on a simultaneous-equation model of demand and supply. Using a reduced form equation and the EGARCH model, the paper finds that the USD/PLN exchange rate is positively associated with the real reference rate in Poland, real GDP in the U.S., the real stock index in Poland and the expected exchange rate and is negatively influenced by the U.S. real federal funds rate, real GDP in Poland, and the real stock index in the U.S. Hence, monetary policy is effective in influencing the USD/PLN exchange rate.*

Keywords: exchange rates, interest rates, real GDP, stock indexes, EGARCH.

JEL Classification: F31, F41.

1. Introduction

The Polish zloty/U.S. dollar exchange rate has experienced fluctuations like most other currencies in transition economies. During its early transformation from a socialist to a market economy, the zloty had declined significantly against the U.S. dollar from 0.0506 in 1989.M1 to 4.6369 in 2000.M10. The adoption of a managed floating exchange rate regime in April 2000, the joining of the EU in May 2004, relative political stability, improvements in international trade, and economic growth had made the zloty stronger as evidenced by the change in the exchange rate against the U.S. dollar from 4.6369 in 2000.M10 to 3.9360 in 2004.M5 and 2.0674 in 2008.M7. In the recent global financial crisis, the zloty depreciated as much as 75.65% against the U.S. dollar from 2.0674 in 2008.M7 to 3.6314 in 2009.M2. After the global financial crisis, the zloty has been less volatile and reached 3.2475 per U.S. dollar in 2014.M9.

This paper attempts to examine the short-run determinants of the USD/PLN exchange rate based on a simultaneous-equation model consisting of the demand for and the supply of the Polish zloty versus the U.S. dollar. An analysis of the literature indicates that few of these studies have applied demand and supply analysis in determining the USD/PLN exchange rate in the short run. Monetary models of exchange rates are based on the validity of purchasing power parity in the long run. A study of the short-run determinants of the U.S. Dollar /Polish zloty exchange rate would provide policymakers with more insights into the behavior of the USD/PLN exchange rate.

2. Literature survey

There have been several studies examining the determinants of exchange rates for Poland or related countries. Dibooglu and Kutan (2001) revealed that nominal shocks were mainly responsible for real exchange rate changes in Poland whereas real shocks were major reasons for real exchange rate changes in Hungary. These results suggest that monetary policy played an important role in affecting real exchange rates in Poland and that increase in productivity and diversification of exports due to privatization and direct foreign investments played significant roles in real exchange rate changes in Hungary.

Ardic, Ergin and Senol (2008) compared forecast performance for six CEE countries including Poland based on three forecast error criteria and six models, namely, random walk, uncovered interest parity, monetary models, ARIMA(2,1,0) and VAR(2). They found that all the structural and time series models performed better and had smaller forecast errors than the random walk model.

Błaszkiewicz-Schwartzman (2009) found that appreciation of the Polish zloty was attributable to productivity shocks in the tradable good sector. The elasticity of real appreciation was reduced by distribution services as the substitution effect was greater than the wealth effect.

Kelm (2010) indicated that changes in exchange rates and tradable good prices in Poland could not be fully explained by the purchasing power parity (PPP) hypothesis because deviations of real exchange rates from the long-term PPP path were influenced by real

interest rate differentials and currency risk. Changes in exchange rates and real shocks due to foreign direct investment inflows and total factor productivity caused price fluctuations.

Kebłowski (2011) examined exchange rate movements for four Central European countries, namely, Poland, the Czech Republic, Hungary and Romania. He found that real exchange rates of the Polish zloty, the Czech koruna and the Hungarian forint versus the euro exhibited long-term relationships and can be explained by the spreads of credit default risk premiums and real interest rate parities. The long-term relationship for the Romanian leu can be rejected. There were some common patterns found among these four countries. These currencies were undervalued during the 2003-2004 period and overvalued during the 2007-2009 period. The Polish zloty and the Hungarian forint were close to their steady-state values after the recent financial crisis, and the Romanian leu and the Czech koruna were overvalued continuously after a short period.

Shevchuk (2014) studied the nominal exchange rate (units of the domestic currency per U.S. dollar) for Poland, the Czech Republic and Hungary. For Poland, the positive coefficient of the money supply in Poland, the negative coefficient of real GDP in Poland, and the positive coefficient of U.S. real GDP were significant at the different levels. The positive coefficient of the domestic interest rate was insignificant at the 10% level. The negative coefficient of the foreign interest rate was significant in the level form and insignificant in the difference form. The recent global financial crisis caused the zloty to depreciate against the U.S. dollar.

Dąbrowski and Wróblewska (2014) showed that the Polish zloty was a shock absorber and that financial shocks played important roles and explained approximately 30% in real exchange rate changes as exchange rate deviations from its long-term equilibrium value have been overshadowed by financial shocks during global financial crises.

3. The model

Extending previous studies, we can express the demand for and supply of the Polish zloty versus the U.S. dollar in the foreign exchange market as:

$$PLN^d = W(\varepsilon, Y^{US}, R^{PL}, S^{PL}, \varepsilon^e) \tag{1}$$
$$\quad\quad -\; +\quad ?\quad +\quad +$$

$$PLN^s = X(\varepsilon, Y^{PL}, R^{US}, S^{US}) \tag{2}$$
$$\quad\quad +\; +\quad ?\quad +$$

where
PLN^d = demand for the Polish zloty;
PLN^s = supply of the Polish zloty;
ε = the USD/PLN exchange rate (units of the U.S. dollar per Polish zloty);
Y^{PL} = real GDP or income in Poland;

R^{US} = the real interest rate in the U.S.;
S^{US} = the real stock index in the U.S.;
ε^e = the expected USD/PLN exchange rate;
Y^{US} = real GDP or income in the U.S.;
R^{PL} = the real interest rate in Poland;
S^{PL} = the real stock index in Poland.

We expect that the demand for the Polish zloty has a negative relationship with the USD/PLN exchange rate, a positive relationship with real GDP or income in the U.S., the real stock index in Poland, the expected USD/PLN exchange rate, and an unclear relationship with the real interest rate in Poland. The supply of the Polish zloty is expected to be positively associated with the USD/PLN exchange rate, real GDP or income in Poland and the real stock index in the U.S., and an unclear relationship with the U.S. real interest rate.

As real GDP or income in the U.S. rises, Americans tend to import more goods and services from Poland and increase the demand for the Polish zloty. When real GDP or income in Poland rises, Polish people tend to import more goods and services from the U.S. and increase the supply of the Polish zloty in exchange for the U.S. dollar.

The traditional view maintains that an increase in the domestic interest rate would cause the currency to appreciate due to capital inflows for higher returns on domestic assets whereas the revisionist view argues that a higher domestic interest rate would cause the currency to depreciate due to a higher default probability, a weaker financial position and a higher exchange rate risk premium (Dekle et al., 2002; Huang et al., 2010).

A higher real stock index in Poland tends to attract American investors to purchase the Polish stocks and to increase the demand for the Polish zloty. Conversely, a higher real stock index in the U.S. tends to attract Polish investors to buy U.S. stocks and increase the supply of the Polish zloty in exchange for the U.S. dollar. (Lee et al., 2011)

Solving for the equilibrium values of the two endogenous variables simultaneously, we can express the equilibrium exchange rate as a function of all the exogenous variables:

$$\bar{\varepsilon} = F(R^{US}, R^{PL}, Y^{US}, Y^{PL}, S^{US}, S^{PL}, \varepsilon^e) \qquad (3)$$
$$\quad\ ?\quad\ ?\quad +\quad -\quad -\quad +\quad +$$

According to comparative static analysis, a change in any one of the exogenous variables is expected to have an impact on the equilibrium USD/PLN exchange rate:

$$\partial \bar{\varepsilon} / \partial R^{US} = -W_{R^{US}} / |J| > or < 0 \qquad (4)$$

$$\partial \bar{\varepsilon} / \partial R^{PL} = -X_{R^{PL}} / |J| > or < 0 \qquad (5)$$

$$\partial \bar{\varepsilon} / \partial Y^{US} = -X_{Y^{US}} / |J| > 0 \qquad (6)$$

$$\partial \bar{\varepsilon} / \partial Y^{PL} = -W_{Y^{PL}} / |J| < 0 \qquad (7)$$

$$\partial \overline{\varepsilon} / \partial S^{US} = -W_{S^{US}} / |J| < 0 \tag{8}$$

$$\partial \overline{\varepsilon} / \partial S^{PL} = -X_{S^{PL}} / |J| > 0 \tag{9}$$

$$\partial \overline{\varepsilon} / \partial \varepsilon^e = -W_{\varepsilon^e} / |J| > 0 \tag{10}$$

where $|J| = (W_\varepsilon - X_\varepsilon) < 0$ is the Jacobian for the endogenous variables.

4. Empirical results

The data came from the *International Financial Statistics*, which is published by the International Monetary Fund. The USD/PLN exchange rate measures units of the U.S. dollar per zloty. Hence, an increase means an appreciation of the Polish zloty or a depreciation of the U.S. dollar. The real interest rate in the U.S. is represented by the federal funds rate minus the inflation rate in the U.S. The real interest rate in Poland is represented by the reference rate (policy rate) minus the inflation rate in Poland. A change in the federal funds rate or the reference rate is expected to affect most other interest rates, which are considered by investors in purchasing or selling some financial assets in the U.S. and Poland. Real GDP in the U.S. is measured in billions at the 2009 year, and real GDP in Poland is measured in billions at the 2005 price. The expected exchange rate is represented by the average USD/PLN exchange rate of past four quarters. The real stock index in the U.S. is represented by the Wilshire 5000 price index adjusted by the CPI. The real stock index in Poland is represented by the WIG20 index adjusted by the CPI. Real GDP and stock indexes are expressed on a log scale. The USD/PLN exchange rate, the expected exchange rate, the real federal funds rate and the real reference rate are expressed in a linear form due to negative values before or after a log transformation. The sample consists of quarterly data ranging from 1999.Q1 to 2013.Q4 and has a total of 60 observations.

The DF-GLS test on the regression residuals is employed to determine whether these time series variables are cointegrated. The value of the test statistic is estimated to be -4.6775, which is greater than the critical value of -2.6054 in absolute values at the 1% level. Therefore, these variables have a long-term stable relationship.

Table 1 presents the estimated regression and related statistics. The EGARCH method is applied in order not to impose any restriction on the parameters and to yield a positive conditional variance. Approximately 82.35% of the variation in the equilibrium USD/PLN exchange rate can be explained by the seven right-hand side variables. The mean absolute percent error of 5.4854% suggests that the forecast error is relatively small. All the coefficients are significant at the 1% level. The equilibrium USD/PLN exchange rate is positively associated with the real reference rate in Poland, real GDP in the U.S., the real stock index in Poland, and the expected exchange rate. It is negatively affected by the real federal funds rate in the U.S., real GDP in Poland, and the real stock index in the U.S.

Specifically, a 1 percentage-point increase in the U.S. real federal funds rate would reduce the USD/PLN exchange rate by 0.0081 whereas a 1 percentage-point increase in the real reference rate in Poland would raise the USD/PLN exchange rate by 0.0033. The impact of a change in the real federal funds rate is 2.45 times greater than a change in the real reference rate in absolute values. When the real refinancing rate replaces the reference rate, its positive coefficient of 0.0018 is significant at the 1% level and slightly less than the coefficient of 0.0033 when the reference rate is used in Table 1. The value of R^2 is 0.8249. Other results are similar.

A $1 billion increase in the log of the U.S. real GDP would raise the USD/PLN exchange rate by 0.1302 whereas a 1 billion increase in the log of the Polish real GDP would reduce the USD/PLN exchange rate by 0.0100. The effect of a change in U.S. real GDP is much greater than the effect of a change in real GDP in Poland.

Table 1. *Estimated regression of the USD/PLN exchange rate*

Dependent variable: USD/PLN exchange rate	Coefficient	z-statistics
U.S. real federal funds rate	-0.0081	-7.9351
Polish real reference rate	0.0033	2.8941
Log(real GDP in the U.S.)	0.1302	3.0130
Log(real GDP in Poland)	-0.0100	-3.4670
Log(real stock index in the U.S.)	-0.0426	-4.2100
Log(real stock index in Poland)	0.0867	11.0418
Expected USD/PLN exchange rate	0.5929	9.8331
Constant	-1.2347	-2.9925
R^2	0.8235	
Mean absolute percent error	5.4854%	
Sample period	1999.Q1-2013.Q4	
Number of observations	60	
Methodology	EGARCH	

Notes: All the coefficients are significant at the 1% level.
The USD/PLN exchange rate measures units of the U.S. dollar per Polish zloty.

A one unit increase in the log of the real stock index in the U.S. would reduce the USD/PLN exchange rate by 0.0426 whereas a one unit increase in the log of the real stock index in Poland would raise the USD/PLN exchange rate by 0.0867. The impact of a change in the log of the real stock index in Poland is 2.04 times greater than the impact of a change in the log of the U.S. real stock index. If the expected exchange rate rises by 1, the actual exchange rate would increase by 0.5929. These results are consistent with the Dornbusch (1976) and Frankel (1979) models that a higher real interest rate in Poland causes the zloty to appreciate versus the U.S. dollar.

5. Summary and conclusions

This paper has examined the determinants of the USD/PLN exchange rate in the short run based on a simultaneous-equation model consisting of the demand for and supply of the Polish zloty. A reduced-form equation is estimated by the EGARCH method. The paper finds that a higher Polish real reference rate, a higher U.S. real GDP, a higher Polish real stock index, and a higher expected exchange rate would raise the USD/PLN exchange

rate whereas a higher U.S. real federal funds rate, a higher Polish real GDP, and a higher U.S. real stock index would reduce the USD/PLN exchange rate.

There are several policy implications. It seems that demand and supply analysis of exchange rates in the short run works reasonably well as it can explain approximately 82.35% of exchange rate movements and the forecast error is relatively small. Policy rates, real GDP, stock indexes and the expected exchange rate in the U.S. and Poland play significant roles in exchange rate movements in the short run. Holding other factors constant, potential increase in the federal funds rate in the future would reduce the USD/PLN exchange rate. Recent more percent increase in the Polish stock index relative to the U.S. stock market index after the global financial crisis would cause the USD/PLN exchange rate to rise. Recent increase in Polish real GDP would reduce the USD/PLN exchange rate whereas recent increase in U.S. real GDP would raise the USD/PLN exchange rate.

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