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What Determines the Forward Exchange Rate of the Euro?

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ABSTRACT

This study examines the determinants of the forward exchange rate of the euro in the context of the “modern approach” for five currency combinations. The co-integration analysis suggests that speculation has played a minor role and arbitrage played a major role in determining the forward exchange rate of the euro.

JEL F31 F37

Keywords Euro, Forward Exchange Rate, Arbitrage, Speculation, Co-integration,

I. Introduction

The “modern approach” to forward exchange rate determination (Tsiang, 1959; Phaup, 1981), asserts that the equilibrium forward exchange rate is jointly determined by the actions of arbitrageurs and speculators. The “modern approach” has been investigated extensively in the literature and the obtained results are mixed (Stoll, 1968; Kesselman, 1971; McCallum, 1977; Moosa and Bhatti, 1997).

Since euro began its life in January 1999, it has fluctuated widely around a downward trend in spot and forward markets, reaching its nadir in the second part of 2000. Thereafter, the trend was reversed and reached its zenith in the first part of 2004. The empirical literature has documented evidence that the spot exchange rate of the euro is driven by fundamentals (Jamaleh, 2002; Karfakis, 2006; Saerore, et. al., 2002).

The purpose of this paper is to examine the determinants of the forward exchange rate of the euro in the context of the “modern approach” for five currency combinations by means of co-integration techniques. An interesting question to be addressed is the role of speculation in explaining the fluctuations of the forward euro.

II. Theory and Empirical Analysis

Suppose that in the forward exchange rate of the euro participate arbitrageurs and speculators. If the forward exchange rate of the euro is greater than the covered interest parity (CIP) forward exchange rate,

arbitrageurs buy euro in the spot market and supply euro in the forward market. Thus, the supply of forward euro can be expressed as

$$S^F \left(\frac{1}{\phi} \right) = F_t - F_t^*; \quad \phi > 0$$

where F_t and F_t^* denote, respectively, the current forward exchange rate and the parity forward exchange rate, which is equal to $S_t(1+R_t^*)/(1+R_t)$, with S_t , R_t and R_t^* denoting, respectively, the spot rate of the euro, the interest rate of the euro and the interest rate of the dollar. If ϕ tends to infinity, the CIP hypothesis will hold. In this case, the arbitrage schedule is perfectly elastic and arbitrageurs determine the forward exchange rate.

On the other hand, when the spot rate of the euro expected to prevail next period is higher than the forward rate, speculators buy euro in the forward market and supply euro in the spot market. Thus, the demand for forward euro can be expressed as

$$D^F \left(\frac{1}{\sigma} \right) = E_t S_{t+1} - F_t; \quad \sigma > 0$$

where $E_t S_{t+1}$ denotes the one period ahead expected spot exchange rate, with expectations formed at period t . If σ tends to infinity, the efficient market hypothesis (EMH) will hold. In this case, the speculation schedule is perfectly elastic and speculators determine the forward exchange rate.

Substituting the two equations in the market-clearing condition, we obtain that the equilibrium forward exchange rate is determined by the parity forward exchange rate and the expected spot exchange rate, that is

$$F_t = \vartheta F_t^* + (1 - \vartheta) E_t S_{t+1}$$

where $\vartheta = \phi/(\phi + \sigma)$ and $1 - \vartheta = \sigma/(\phi + \sigma)$. If $\sigma=0$, which implies $\vartheta=1$, in the forward market will participate only arbitrageurs. On the other hand, if $\phi=0$, which implies $\vartheta=0$, in the forward market will participate only speculators.

To test the “modern approach”, we conduct the following equation:

$$F_t = \alpha + \beta F_t^* + \gamma S_{t+1} + \varepsilon_t$$

where F_t , F_t^* , S_{t+1} and ε_t denote, respectively, the natural logarithm of the forward exchange rate, the natural logarithm of the parity forward exchange rate, the natural logarithm of the one period ahead spot exchange rate and the error term. By assuming rational expectations, the one period ahead actual spot exchange rate replaces the unobservable one period ahead expected spot exchange rate, that is $S_{t+1} = E_t(S_{t+1} | \Omega_t) + \eta_{t+1}$, where Ω_t is the information set and η_{t+1} is the error term.

The coefficient restrictions implied by the “modern approach” is that $\alpha=0$, β and $\gamma > 0$ and $\beta + \gamma = 1$. Since the one period ahead spot exchange rate is correlated with the error term, the OLS estimation suffers from simultaneity bias. In order to correct for this problem, we employ the Phillips & Hansen (1990) modified OLS co-integration approach.

We have estimated the forward exchange rate equation for five currencies (dollar, yen, sterling, Canadian dollar, Australian dollar) against the euro, from January 1999 to November 2005. The spot exchange rates were obtained from European Central Bank (ECB), the one-month forward exchange rates were obtained from Data Stream and the one-month London inter-bank interest rates were obtained from British Bankers' Association. All the data are end of month observations.

With respect to the univariate time series properties of the data, the ADF tests indicated that the nonstationarity cannot be rejected for the series concerned. The lag structure in the co-integration equation was determined in the context of a trivariate VAR system by reference to Schwarz Bayesian Criterion. The results reported in Table 1 indicate that the forward exchange rate is co-integrated with the parity forward exchange rate and

the one period ahead spot exchange rate. The co-integrating residuals, which are presented in Figures 1 to 5, are stationary and serially uncorrelated. The estimated values of the DF statistics lie below the critical value of -3,48 and the estimated values of the Q statistics for 30 lags in the autocorrelation function are all insignificant.

The hypothesis $\alpha=0$ and $\beta=1$ is not rejected in all cases, implying that the CIP hypothesis holds. In the case of $\text{€}/\text{\$}$, $\text{€}/\text{¥}$ and $\text{€}/\text{£}$, the one period ahead spot exchange rate significantly affects the forward exchange, but the estimated coefficients are far away from unity, implying that the EMH is not valid, thus rejecting the uncovered interest parity. The joint restriction $\beta+\gamma=1$ is also supported by the data, suggesting that the “modern approach” is valid for the three currency combinations. However, the very large size of the estimated coefficient of the parity forward exchange rate, which is close to one, and the very small size of the estimated coefficient of the one period ahead spot exchange rate, which is close to zero, implies that the arbitrage schedule is highly elastic and the speculation schedule is highly inelastic. One implication of this finding is that the intervention of the ECB in the foreign exchange market is asymmetric. If the ECB wants to increase the forward rate of the euro, she will demand a large amount of forward funds. On the other hand, if the ECB wants to reduce the forward exchange rate of the euro, she will supply a small quantity of forward funds.

Having established the co-integrated relationships, we then examine the associated error correction (EC) models, which describe the short-run dynamics. The five equations are estimated by instrumental variables and the results with all diagnostics are reported in Table 2. The growth rate of the parity forward exchange rate significantly affects the growth rate of the current forward exchange rate of the euro in all cases. The estimated

coefficients are very large but they are statistically different from one. The EC term has the correct sign and its size indicates that any deviations from the systematic long-run relationship are immediately corrected. The diagnostic tests reject the presence of serial correlation, functional misspecification and heteroscedasticity. The normality test suggests that the error process represents a random sample from a normal distribution in all cases. The high values of the coefficient of determination indicate that a significant portion of the growth rate of the current forward exchange rate of the euro is explained by the data.

III. Concluding Remarks

This study has examined the determinants of the forward exchange rate of the euro in the context of the “modern approach” for five currency combinations. The co-integration revealed the presence of a systematic long-run relationship between the current forward exchange rate, the parity forward exchange rate and one period ahead spot exchange rate. An interesting aspect of the analysis is the evidence that the CIP hypothesis holds in all cases. In addition, the evidence has showed that the speculation has played a minor role in determining the forward exchange rate of the euro.

References

- Jamaleh, A. (2002), Explaining and Forecasting the Euro/dollar Exchange Rate through a Non-linear Threshold Model, *The European Journal of Finance*, 8, 422-448.
- Karfakis, C. (2006), "Is there an Empirical Relationship Between the Dollar Price of the Euro and the Monetary Fundamentals?", *Applied Financial Economics*, 16, 973-980.
- Kesselman, J. (1971), "The Role of Speculation in the Forward-Rate Determination: The Canadian Flexible Dollar 1953-1960", *Canadian Journal of Economics*, 4, 3, 279-298.
- McCallum, B.T. (1977), "The Role of Speculation in the Canadian Forward Exchange Market; Some Estimates Assuming Rational Expectations", *The Review of Economics and Statistics*, 59, 2, 145-151.
- Phaup, E.D. (1981), "A Reinterpretation of the Modern Theory of Forward Exchange Rates", *Journal of Money, Credit and Banking*, 13, 4, 477-84.
- Phillips, P., and B.E. Hansen (1990), "Statistical Inference in Instrumental Variables Regressions with I(1) Processes", *Review of Economic Studies*, 57, 277-125.
- Saerore, D., L. Trevisan, M. Trova and F. Volo (2002), "US dollar/Euro Exchange Rate: A Monthly Econometric Model for Forecasting", *The European Journal of Finance*, 8, 480-501.
- Stoll, H.R. (1968), "An Empirical Study of the Forward Exchange Market Under Fixed and Flexible Exchange Rates", *Canadian Journal of Economics*, 1, 55-78.
- Tsiang, S. C (1959), "The Theory of Forward Exchange and the Effects of

Government Intervention on the Forward Market”, *IMF Staff Papers*, 6, 75-106.

Table 1. Estimates of Forward Exchange Rate Co-integrating Equation

F_t	F_t^*	S_{t+1}	$\chi^2(1):\beta=1$	$\chi^2(1):\beta+\gamma=1$	Q(30) test	D-F test
€/\$	0,9687 (0,1695)***	0,0368 (0,017)**	3,41[0,07]	2,47[0,12]	26,22[0,66]	DF=-7,37**
€/¥	0,9652 (0,0179)***	0,0385 (0,018)**	3,78[0,05]	0,59[0,44]	42,96[0,06]	ADF(4)=-4,55**
€/£	0,9661 (0,0135)***	0,0368 (0,014)***	6,31[0,01]	0,31[0,58]	41,94[0,07]	ADF(1)=-7,07**
€/C\$	0,9938 (0,0173)***	0,0106 (0,017)	0,13[0,72]	-----	28,03[0,57]	ADF(2)=-3,77**
€/A\$	0,9983 (0,0169)***	0,0024 (0,017)	0,01[0,92]	-----	30,26[0,45]	ADF(3)=-5,41**

Notes: The Phillips-Hansen estimates used the Bartlett weights in the estimation of long-run variances. Two lags were used in €/\$, €/£, €/C\$, €/A\$ equations, and four lags were used in the €/¥ equation. Each equation includes a constant term which was insignificant in all cases. Numbers in parentheses are standard errors and numbers in square brackets are p-values. The critical value of the D-F test is -3,48 at 5 percent significance level. *** indicate significance at 1%, ** indicate significance at 5%.

Table 2. Estimates of Forward Exchange Rate EC Model: ΔF_t

Regressors	€/€	€/¥	€/£	€/C\$	€/A\$
ΔF_t^*	0,92 (0,04)***	0,93 (0,16)***	0,90 (0,03)***	0,85 (0,10)***	0,89 (0,11)***
ΔS_{t+1}	0,02 (0,05)	0,10 (0,06)*	0,07 (0,05)	0,06 (0,10)	0,02 (0,13)
ε_{t-1}	-0,93 (0,12)***	-0,80 (0,19)***	-1,02 (0,15)***	-0,96 (0,17)***	-1,05 (0,18)***
R ² -bar	0,98	0,98	0,98	0,95	0,96
SEE	0,004	0,005	0,003	0,006	0,005
ST: $\chi^2(10)=15,04$ [0,13]	$\chi^2(4)=5,92$ [0,21]	$\chi^2(7)=11,26$ [0,13]	$\chi^2(5)=3,50$ [0,62]	$\chi^2(5)=3,56$ [0,62]	
SC: $\chi^2(12)=13,59$ [0,33]	13,89 [0,31]	14,11 [0,30]	11,89 [0,46]	9,35 [0,67]	
FF: $\chi^2(1)=1,05$ [0,31]	0,94 [0,33]	0,79 [0,37]	0,002 [0,96]	0,54 [0,46]	
NO: $\chi^2(2)=4,20$ [0,12]	2,79 [0,25]	4,48 [0,11]	1,65 [0,44]	0,99 [0,61]	
HE: $\chi^2(1)=0,33$ [0,57]	0,44 [0,51]	0,22 [0,64]	0,92 [0,34]	0,16 [0,69]	

Notes: Numbers in parentheses are standard errors and numbers in square brackets are p -values. The instruments are: ε_{t-1} , six lags of ΔF^* and ΔF (€/€ equation), ε_{t-1} , six lags of ΔF^* (€/¥ equation), ε_{t-1} , seven lags of ΔF^* , two lags of ΔF (€/£ equation), ε_{t-1} , seven lags of ΔF^* (€/C\$ and €/A\$ equations). ST=Sargan's test for the adequacy of the selected instruments. SC, FF, NO and HE stand for serial correlation, functional form, normality and heteroscedasticity. *** indicate significance at 1%, ** indicate significance at 5% and * indicates significance at 10%.

Figure 1. Co-integrating Residuals from Euro/\$ Equation

Figure 2. Co-integrating Residuals from Euro/Yen Equation

Figure 3. Co-integrating Residuals from Euro/Sterling Equation

Figure 4. Co-integrating Residuals from Euro/C\$ Equation

Figure 5. Co-integrating Residuals from Euro/A\$ Equation

Figure 6. Actual and Fitted Values of Euro/\$ EC Model