

# **Random Walk and the Foreign Exchange Rate Movement : An Empirical Analysis of the Major Currencies**

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## **I . Introduction**

Since the advent of the floating exchange rate system in 1973, the movement of the exchange rate, both nominal and real, has been of much concern to policy-makers, bankers, and academic economists. The resultant increase in the volatility of exchange rates during the floating exchange rate period has made the analysis and forecasting of exchange rate movement more interesting and difficult.

Recently, a number of authors have argued that the nominal exchange rates follow a random walk. They include Mussa(1979), Meese and Rogoff(1983), among others. The latter authors provided an update of their results, confirming their previous argument(Meese and Rogoff(1985)). At the same time, several authors have argued that the real exchange rates, or the deviations from purchasing power parity follow a random walk. They include Roll(1979), Darby(1980), Frenkel(1981), Adler and Lehmann(1983). However, pipPenger(1986) presents results inconsistent with the random walk hypothesis,

However, as is shown below, the theoretical conditions under which the nominal and real exchange rates follow a random walk are very stringent and these conditions are often violated empirically. Recently, Hakkio(1985) argued that these puzzling results are due to the low statistical power of the tests used in those studies. From a different angle, Shiller and Perron(1985) argued that the statistical power of a t-test for a random

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walk hypothesis depends on the span of data rather than the number of observations, and it increases clearly when both the span of data and number of observations are increased simultaneously.

The main objective of this paper is to investigate the behavior of both nominal and real exchange rates with a particular attention paid to the random walk hypothesis. Following Hakkio, we investigate the sensitivity of test results to the statistics used. Secondly, we investigate the reactions of nominal and real exchange rates to the change of monetary policy regime of October 1979. The increased variability of the money supply growth and the short-term nominal interest rates since the change might have led to an increase of the volatility of both nominal and real exchange rates and to a change in the random behavior of exchange rates.

The paper is organized as follows. Section 2 describes the theoretical consideration of under what conditions the nominal and real exchange rates follow a random walk. Section 3 presents explanations of the data used and empirical results. Section 4 concludes the paper with conclusions.

## II. Foreign Exchange Rate Movement and the Random Walk Hypothesis

### 2.1 Conditions for a Random Walk Hypothesis

In this section we present the conditions under which the nominal and real exchange rates will follow a random walk. We start first with the uncovered interest parity(UIP) relationship:

$$i_t = i_t^* + (E_t s_{t+1} - s_t) \quad (1)$$

where  $i_t$  is the nominal interest rate paid on bonds between the period  $t$  and  $t+1$ ,  $s_t$  is the logarithm of spot exchange rate expressed as the domestic currency price of a unit of foreign currency, and  $E$  is expectations operator.  $*$  denotes foreign variable.

Next we assume a standard Fisher relationship between the interest rates and the expected inflation rates:

$$i_t = r_t + (E_t P_{t+1} - P_t) \quad (2a)$$

$$i_t^* = r_t^{*2} + (E_t P_{t+1}^* - P_t^{*2}) \quad (2b)$$

where  $r_t$  is the real interest rate and  $P_t$  is the logarithm of the price level. The domestic and foreign real interest rates are assumed to depend on some stochastic processes.

We further assume that agents form their expectations rationally about the future exchange rates and the price level:

$$E_t s_{t+1} = s_{t+1} + e_{t+1}, \quad E(e_{t+1} | I_t) = 0 \quad (3a)$$

$$E_t p_{t+1} = p_{t+1} + v_{t+1}, \quad E(v_{t+1} | I_t) = 0 \quad (3b)$$

$$E_t p^*_{t+1} = p^*_{t+1} + w_{t+1}, \quad E(w_{t+1} | I_t) = 0 \quad (3c)$$

where  $I_t$  is the information set available at  $t$ .

The conditions under which the nominal exchange rate,  $s_t$ , follows a random walk can be derived by substituting(3a) into(1):

$$(s_{t+1} - s_t) = (i_t - i_t^*) - e_{t+1} \quad (4)$$

This states that the time-series behavior of nominal exchange rates depends on the time-series behavior of the nominal interest rate differential.

The condition under which the real exchange rate, defined as  $q_t = s_t - (p_t - p^*_t)$  follows a random walk can be derived by substituting(2) and(3) into(1):

$$q_{t+1} - q_t = (r_t - r^*_t) + u_{t+1} \quad (5)$$

where  $u_{t+1} = v_{t+1} + w_{t+1} - e_{t+1}$ . Equation(5) indicates that the behavior of the real exchange rate depends on the time-series behavior of the real interest rate differential. Only in special cases of behavior of the real interest rate differential would the real exchange rate follow a random walk.<sup>1</sup>

These three assumptions used to derive the above relationship, namely the uncovered interest parity, the Fisher relationship, and the rational expectations would constitute the sufficient conditions for the real nominal exchange rates to follow a random walk. In addition to these three conditions, only special real and nominal interest rate differential processes are

acceptable for the real and nominal exchange rates to follow a random walk. The empirical validity of these three relationships is at best mixed.<sup>2</sup>

As noted in the introduction, a number of authors have presented results indicative of the random walk behavior for both nominal and real exchange rates. However, the sufficient conditions for which the nominal and real exchange rates follow a random walk are stringent and empirically often violated. This presents a contradiction between theoretical models and empirical evidence. Hakkio(1985) reconciles this by arguing that the tests for a random walk have very low statistical power. His Monte Carlo study shows that the four test statistics, namely the Dickey-Fuller Q statistic, the Sargan-Bhargava R statistic, the F test, and the Box-Pierce Q statistic have all low power so that when the exchange rate movement is close to a random walk but not a random walk, the test statistics are generally unable to detect it.

In a different vein, Shiller and Perron(1985) argue that the power of test for random walk hypothesis increases when both span of data and number of observations are increased. With short spans of data, there is not much power. Over a substantial range of span, power depends more on the span of data rather than on the number of observations and hence it is wrong to argue that power of test is high when there are many observations even if the data may come from a short time period.

## 2.2 Test of Random Walk Hypothesis

A series is said to follow a random walk if its changes are serially uncorrelated. Four statistical tests are available to test whether a series follows a random walk. First, the traditional F test determines in equation

$$x_t = a + \sum_{i=1}^N b_i x_{t-1} + e_t \quad (6)$$

where  $x_t = X_t - X_{t-1}$ , whether  $b_i$ 's are jointly equal to zero for  $i=1, \dots, N$ . The alternative hypothesis is that  $x$  is an AR process. In this case the F is distributed as  $F(N, T)$  where  $N$  is the number of lagged autocorrelation and  $T$  is the number of observations. Second, the Q statistic tests for "whitenoise" of  $x_t$ . The alternative hypothesis is that  $x_t$  is not white noise and hence  $x_t$  does not follow a random walk. The Q is distributed as

chi-square(N). Then, the Dickey-Fuller(1981)  $\phi$  statistic tests in equation

$$x_t = a + cx_{t-1} + e_t \quad (7)$$

whether  $c=1$  with the alternative being  $c \neq 1$ . This alternative hypothesis,  $c \neq 1$  is an AR(1) process which is potentially nonstationary. Fourth, the Sargan-Bhargava(1983) R statistic tests whether  $c=1$  with the alternative being  $c < 1$ . This alternative,  $c < 1$  is a stationary process.

These four statistics for the test of random walk have identical null hypothesis that  $x$  follows a random walk. However, their alternatives range from most restrictive (stationary AR(1)) to least restrictive(not a random walk). In the next section, I report statistical tests of random walk of both nominal and real exchange rate movements using F and Q statistics. It may shed some light on the sensitivity of test results to the statistics used.

### III. Empirical Results

#### 3.1 The Data

All of the nominal exchange rates used in this study, daily, weekly, monthly are taken from the Federal Reserve tape of foreign exchange rates.<sup>3</sup> The currencies include Canadian dollar, French franc, German mark, Italian lira, Japanese yen, Swiss franc, and U. K. pound. The time period considered in this study is January 1973 through June 1986. Both the consumer price indexes (1967=100.0 for all countries except Switzerland which has 1980=100.0) and wholesale price indexes (1980=100.0 for all countries) for these countries are obtained from the Main Economic Indicators, OECD, various issues.

#### 3.2 Results of Statistical Tests for a Random Walk

In this section, we present the empirical results of behavior of both nominal and real exchange rates. The nominal exchange rate is defined as the US dollar price of a unit of foreign currency.

The log first-difference is taken for all exchange rates and it is regressed against a constant and 12, 18, and 24 lags of the dependent variable respectively.<sup>4,5</sup> Table 1 presents the results of the test for random

walk hypothesis for monthly nominal exchange rates for the period of January 1973 through June 1985. The British sterling exchange rate strongly rejects the null hypothesis of random walk at less than 1%, according to both F and Q statistics. The Japanese yen exchange rate reject the null hypothesis in 2 out of 3 cases at 5% level. The Canadian exchange rate rejects the random walk hypothesis at 12 lags by F and at 18 and 24 lags by Q statistic. Italian lira shows a rejection of the null hypothesis at 12 lags according to Q statistic.

Table 2 presents the results of the same test using weekly data. Surprisingly, all exchange rates at all lags reject the null hypothesis at less than 0.1% level of significance according to both F and Q. Similar results obtained in Table 3 when daily data are used.<sup>6</sup> The exchange rates of the Canadian dollar, French franc, German mark, and Italian lira strongly reject the null hypothesis of random walk, while those of Japanese yen, Swiss franc, and British pound show some acceptance at 5% level. The reason for some degree of autocorrelation of the nominal exchange rates, weekly and daily, is that the market does not completely adjust to the new information available during the period, or in other words, the new information or any change of policy does have some lasting effects. Both the F and Q statistics have almost identical power in rejecting the null hypothesis.

In Table 4, we present the result of the random walk test for monthly real exchange rates of those currencies. Both the wholesale price index and consumer price index<sup>7</sup> are used to calculate the real exchange rates,  $q_t$ , defined as  $q_t = s_t p^*/p_t$ . The Q statistics are identical for both WPI and CPI real exchange rates. The British WPI real exchange rate strongly rejects the null hypothesis at less than 1% significance level by both F and Q. The Japanese yen rejects the random walk hypothesis at 5% level at all three lags for both WPI and CPI rates by F test, but cannot reject it by Q test. The CPI Swiss franc real exchange rate shows a rejection at 12 lags at 5% level by F test. The German mark CPI real exchange rate strongly rejects the null hypothesis at less than 1% level. The rest of the currencies all do not reject the null hypothesis of random walk at even 10% level. This is consistent with the results reported by many authors recently. Contrary

to Hakkio's observation, F test exhibits stronger rejections than Q test in this case of real exchange rates.

Our results suggest that the random walk as an exchange rate behavior is more frequently rejected for daily and weekly data than for monthly data. This may be due to the fact that markets may not adjust to new information completely in a day and that market anomalies affect the otherwise efficiently determined exchange rates more significantly in a day or a week than a month. For real exchange rates, the CPI-defined real exchange rate rejects the random walk hypothesis more often than the WPI-defined real exchanged rate during the same period. This is explained by the fact the CPI contained many nontraded goods whose prices are not as closely linked to those of trading counterparts as traded goods and that the WPI contains the traded goods more heavily. All in all, our results indicate that contrary to the results reported in some recent studies, the random walk is not a very powerful explanation of the behavior of both real and nominal exchange rates.

### 3.3 Policy Regime Change and Exchange Rate Behavior

It has been argued that the much publicized change of operating procedure by the Federal Reserve in October 1979 has led to changes in the behavior of the real interest rates (Huizinga and Mishkin (1985), in the volatility of nominal interest rates (Evans(1982), Taton(1984), and in the effects of money supply announcements on nominal interest rates (Hakkio and Pearce (1985). The well known 'Lucas Critique' states that as the policy regime changes, people's way of forming their expectations will change accordingly and hence forecasting the future values based on the same parameter specification would produce erroneous results. This would be particularly appropriate in the foreign exchange markets in which agents' expectations exert a crucial role in the exchange rate movement. In this section, we investigate whether the monetary policy regime change in October 1979 changed the pattern of exchange rate movement.<sup>8</sup>

Table 5 presents the results of the test for random walk hypothesis for monthly exchange rates during the post October 1979 period. Compared to the results of Table 1, the null hypothesis cannot be rejected for British

pound, Canadian dollar, and the Japanese yen. For the seven currencies, rejection occurs only in 5 of 42 cases (21 F statistics and 21 Q statistics). This is a significant change in the pattern of behavior. In Table 6, we see even more significant changes. The random walk hypothesis could not be rejected in all currencies except the Canadian dollar. Only 10 rejections occur out of 42 cases, compared to all 42 rejections at less than 0.1% level in Table 2. Similar results obtain in Table 7 for daily data. The random walk hypothesis is rejected only in 12 out of 42 cases, compared to 33 rejection out of 42 in Table 3.

Table 8 reports the results of real exchange rates for the post October 1979 period. Significant change occurs for British pound and Japanese yen. The random walk cannot be rejected now. Again, fewer rejections(3) of the random walk occur than in Table 4, in which 10 rejections occurred.

It is apparent that the random walk hypothesis is much less frequently rejected in recent years than in earlier years of the floating exchange rate system. This may be explained in part by the fact that in recent years, there has been relatively less intervention into the foreign exchange market by the authorities and that on significant supply shocks have occurred in recent years whose effects are often commonly shared among the countries and that rapid development of the markets in terms of information collection and processing has rendered the market more efficient.

Our results in this paper shed some interesting lights on the behavior of both nominal and real exchange rates. First, acceptance and rejection of the random walk behavior of the exchange rates depends critically on the data series used, namely whether they are monthly, weekly, or daily. The shorter the time interval is, the more likely the data reject the random walk behavior. Second, there is some sensitivity of results detected depending on the lag length adopted, but no consistent pattern is found. Third, there is a significant change in the random walk behavior of the exchange rates before and after the October 1979 policy regime change. The random walk hypothesis is much less frequently rejected since the regime change. However, it should be noted that this change may be in part due to other factors than the policy regime change. Our approach cannot differentiate the effects on the exchange rate movement of the policy change from those



of other factors.

#### **IV. Conclusions**

In this paper, we have studied the random walk behavior of both nominal and real exchange rates for the period of January 1973 through June 1985. The currencies include the Canadian dollar, French franc, German mark, Italian lira, Japanese yen, Swiss franc, and British pound.

The theoretical conditions under which the nominal and real exchange rates follow a random walk are stringent and often empirically violated. Despite these, many authors have recently presented the results consistent with a random walk behavior. One way to explain this puzzle is the low statistical power of the statistics used in the tests for random walk.

In this paper, we have investigated the random walk behavior of monthly, weekly, and daily foreign exchange rates. We have found that the random walk hypothesis is decisively rejected for daily and weekly nominal exchange rates, while it is much less frequently rejected in the case of monthly nominal exchange rate. Similar results obtained for monthly real exchange rates. However, the random walk behavior is not as overwhelming even in monthly rates as some of recent studies have argued. The CPI-defined real exchange rate rejects the random walk hypothesis more often than the WPI-defined rate. This is due to the fact that CPI contains the nontraded goods more heavily whose prices are not as closely linked internationally as the traded goods. Some sensitivity of results to the lag length used was detected but no consistent pattern was found.

We have also investigated the random walk behavior of exchange rates in recent years, namely since the late 1970s. In general, random walk hypothesis is much more frequently accepted in recent years and this may be due to the fact that there has been less intervention into the foreign exchange market by the authorities and that development of the market in terms of information processing and financial innovation has rendered the market more efficient.

Our findings in this paper provide some caution to interpreting the previous empirical results on the random walk behavior of both nominal and real exchange rates. Our results appear more plausible in view of the fact

that the market fundamentals are not likely to follow a random walk, which was a condition for exchange rate to follow a random walk.

Table 1  
Test for Random Walk Hypothesis for Nominal Exchange Rates:  
Monthly Data: 1973.1-1985.6

$$x_t = a + \sum_{i=1}^N b_i x_{t-i} + e_t$$

	Number of lags	F <sup>a</sup>	Q <sup>b</sup>
Canadian	12	2.228(0.015) <sup>c</sup>	19.35(0.080)
Dollar	18	1.559(0.084)	30.44(0.033)
	24	1.460(0.100)	36.42(0.050)
French	12	0.880(0.569)	19.75(0.072)
Franc	18	0.924(0.522)	26.82(0.082)
	24	0.803(0.725)	30.82(0.159)
German	12	0.789(0.661)	17.02(0.149)
Mark	18	0.777(0.723)	20.98(0.281)
	24	0.637(0.897)	25.62(0.373)
Italian	12	1.808(0.055)	23.42(0.024)
Lira	18	1.392(0.151)	26.38(0.091)
	24	1.116(0.341)	30.55(0.167)
Japanese	12	1.949(0.036)	21.08(0.049)
Yen	18	1.592(0.075)	27.79(0.065)
	24	1.736(0.031)	41.93(0.013)
Swiss	12	1.657(0.086)	18.62(0.098)
Franc	18	1.273(0.221)	24.79(0.131)
	24	1.086(0.373)	33.03(0.103)
U.K.	12	2.486(0.006)	32.70(0.001)
Pound	18	2.488(0.002)	40.68(0.002)
	24	2.107(0.006)	43.57(0.009)

Notes: a. The F statistic has (N, T) degrees of freedom, where N is the number of autocorrelations and T is the number of observations.

b. The Ljung-Box Q statistic has N degrees of freedom.

c. The figures in the parentheses are marginal significance level, which are defined as the maximum probability that the test statistic will assume a value as or more extreme than the critical value when the null hypothesis is true. Reporting marginal significance level has an advantage of letting the readers pick the appropriate critical values.

Table 2  
Test for Random Walk Hypothesis for Nominal Exchange Rates: Weekly Data,  
1973. Jan.  
1985. Jan.

$$x_t = a + \sum_{i=1}^N b_i x_{t-i} + e_t$$

	Number of lags	F	Q
Canadian Dollar	12	8.364(0.000)	107.36(0.000)
	18	5.855(0.000)	111.43(0.000)
	24	4.634(0.000)	114.32(0.000)
French Franc	12	6.099(0.000)	100.32(0.000)
	18	4.297(0.000)	104.62(0.000)
	24	3.402(0.000)	117.12(0.000)
German Mark	12	5.047(0.000)	88.67(0.000)
	18	3.753(0.000)	91.33(0.000)
	24	2.916(0.000)	93.13(0.000)
Italian Lira	12	5.754(0.000)	71.39(0.000)
	18	4.629(0.000)	92.38(0.000)
	24	3.496(0.000)	94.77(0.000)
Japanese Yen	12	7.105(0.000)	96.57(0.000)
	18	5.686(0.000)	109.30(0.000)
	24	4.030(0.000)	113.22(0.000)
Swiss Franc	12	2.890(0.001)	48.40(0.000)
	18	2.278(0.002)	54.49(0.000)
	24	1.938(0.005)	59.41(0.000)
U.K. Pound	12	5.158(0.000)	65.64(0.000)
	18	3.978(0.000)	72.78(0.000)
	24	3.276(0.000)	84.20(0.000)

Notes: See the notes of Table 1.

Table 3  
 Test for Random Walk Hypothesis for Nominal Exchange Rates :  
 Daily Data, 1973. Jan.-1979. Sep.

$$x_t = a + \sum_{i=1}^N b_i X_{t-i} + e_t$$

	Number of lags	F	Q
Canadian Dollar	12	2.979(0.000)	41.19(0.000)
	18	2.152(0.003)	45.08(0.000)
	24	1.783(0.011)	49.34(0.002)
French Franc	12	1.780(0.046)	21.16(0.048)
	18	1.912(0.012)	34.02(0.013)
	24	1.876(0.006)	42.93(0.010)
German Mark	12	3.561(0.000)	41.35(0.000)
	18	2.597(0.000)	45.32(0.000)
	24	2.414(0.000)	56.14(0.000)
Italian Lira	12	4.989(0.000)	62.06(0.000)
	18	4.472(0.000)	91.73(0.000)
	24	3.676(0.000)	104.27(0.000)
Japanese Yen	12	2.067(0.016)	25.34(0.013)
	18	1.575(0.059)	30.49(0.033)
	24	1.378(0.105)	36.21(0.052)
Swiss Franc	12	1.737(0.054)	20.77(0.054)
	18	1.503(0.080)	27.14(0.076)
	24	1.631(0.028)	38.29(0.032)
U.K. Pound	12	2.082(0.015)	23.81(0.022)
	18	1.580(0.057)	27.52(0.070)
	24	1.713(0.017)	39.72(0.023)

Notes : See the notes of Table 1.

Table 4  
 Test for Random Walk Hypothesis for Real Exchange Rates :  
 Monthly Data, 1973. Jan.-1985. June.

$$X_t = a + \sum_{i=1}^N b_i x_{t-i} + e_t$$

	Number of lags	F	WPI	Q	F	CPI	Q
Canadian Dollar	12	1.123(0.349)	8.64(0.734)	2.334(0.010)	8.64(0.734)		
	18	1.062(0.400)	16.48(0.559)	1.660(0.058)	16.48(0.559)		
	24	0.932(0.559)	20.89(0.645)	1.531(0.075)	20.89(0.645)		
French Franc	12	0.576(0.857)	13.74(0.318)	0.808(0.642)	13.74(0.318)		
	18	0.812(0.683)	20.96(0.282)	0.848(0.640)	20.96(0.282)		
	24	0.713(0.828)	24.85(0.414)	0.731(0.808)	24.85(0.414)		
German Mark	12	0.744(0.705)	11.72(0.468)	11.117(0.000)	11.72(0.468)		
	18	0.632(0.867)	13.67(0.750)	7.794(0.000)	13.67(0.750)		
	24	0.679(0.861)	18.85(0.760)	6.384(0.000)	18.85(0.760)		
Italian Lira	12	1.342(0.205)	9.37(0.671)	3.852(0.000)	9.37(0.671)		
	18	1.027(0.437)	12.40(0.826)	2.544(0.002)	12.40(0.826)		
	24	1.030(0.437)	20.23(0.683)	1.828(0.021)	20.23(0.683)		
Japanese Yen	12	2.164(0.018)	17.33(0.138)	1.979(0.033)	17.33(0.138)		
	18	1.753(0.041)	22.48(0.212)	1.936(0.020)	22.48(0.212)		
	24	1.810(0.022)	32.01(0.127)	1.820(0.021)	32.01(0.127)		
Swiss Franc	12	2.115(0.021)	15.01(0.241)	1.468(0.147)	15.01(0.241)		
	18	1.470(0.116)	18.29(0.436)	1.157(0.311)	18.29(0.436)		
	24	1.234(0.233)	22.52(0.548)	0.109(0.371)	22.52(0.548)		
U.K. Pound	12	2.443(0.007)	29.14(0.004)	0.438(0.945)	29.14(0.004)		
	18	2.566(0.002)	38.32(0.004)	0.626(0.872)	38.32(0.004)		
	24	2.204(0.004)	41.81(0.014)	0.485(0.978)	41.81(0.014)		

Notes: See the notes of Table 1.

Table 5  
 Test for Random Walk Hypothesis for Nominal Exchange Rates :  
 Monthly Data, 1979. Oct.-1985. June.

$$X_t = a + \sum_{i=1}^N b_i x_{t-i} + e_t$$

	Number of lags	F	Q
Canadian dollar	12	0.629(0.802)	7.74(0.805)
	18	0.432(0.965)	8.52(0.970)
	24	0.505(0.943)	14.14(0.943)
French Franc	12	1.740(0.106)	12.61(0.398)
	18	2.207(0.034)	25.93(0.101)
	24	1.631(0.140)	33.34(0.097)
German Mark	12	1.369(0.233)	14.61(0.263)
	18	1.250(0.298)	24.91(0.127)
	24	1.736(0.112)	32.08(0.125)
Italian Lira	12	1.571(0.152)	14.05(0.297)
	18	2.440(0.020)	24.68(0.134)
	24	2.752(0.014)	29.42(0.205)
Japanese Yen	12	0.838(0.613)	17.40(0.135)
	18	0.645(0.830)	19.14(0.383)
	24	1.134(0.395)	36.96(0.044)
Swiss Franc	12	1.795(0.094)	17.25(0.140)
	18	1.695(0.110)	29.45(0.043)
	24	1.269(0.301)	35.44(0.062)
U.K. Pound	12	1.039(0.441)	15.08(0.237)
	18	1.028(0.466)	17.43(0.494)
	24	0.912(0.590)	21.40(0.615)

Notes : See the notes of Table 1.

Table 6  
 Test for Random Walk Hypothesis for Nominal Exchange Rates :  
 Weekly Data, 1979. Oct.-1985. June.  

$$X_t = a + \sum_{i=1}^N b_i x_{t-i} + e_t$$

	Number of lags	F	Q
Canadian	12	8.364(0.000)	107.36(0.000)
Dollar	18	5.855(0.000)	111.43(0.000)
	24	4.634(0.000)	114.32(0.000)
French	12	1.740(0.106)	12.61(0.398)
Franc	18	2.207(0.034)	25.93(0.101)
	24	1.631(0.140)	33.34(0.097)
German	12	1.369(0.233)	14.61(0.263)
Mark	18	1.250(0.298)	24.91(0.127)
	24	1.736(0.112)	32.08(0.125)
Italian	12	1.571(0.152)	14.05(0.297)
Lira	18	2.440(0.020)	24.68(0.134)
	24	2.752(0.014)	29.42(0.205)
Japanese	12	0.838(0.613)	17.40(0.135)
Yen	18	0.645(0.830)	19.14(0.383)
	24	1.134(0.395)	36.96(0.044)
Swiss	12	1.795(0.094)	17.25(0.140)
Franc	18	1.695(0.110)	29.45(0.043)
	24	1.269(0.301)	35.44(0.062)
U.K.	12	1.039(0.441)	15.08(0.237)
Pound	18	1.028(0.466)	17.43(0.494)
	24	0.912(0.590)	21.40(0.615)

Notes : See the notes of Table 1.

Table 7  
 Test for Random Walk Hypothesis for Nominal Exchange Rates :  
 Daily Data. 1979. Oct.-1985. June.

$$X_t = a + \sum_{i=1}^N b_i x_{t-i} + e_t$$

	Number of lags	F	Q
Canadian	12	1.701(0.061)	20.29(0.006)
Dollar	18	2.310(0.001)	38.38(0.062)
	24	2.599(0.000)	60.29(0.000)
French	12	1.064(0.387)	13.47(0.336)
Franc	18	1.207(0.247)	21.70(0.245)
	24	1.646(0.026)	37.43(0.040)
German	12	0.770(0.684)	9.50(0.660)
Mark	18	0.941(0.528)	16.96(0.526)
	24	1.188(0.242)	29.22(0.212)
Italian	12	1.229(0.257)	16.39(0.174)
Lira	18	1.311(0.171)	25.74(0.106)
	24	1.323(0.136)	37.07(0.043)
Japanese	12	1.450(0.137)	17.59(0.129)
Yen	18	1.094(0.352)	20.81(0.289)
	24	1.690(0.020)	44.48(0.007)
Swiss	12	0.732(0.721)	9.02(0.701)
Franc	18	1.120(0.325)	20.09(0.328)
	24	1.282(0.164)	31.78(0.133)
U.K.	12	1.604(0.084)	18.75(0.095)
Pound	18	1.649(0.042)	27.21(0.075)
	24	1.850(0.008)	44.63(0.006)

Notes : See the notes of Table 1.



Table 8  
 Test for Random Walk Hypothesis for Real Exchange Rates :  
 Monthly Data, 1979. Oct.-1985. June.

$$X_t = a + \sum_{i=1}^N b_i x_{t-i} + e_t$$

	Number of lags	F	WPI	Q	F	CPI	Q
Canadian	12	0.303(0.984)	13.73(0.318)		0.930(0.530)	13.73(0.318)	
Dollar	18	0.224(0.998)	17.99(0.456)		0.813(0.671)	17.99(0.456)	
	24	0.348(0.992)	20.66(0.659)		0.833(0.668)	20.66(0.659)	
French	12	1.462(0.192)	9.94(0.621)		2.189(0.039)	9.94(0.621)	
Franc	18	1.682(0.127)	23.77(0.163)		1.846(0.077)	23.77(0.163)	
	24	1.481(0.193)	30.54(0.168)		1.368(0.245)	30.54(0.168)	
German	12	1.023(0.453)	13.87(0.309)		3.637(0.002)	13.87(0.309)	
Mark	18	0.784(0.700)	19.06(0.388)		2.401(0.023)	19.06(0.388)	
	24	1.076(0.441)	26.36(0.335)		1.796(0.103)	26.36(0.335)	
Italian	12	1.987(0.061)	11.83(0.460)		1.151(0.358)	11.83(0.460)	
Lira	18	2.073(0.046)	17.63(0.480)		2.060(0.047)	17.63(0.480)	
	24	2.515(0.022)	24.18(0.451)		3.050(0.008)	24.18(0.451)	
Japanese	12	0.794(0.653)	18.19(0.110)		0.941(0.521)	18.19(0.110)	
Yen	18	0.676(0.803)	19.73(0.348)		0.733(0.749)	19.73(0.348)	
	24	0.982(0.524)	35.76(0.058)		1.067(0.448)	35.76(0.058)	
Swiss	12	2.213(0.037)	18.07(0.114)		2.068(0.051)	18.07(0.114)	
Franc	18	1.875(0.073)	28.12(0.060)		2.147(0.039)	28.12(0.060)	
	24	1.562(0.162)	32.98(0.105)		1.746(0.109)	32.98(0.105)	
U.K.	12	0.905(0.552)	16.80(0.157)		1.090(0.409)	16.80(0.157)	
Pound	18	0.923(0.562)	20.62(0.229)		1.178(0.346)	20.62(0.299)	
	24	0.833(0.668)	25.11(0.400)		1.179(0.361)	25.11(0.400)	

Notes : See the notes of Table 1.

## Footnotes

1) These results are not dependent on the particular model used. Hakkio(1985)demonstrates that using a model of Frenkel and Mussa(1980), the exchange rate follows a random walk if and only if the market fundamentals follow a random walk. Since the market fundamentals are a function of real income, money supply growth, interest rates, and exogenous shocks, it would be surprising if the market fundamentals did in fact follow a random walk.

2) The interest parity relationship is well documented with respect to Eurocurrency rates as an acceptable hypothesis(see, Aliber(1973), Frenkel and Levich(1975)). However, due to differential exchange controls and default risk, the interest arbitrage won't hold with respect to national interest rates(see, Dooley and Isard(1980)). The evidence on Fisher relation is that nominal interest rates do not fully adjust to expected inflation(see, Howard and Johnson(1982)). The evidence on foreign exchange market efficiency is at best mixed. While early empirical results show support for efficiency(Frenkel(1979)), more recent studies report that while the forward rate is generally found to be unbiased, it does not reflect all available information (Levich(1985)).

3) We investigate the exchange rate behavior using daily, weekly, and monthly data in view of the fact that different exchange rates are more interesting depending on the purpose of study. Hakkio, for example, chose quarterly data in his study of ppp because "monthly prices are relatively sticky while exchange rates are much more volatile"(Hakkio, 1984, p 267). We do not agree with this logic. Instead, investigation of ppp behavior using data of different interval would shed more light for our understanding of the exchange rate or ppp behavior.

4) Nelson and Plosser(1982)have argued that it is the first or first or higher-order difference that is stationary, not the level, for many macroeconomic variables. In the literature, exchange rates are customarily written in log first-difference form to avoid the 'Siegel's paradox' and the problem of nonstationarity. We hereby follow the custom.

- 5) There is no a priori criterion as to the length of lags to take when to test the joint significance of the lagged variables. Granger and Newbold (1977) suggest a rather large number of lags at least 20, while Sims (1974) recommends a deterministic function of sample size, such as  $T/\log T$ . We use 12, 18, and 24 lags in order to see any sensitivity of results to the lag length.
- 6) We use the time period of January 1973 through September 1979 in the case of daily data because the SAS ARIMA program cannot handle observations greater than 2000.
- 7) Since the CPI for Switzerland has 1980=100.0 as the base year, we used the U. S. CPI, 1980=100.0 for the conformity of base year.
- 8) Here, we are not concerned with any underlying causal relationship between the regime change and any change of exchange rate behavior. In that sense, any change of exchange rate behavior shown since October 1979 could be very well caused by other factors along with the policy regime change.

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