Interest Rate Differentials and Spot Exchange Rates: Korea and Japan

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INTRODUCTION

The interdependence between foreign exchange and money markets can be induced through interest rate parity conditions. Uncovered interest rate parity (UIP) states that the differential between domestic and foreign interest rates is associated with the spread between expected future spot and current spot exchange rates, while covered interest rate parity (CIP) relates the differential to the forward exchange rate less the current spot exchange rate. These parity conditions suggest theoretical groundworks for the contemporaneous correlations between spot exchange rates and interest rate differentials.

This paper conducts an empirical test on the interdependence between foreign exchange and money markets during the period of 1999-2002 for Korea and Japan. Our central questions are:[1] what is the correlation between spot exchange rate and interest rate differential? [2] Is there any difference between Korea and Japan in the effect of interest rate movements on the changes in spot exchange rates? [3] If interest rate differential is not a significant contributor to the shifts of spot exchange rates, what would be the alternative explanatory factors?

In case of Japan, it is expected to have a higher interdependency between foreign and money markets since these markets are relatively more open, internationalized, flexible and integrated. According to UIP theory, in a highly integrated market of foreign exchange and money like Japan, an increase of domestic interest rates will directly trigger the appreciation of spot exchange rates. In case of Korea, however, currency is not that internation alized (no Euro-currency market exists for it), markets are not flexible and developed enough to have an integrated pattern of economic variables. Different economic environments in Korea and Japan will lead to different empirical findings, we expect.

In the empirical literature on the relationship between interest and exchange rates, the evidence is mixed. For example, using trivariate GARCH model, Ji and Kim(2000) found that increases in interest rates are associated with exchange rate depreciations in Korea. Correlation between interest and exchange rates was ignorable in Japan. Using VAR model with daily data during 1992-1996, Lee(1997) showed that increases of interest rates in Korea caused exchange rate appreciations with 3-4 day lagging effects. However, the sign got reversed when exchange rate became explanatory

variable. Due to the expected exchange loss, depreciation of Korean Won reduces inflows of foreign capital, which increases domestic interest rates. Cho and West(2001) used weekly data from 1997 to 1998 and found that increases in interest rates, that is introduced by a surprise in monetary policy, led to exchange rate appreciation for Korea and Philippine but depreciation in Thailand. Goldfajn and Gupta(1999) showed that dramatic increases in interest rates have been associated with currency appreciations, in general, but no clear association was found for the four countries that have undergone currency crises. Gould and Kamin(2000) were unable to find a reliable relationship between interest rates and exchange rates in Korea, Indonesia, Malaysia, the Philippines and Thailand.

MODEL

Data

In this article, we examine daily data of interest rates, spot exchange rates and stock returns for Korea and Japan over the three-year and seven-month period, January 4, 1999, to July 24, 2002. We use the sample period of 1999-2002 since we want to omit 1998, the year of Korean currency crisis, separating out the "crisis" effect. Transition to free floating system in Korea was completed not until December 1997. We study daily close data from foreign exchange, stock and money markets. A technical problem in studying pricing relations across markets is the existence of nonsynchronous holidays. We simply eliminate all the data for holidays and no substitution was made for the omitted data. For interest rates in money markets, we use call rates for Korea, T/B 3 month rates for both Japan and the U.S. For spot exchange rates, we use Won/Dollar spot rates in Seoul exchange market and Yen/Dollar spot rates in Tokyo exchange market. For stock returns, we use the first differenced log of KOSPI and NIKKEI indices.

Before estimating the effect of interest rate differentials on spot exchange rates, we test whether the data are stationary or not using Augmented Dickey-Fuller (ADF) tests. For spot rates, stock returns and interest rate differentials, all in level, the null hypothesis of a unit root could not be rejected. We first differenced the log of data and tested again using ADF and find that the null hypothesis of a unit root for both spot rates were rejected. DSPOT denotes daily change rates of spot exchange rates while STOCK represents returns for stock indices. DRATE is daily change rates of interest rate differentials. <Table 1> summarizes the results of unit root tests.

<Table 1> Summary of ADF Unit Root Test (1999.1-2002.7)

	KOREA	JAPAN
Spot rate(Won, Yen/dollar)	-1.3030	-1.3796
Stock Index(Kospi, Nikkei)	-1.7577	-0.4592
Interest rate difference	-0.1045	-0.8444
DSPOT	-11.761**	-13.429**
STOCK	-13.904**	-13.333**
DRATE	-12.219**	-12.619**

** : 1% significance level

<Table-2> summarizes the data of Korea. For the entire sample period, mean of STOCK is positive while those of DSPOT and DRATE are negative. As economy started to recover from the crisis, stock returns kept growing. Also, for the sample period, Korean Won persistently appreciated against U.S. dollar and interest rate differentials got reduced. Jarque-Bera test shows that the null hypotheses of normal distribution are strongly rejected.

The primary specification tests for the

<Table 2> Data summary: Korea

	DSPOT	STOCK	DRATE
Mean	-2.52E-05	0.0452	-0.0375
Std. Dev.	0.0048	2.4814	3.2404
Skewness	0.1422	-0.2053	7.4518
Kurtosis	6.0792	4.4067	319.68
Jarque-Bera	336.29	75.61	3534691
Q(n)			
Q(5)	11.95(0.035)	6.94(0.225)	3.37(0.642)
Q(10)	15.74(0.102)	9.05(0.527)	98.07(0.000)
Q(15)	28.17(0.030)	12.87(0.612)	99.46(0.000)
Q^2(n)			
Q^2(5)	113.68(0.000)	16.07(0.007)	0.29(0.998)
Q^2(10)	175.50(0.000)	19.91(0.030)	40.86(0.000)
Q^2(15)	200.82(0.000)	22.40(0.098)	40.89(0.000)

( ) : p-value

<Table 3> Data summary: Japan

	DSPOT	STOCK	DRATE
Mean	4.89E-05	-0.0167	-0.0009
Std. Dev.	0.0070	1.5513	0.0156
Skewness	-0.1811	0.1259	-1.1538
Kurtosis	4.9957	4.7231	22.8338
Jarque-Bera	147.25	108.67	14270.32
Q(n)			
Q(5)	8.22(0.144)	3.23(0.657)	15.74(0.008)
Q(10)	13.59(0.192)	12.17(0.273)	24.42(0.007)
Q(15)	17.25(0.304)	17.25(0.304)	30.50(0.010)
Q^2(n)			
Q^2(5)	9.27(0.098)	48.77(0.000)	114.55(0.000)
Q^2(10)	13.17(0.214)	74.02(0.000)	122.91(0.000)
Q^2(15)	19.43(0.195)	94.46(0.000)	123.59(0.000)

( ) : p-value

model involve the Ljung-Box statistic, which is used to test for a lack of serial correlation in the model residuals and in the residuals squared. Skewness and kuritosis coefficiens for the normalized residuals are also reviewed. For DSPOT, cases of lag 5, 10, 15 in Korea show that serial correlation is strong in Korea while weak in Japan. We also find strong serial correlatons of DRATE both in Korea and Japan. The same results applicable to STOCK.

Methodology

To capture the effect of changing interest rate differential on spot exchange rate, we developed the GARCH(1,1) model as follows:

$$\begin{aligned} DSPOT_t &= \alpha + \beta_1 DRATE_t + \varepsilon_t \\ \varepsilon_t &\sim N(0, h_t) \qquad \cdots(1) \\ h_t &= \gamma_0 + \gamma_1 \varepsilon^2_{t-1} + \gamma_2 h_{t-1} \end{aligned}$$

, where DSPOT is the log difference of spot rates, i.e., daily change rates of spot rates, and DRATE is daily change rates of interest rate differentials . The GARCH formulation defines the conditional variance of DSPOT at time t be a function of not only last period's error squared but also its conditional variance.

$$DSPOT_t = \frac{S_t - S_{t-1}}{S_{t-1}}$$

$$DRATE_t = \Delta(i - t^*) = \frac{(i_t - i_t^*) - (i_{t-1} - i_{t-1}^*)}{(i_{t-1} - i_{t-1})}$$

St : spot rates

i : domestic interest rates

i* : foreign interest rates(U.S.)

We expect the results as follows:

Korea : $\beta_1 = 0$

Japan : $\beta_1 < 0$

EMPIRICAL RESULTS

Interest rate differentials and spot rates

The results of estimating our model for both the full sample period and the annual subperiod are shown in Table 4. The effect of changing differentials of interest rates on spot rates is statistically insignificant and negligible.

The above evidence supports our earlier expectation that the arbitrage transactions in Korea are not viable since the markets are not efficient. We find that the interest rate effect in conditional mean is not significant in both the full period and subperiod cases. While parity conditions suggest theoretical reasons for the contemporaneous negative correlations between differentials of domestic and foreign interest rates and spot exchange rates, the influence of interest rate differentials on spot exchange rates is likely to be attenuated by the fact that Korean Won is not internationalized enough to allow any flexible and spontaneous arbitrage transactions. This result is consistent with the study by BOK(2001, 2002). BOK(2001, 2002) shows that correlation between money and foreign exchange markets in Korea is weak since these markets are inefficient and underdeveloped. The volume of transactions in foreign exchange market in Korea is about 5% of OECD average. Korean money market lacks diversity in both its products and participants. Transaction costs, bid-ask spreads and capital controls may also explain the statistical insignificancy of β_1. This result may also follow the Eichenbaum-Evans(1993) pattern that the dollar appreciates gradually in the aftermath

<Table 4> Won/Dollar spot rates and interest rate differentials

	1999	2000	2001	2002. 7	99-02
Conditional mean equation					
A	-0.000203 (0.513)	2.97E-05 (0.853)	-9.75E-05 (0.720)	-0.000209 (0.479)	-0.000131 (0.270)
B_1	6.07E-05 (0.797)	0.000773 (0.186)	3.40E-05 (0.648)	-0.018726 (0.149)	3.91E-05 (0.654)
Conditional variance equation					
Γ_0	4.85E-06 (0.000)**	6.64E-07 (0.017)*	9.51E-07 (0.030)*	2.18E-07 (0.397)	2.43E-07 (0.000)**
Γ_1	0.150723 (0.000)**	0.355253 (0.000)**	0.130908 (0.004)**	0.145373 (0.005)**	0.117656 (0.000)**
Γ_2	0.600127 (0.000)**	0.652436 (0.000)**	0.833693 (0.000)**	0.863412 (0.000)**	0.882803 (0.000)**
Log likelihood	968	1007	936	532	4157

( ) : p-value

*,** : 5%, 1% significance level, respectively

<Table 5> Yen/Dollar spot rates and interest rate differentials

	1999	2000	2001	2002. 7	99-02
Conditional mean equation					
A	-0.000657 (0.253)	0.000465 (0.263)	0.000796 (0.067)	-0.001294 (0.010)**	0.000100 (0.675)
B_1	-0.032653 (0.570)	0.045376 (0.137)	0.060026 (0.019)*	0.057788 (0.135)	0.036644 (0.009)**
Conditional variance equation					
Γ_0	2.23E-06 (0.000)**	8.16E-06 (0.547)	4.18E-05 (0.435)	5.56E-05 (0.000)**	0.15E-06 (0.008)**
Γ_1	-0.035157 (0.000)**	0.040963 (0.192)	-0.061361 (0.260)	0.106413 (0.000)**	0.015103 (0.040)*
Γ_2	0.998374 (0.000)**	0.746171 (0.033)*	0.031853 (0.980)	-0.705578 (0.003)**	0.960713 (0.000)**
Log likelihood	811	886	877	488	3055

( ) : p-value

*,** : 5%, 1% significance level, respectively

of an increase in the interest differential, rather than contemporaneously. Other coefficients estimated in the model are statistically significant enough to justify the use of GARCH model, which allows conditional heteroscedasticity.

In case of Japan, as shown in <Table-5>, however, the results of estimating the interest rate effects on spot rates are contrary to our expectation. We find the effect of changing differentials of interest rates on spot rates is positive and statistically significant at 1% level for the full sample period. Our earlier expectation was that there would be contemporaneous negative correlations between differentials of domestic and foreign interest rates and spot exchange rates since Japanese Yen is internationalized enough to have a well developed open money and exchange markets. The expected sign of β_1 was negative(-) but in our analysis, it turned out to be positive and statistically significant. The possible explanations for this result could be; first, decreases of interest rates, incurred by unexpected changes in monetary policy, may give prospects of economic recovery, which in turn increases foreign capital inflows and appreciates Japanese Yen, second, depreciation may magnify worries over exchange loss and thus increases foreign capital outflows, which reduces liquidity in the economy and increases interest rates, third, the assumptions on which the interest parity hypothesis is based on can be against the reality and easily violated, fourth, these variables may be affected by some missing international factors such as the U.S. stock market, international oil price, etc. and lastly the microeconomic approaches of foreign exchange rates focusing on the behavior of market makers and the nature of trading and volatility may offer some explanatory powers for that.

Other coefficients estimated in the model are statistically significant enough to justify the use of GARCH model, which allows conditioanal heteroscedasticity.

Stock market included

Our prior model includes interest rate differential as the only explanatory variable for the changes of spot exchange rates. We modify the specification in model (1) by expanding the explanatory variables in the conditional mean equation to include the daily stock return. This is to consider the possibility of a foreign investment effect on the conditional mean. In case of Korea, the openness of money market is considerably low and investment by foreigners into Korea is focused on stock. The modified form of the model is

$$\begin{aligned} DSPOT_t &= \alpha + \beta_1 DRATE_t + \beta_2 STOCK_t + \varepsilon_t \\ \varepsilon_t &\sim N(0, h_t) \\ h_t &= \gamma_0 + \gamma_1 \varepsilon^2_{t-1} + \gamma_2 h_{t-1} \end{aligned} \quad \cdots(2)$$

, where STOCK is defined as stock return of KOSPI or NIKKEI.

$$STOCK_t = \frac{KOSPI_t - KOSPI_{t-1}}{KOSPI_{t-1}}$$

The results of the estimation for both full sample periods and subperiod cases in Korea are shown in Table 6. The estimates are consistent with the empirical findings in Table 4. The

<Table 6> Spot rates, interest rate differentials, stock returns: Korea

	1999	2000	2001	2002. 7	99-02
Conditional mean equatioan					
A	-0.000153	-4.58E-05	-3.35E-05	-0.000235	-0.000106
	(0.589)	(0.722)	(0.804)	(0.419)	(0.329)
β_1	5.48E-05	0.001112	3.64E-05	-0.017614	3.51E-05
	(0.851)	(0.070)	(0.601)	(0.169)	(0.635)
β_2	-5.15E-05	-0.000372	-0.000710	6.85E-05	-0.000338
	(0.571)	(0.000)**	(0.000)**	(0.487)	(0.000)**
Conditioanal variance equation					
γ_0	3.93E-06	7.51E-07	8.78E-07	2.24E-07	3.19E-07
	0.000)**	(0.018)*	(0.027)*	(0.396)	(0.000)**
γ_1	0.163518	0.541674	0.149928	0.145893	0.160168
	(0.000)**	(0.000)**	(0.003)**	(0.009)**	(0.000)**
γ_2	0.605212	0.499852	0.819270	0.862128	0.842241
	(0.000)**	(0.000)**	(0.000)**	(0.000)**	(0.000)**
Log likelihood	981	1028	946	532	3441

( ) : p-value

*,** : 5%, 1% significance level, respectively

<Table 7> Spot rates, interest rate differentials, stock returns: Japan

	1999	2000	2001	2002. 7	99-02
Conditional mean equatioan					
A	-0.000673	0.000301	0.000986	-0.001324	9.39E-05
	(0.292)	(0.428)	(0.020)*	(0.013)*	(0.694)
β_1	-0.037285	0.039896	0.065615	0.059502	0.037062
	(0.566)	(0.070)	(0.002)**	(0.158)	(0.008)**
β_1	-0.000183	-0.000122	-0.000162	-0.000104	-0.000237
	(0.716)	(0.631)	(0.436)	(0.727)	(0.110)
Conditioanal variance equation					
γ_0	1.90E-06	2.50E-07	-3.63E-07	5.99E-05	1.07E-06
	(0.000)**	(0.680)	(0.382)	(0.000)**	(0.007)**
γ_1	-0.038233	0.015848	0.014619	0.115091	0.014953
	(0.000)**	(0.229)	(0.432)	(0.000)**	(0.040)*
γ_2	1.005436	0.973860	0.990206	-0.723688	0.960445
	(0.000)**	(0.000)*	(0.000)	(0.000)**	(0.000)**
Log likelihood	812	891	880	489	3056

( ) : p-value

*,** : 5%, 1% significance level, respectively

influence of interest rate differentials on spot exchange rate changes is statistically insignificant even though we control the stock market. A notable result, which is different from the case in Japan, is that stock return has a negative and statistically significant effect on spot exchange rate. The effect is strengthened in subperiod cases of year 2000 and 2001. The evidence above supports the prior observations(KDB, 2001; BOK, 2001, 2002; Ji and Kim,2000) that increases of stock index enlarge the inflowing volume of foreign capitals, which in turn leads to the appreciation of Korean Won.

The results of the estimation for both full sample periods and subperiod cases in Japan are shown in Table 7. The estimates are consistent with the empirical findings in Table 5. The influence of interest rate differentials on spot exchange rate changes is positive and statistically significant even though we control the stock market. The effect is strengthened in subperiod case of year 2001. A notable result, which is different from the case in Korea, is that stock return has an insignificant effect on spot exchange rate. The evidence above is contrary to our earlier conclusions that significant appreciation does occur when interest rate gap widens.

Summary and Conclusion

We summarize our findings as follows.

1) The effect of changing differentials of interest rates on spot rates is statistically insignificant and negligible in Korea. Money and exchange markets are inefficient and underdeveloped.
2) The results of estimating the interest rate effects on spot rates in Japan are contrary to our expectation. We find the effect of changing differentials of interest rates on spot rates is positive and statistically significant at 1% level for the full sample period.
3) A notable result in Korea is that stock return has a negative and statistically significant effect on spot exchange rate. The effect is strengthened in subperiod cases of year 2000 and 2001. The evidence above confirms the prior observations that higher stock return enlarges the inflowing volume of foreign capitals, which in turn leads to the appreciation of Korean Won. In Japan, stock return has an insignificant effect on spot exchange rate. Researches on the determinants of spot exchange rates in Japan considering both missing international and microstructure factors will be a good extension of the study.

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