Inter-Currency Transmission of Volatility in Foreign Exchange Futures

Mohammad Najand
Hamid Rahman
Kenneth Yung

INTRODUCTION

Although research on spot and forward prices for currencies is voluminous, there have been surprisingly few studies on the price dynamics of currency futures markets.[1] Naidu and Shin (1979) examine weekly currency futures price changes and find that 21 of 66 contracts in five currencies traded on the International Monetary Market (IMM) in Chicago display significant autocorrelation up to six lags. Cavanaugh (1987) investigates the stochastic process of currency futures prices and finds significant serial correlation in daily changes of log prices for four of ten currency contracts examined. He also shows that the serial dependence among currency futures can be exploited by members of the futures exchange to generate profit opportunities. Moreover, McCurdy and Morgan (1988) reject the hypothesis that currency futures price movements follow a martingale process and concur with Hodrick and Srivastava (1987) that currency futures have a time varying risk premium.

Harvey and Huang (1991) examine the volatility implications of around-the-clock foreign exchange trading with transaction data on futures contracts from the Chicago Mercantile Exchange and the London International Financial Futures Exchange. They find U.S.–European foreign currency futures are, on average, twice as volatile during U.S. trading hours as during European trading hours. They suggest that this is because " . . . U.S. macroeconomic news released during U.S. trading hours dominates the effect of news released in the European markets in determining the volatility of U.S.–European rates" (p. 544). In their study, public information is found to be

[1]For a survey of the empirical literature on foreign exchange markets, see Levich (1979) and Hertzel et al. (1990). Studies of the stochastic properties of exchange rates include Booth et al. (1981, 1982), Dooley and Shafer (1983), and Messe and Rogoff (1983).

Mohammad Najand is an Assistant Professor in the Department of Finance at Old Dominion University.

Hamid Rahman is an Assistant Professor in the Department of Finance at Old Dominion University.

Kenneth Yung is an Assistant Professor in the Department of Finance at Old Dominion University.

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the prime motivator of volatility in the currency futures market (Public Information Hypothesis). One implication of this hypothesis is that the effect of public economy-wide information on one currency is transmitted across national borders. This new information regarding a currency future, as reflected by changes in its volatility, can actually exert influence on the futures contracts of other currencies. The implications of the Harvey and Huang (1991) study need to be validated.

The objective of this study is to validate the implications of the Harvey and Huang study and to expand the knowledge of price dynamics in currency futures markets by empirically examining the transmission of volatility among currency futures. The principal aim is to explore the extent to which foreign currency futures shocks impinge upon other currencies and the channels through which they are transmitted. A better understanding of the volatility of currency futures prices is important for several reasons. First, it has significant implications for hedging strategies in exchange risk management. Howard and D'Antonio (1984) suggest that hedging strategies should be formulated in a risk–return portfolio framework. Second, given the evidence of serial dependence in currency futures prices, a better understanding of the volatility of currency futures price movements would allow speculators to forecast more accurately and improve their opportunities of making profits. Third, since evidence shows that volatility of currency futures is time varying, and understanding of the volatility transmission mechanism would further shed light on the stochastic properties of currency futures prices.

LITERATURE

Most of the studies in the last two years on volatility transmission have focused on the spot markets instead of futures markets. In general, these studies rely on the information dissemination process as the cause of volatility transmission. King and Wadhani (1990) provide a theoretical framework in which volatility transmission exists in the form of "contagion effect" because rational agents attempt to infer information from price movements in other markets. Hamao, Masulius, and Ng (1990) examine volatility transmission among international equity markets and suggest that volatility spillover is due to information surprises transmitted from one market to another. On the other hand, Engle, Ito, and Lin (1990) provide empirical evidence of volatility transmission in the spot currency (yen/dollar) markets. They formulate two possible hypotheses which they name "meteor showers" and "heat waves." The heat wave hypothesis maintains that volatility has only country-specific autocorrelation, whereas the meteor shower hypothesis implies volatility spillovers from one market to the next. Their empirical findings support the meteor shower hypothesis.

The choice of methodology for this study is affected by the recent literature on statistical properties of foreign currency futures. McCurdy and Morgan (1988) report the presence of conditional heteroscedasticity in futures contracts of five major foreign exchange rates traded at the IMM. They show that exchange rate futures data exhibits significant volatility clustering, i.e., large changes of either sign cluster together with intervening periods of relative stability. This clustering could represent the arrival of information in clusters or delays in the market adjustment process as traders try to gauge its content. As Engle et al. (1990) point out, if information arrives in clusters, then the asset returns or prices may exhibit ARCH (Autoregressive Conditional Heterscedasticity) behavior. Another statistical property of currency futures data that has a bearing on the appropriateness of the modeling technique employed is the divergence of the distribution from normal. Both Cavanaugh (1987) and McCurdy and Morgan (1988) find that the distribution of currency futures returns is leptokurtic.

A modeling technique that particularly fits the conditional heteroscedasticity and leptokurtic distribution noted above is the Autoregressive Conditional Heteroscedastic (ARCH) and Generalized Autoregressive Conditional Heteroscedastic (GARCH) formulations. These models allow the variance of returns to change over time. The variance in one period can depend upon variables and disturbances from previous periods. Diebold and Nerlove (1989) show that ARCH and GARCH models are consistent with the leptokurtosis in exchange rate changes. Hsieh (1989a) and Baillie and Bollerslev (1989) apply the ARCH and GARCH specifications to model spot exchange rates.

DATA AND METHODOLOGY

A. Data

Daily currency futures prices between January 1980 and December 1989 are from the Chicago Mercantile Exchange. The data set contains daily data for five currencies (in terms of U.S. dollars): the British pound, the Canadian dollar, the German Deutsche mark, the Japanese yen, and the Swiss franc. Since most trading activity takes place in the near-month contract, only the near-month contract data are examined. As a result, it is possible to control for the maturity effect on futures prices. A continuous sequence of 2631 observations of futures price data are gathered over the ten-year period. To calculate price change, the logarithm of the price relative is taken. The use of logarithmic price changes prevents the nonstationarity of price level in the data from affecting futures price variability.

B. Methodology

Econometric models with time-varying conditional variances have recently received much attention. Bollerslev et al. (1990) provide a detailed survey of papers employing ARCH and GARCH models to explain time-varying volatility in financial time series. Consider the following GARCH model:

$$y_t = x_t + \varepsilon_t, \tag{1}$$

$$(\varepsilon_t | \varepsilon_{t-1}, \varepsilon_{t-2}, \ldots) \sim \mathbb{N}(O, h_t), \tag{2}$$

$$h_t = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j h_{t-j}, \tag{3}$$

where y_t is a random variable, x_t is an exogenous variable, and ε_t is a random error. The GARCH(p,q) model in eqs. (1)–(3) allows the conditional variance of the random disturbance to depend on the behavior of past squared errors. The conditional normality assumption in ARCH generates some degree of unconditional excess kurtosis which, as Diebold and Nerlove (1989) observe, make ARCH and GARCH models consistent with the leptokurtosis in exchange rate changes. Although standard time series could be used to identify the orders of p and q, as noted by

Bollerslev (1986), the GARCH(1, 1) specification has been proven to be an adequate representation for most financial time series.

The test for spillover of volatility across currency futures uses lagged price change and squared residuals for the currency of investigation as well as the other currencies in a GARCH formulation. The following GARCH(1, 1) model is employed.

$$y_{i,t} = y_{i,t-1} + \varepsilon_{i,t} \tag{4}$$

$$(\varepsilon_{i,t} | \varepsilon_{i,t-1}, \varepsilon_{i,t-2}, \ldots) \sim \mathbb{N}(O, h_{i,t}) \tag{5}$$

$$h_{i,t} = \omega_i + \beta_i h_{i,t-1} + \sum_{i=1}^{5} \alpha_i \varepsilon_{i,t-1}^2 \tag{6}$$

where y is the price change measured as $\ln(\text{close}_t/\text{close}_{t-1})$ for each currency. Through the use of the above model, this study hypothesizes that the rate of information arrival is a function of the residual terms of other currencies.

EMPIRICAL RESULTS

Specification tests for the appropriateness of the model used are given in Tables I and IIA–C. Table I gives the summary statistics describing the distributional properties of each foreign exchange returns series. The currency futures returns are only mildly skewed. However, the excess kurtosis of each currency futures returns series confirms that the distributions of currency futures are leptokurtic in nature. This finding is consistent with numerous recent findings on distributions of asset returns [Bollerslev (1986)]. Furthermore, the null hypothesis of normal distribution is rejected for each exchange rate using the Kolomogrov-Smirnov D test.

Hsieh (1989a) shows that though the spot market foreign exchange rates are not highly autocorrelated, they are strongly heteroscedastic. Results in Table IIA report similar findings in the currency futures markets. For the raw returns, the Box-Pierce Q statistic shows that (with the exception of BP futures) currency futures show very low or insignificant autocorrelation in general up to lag 24. When the Box-Pierce test is performed on squared returns, substantially higher autocorrelations are found, as reported in Table IIB. This indicates the presence of strong conditional

Table I
SUMMARY STATISTICS OF CURRENCY FUTURES RETURNS

Statistics	BP	CD	DM	JY	SF
Mean (μ)	−0.0100	−0.0003	−0.0003	0.0165	0.0029
$t(\mu = 0)$	−0.68	−0.06	−0.02	1.19	0.17
Median	0.0	0.0	−0.0327	−0.0231	−0.0195
SD	0.7576	0.2849	0.7417	0.7104	0.8459
Skewness	0.1545	−0.2807	0.3407	0.4183	0.3322
Kurtosis	2.7910	−5.0838	1.8584	3.0921	1.7192
Max.	4.5529	1.9916	4.8321	5.3327	4.9672
Min.	−3.4467	−1.7946	−3.2639	−4.1325	−3.6919
D:normal	0.06[a]	0.08[a]	0.06[a]	0.07[a]	0.05[a]

SD = standard deviation, kurtosis = excess kurtosis, D: normal = Kolomogrov-Smirnov D test statistics for normal distribution.

[a] Significant at 1%.

Table II
BOX-PIERCE Q TEST RESULTS

Q-Statistics	BP	CD	DM	JY	SF
A. Box-Pierce Q Test for Autocorrelation of Raw Returns					
Lag(6)	22.65[a]	3.56	2.53	3.53	7.77
Lag(12)	30.31[a]	14.07	8.90	5.59	12.78
Lag(18)	40.17[a]	24.55	15.58	27.28[c]	34.42[b]
Lag(24)	45.07[a]	37.63[c]	20.15	32.36	41.38[b]
B. Box-Pierce Q Test for Autocorrelation of Squared Raw Returns					
Lag(6)	182.18[a]	144.70[a]	13.82[a]	80.60[a]	11.79[a]
Lag(12)	306..43[a]	191.51[a]	24.37[a]	106.67[a]	23.17[a]
Lag(18)	437.52[a]	314.14[a]	32.63[a]	111.81[a]	26.58[b]
Lag(24)	507.54[a]	333.31[a]	34.41[b]	120.77[a]	28.82[b]
C. Box-Pierce Q Test for Autocorrelation of Residuals					
Lag(6)	1.42	3.56	6.77	3.43	2.13
Lag(12)	7.68	14.07	11.88	16.86	4.18
Lag(18)	14.58	24.55	22.44	24.46	25.33
Lag(24)	18.83	30.63	30.39	33.57	30.16

[a] Significant at 1%.
[b] Significant at 5%.
[c] Significant at 10%.

heteroscedasticity. The ARCH models assume that the conditional error is serially uncorrelated. Table IIC shows that there is no significant autocorrelation among the residuals, and this suggests that the model is well specified. The general absence of a significant higher order serial correlation leads to the conclusion that specifying an AR(1) process in conjunction with the GARCH model would result in the most parsimonious model for this data [see, e.g., Bollerslev (1986)].

Table III reports the maximum likelihood estimates of model (4)–(6) for the full 1980–1989 period. The h_t in the model represents the conditional variance of the $\ln(\text{close}_t/\text{close}_{t-1})$ price change and evidences the effect of past volatility of a currency future on its current volatility. For all the five currencies in the data set, this effect is positive and significant. This is an indication that there is a very strong GARCH effect in the returns-generating process of each currency future. This finding is consistent with results suggesting that, in many financial time series data, large changes are followed by large changes and small changes are followed by small changes [Mandelbrot (1963)].

In eq. (6), the lagged squared error terms are used as explanatory variables to determine if there is any predictive informational content in them. Volatility spillover effect from other currencies is then concluded if their squared error terms with lags are found to be significant in the GARCH model (6) of a particular currency. The empirical estimation of the model is shown in Table III. Two distinct and somewhat mutually exclusive effects can be observed. These are the ARCH effect and the spillover effect. In the case of two currency futures, the Canadian dollar and the

Table III
THE GARCH ESTIMATION OF VOLATILITY TRANSMISSION AMONG FOREIGN CURRENCY FUTURES BETWEEN 1980 AND 1989

$$y_{i,t} = y_{i,t-1} + \varepsilon_{i,t}$$

$$(\varepsilon_{i,t} | \varepsilon_{i,t-1}, \varepsilon_{i,t-2}, \ldots) \sim \mathbb{N}(O, h_{i,t})$$

$$h_{i,t} = \omega_i + \beta_i h_{i,t-1} + \sum_{i=1}^{5} \alpha_i \varepsilon_{i,t-1}^2$$

WHERE y IS THE PRICE CHANGE MEASURED AS $\ln(close_t/close_{t-1})$ FOR EACH CURRENCY

Maximum Likelihood Estimates	BP	CD	DM	JY	SF
Intercept	0.0004	0.0010[a]	0.0035[a]	0.0050[a]	0.0104[a]
$h_{i,t-1}$	0.9985[a]	0.9878[a]	0.9931[a]	0.9903[a]	0.9859[a]
$\varepsilon^2_{bp,t-1}$	0.0000[c]	0.0000	0.0001	0.0001	0.0001
$\varepsilon^2_{cd,t-1}$	0.0004	0.0002[a]	0.0005	0.0001	0.0006
$\varepsilon^2_{dm,t-1}$	0.0003[a]	0.0000	0.0000	0.0000	0.0000
$\varepsilon^2_{jy,t-1}$	0.0000	0.0003[b]	0.0000	0.0001	0.0006
$\varepsilon^2_{sf,t-1}$	0.0005[a]	0.0001	0.0003[a]	0.0006[a]	0.0006[a]

[a] Significant at 1%.
[b] Significant at 10%.
[c] Numbers which are 0.0000 only suggest that they are less than 0.0001 and should not be interpreted as zeros.

Swiss franc, the error term variable of the currency itself is found to be significant. This indicates that the lagged conditional variance alone does not capture all of the explanatory power but that the information impounded in the lagged residual variable also contributes toward explaining the conditional variance. Thus, past innovations in the currency itself exerts influence on the conditional variance of the Canadian dollar and the Swiss franc futures. However, the second group of currencies, the British pound, the Deutsche mark, and the Japanese yen, do not exhibit the ARCH effect. Thy are influenced by highly significant inter-currency volatility spillover effects that are either absent in the first group as in the case of the Swiss franc or barely significant as in the case of the Canadian dollar.[2]

An explanation of this phenomena may be sought in the mixture model [Lamoureux and Lastrapes (1990)]. This model explains the presence of ARCH by hypothesizing that price changes are generated by a mixture of distributions in which the rate of daily information arrival is the stochastic mixing variable. There is a positive relationship between the heteroscedastic daily price increments and the rate of daily information arrival. When Lamoureux and Lastrapes proxy the rate of daily information arrival by volume and include it as an explanatory variable in the conditional variance equation, the ARCH effects tend to disappear. Through the

[2]The squared error terms of the model are characterized as being: highly or strongly significant, relatively weak, or weakly or barely significant if the terms are found to be significant at the 1%, 5%, or 10% level, respectively.

model used in this study, it is conjectured that the rate of information arrival is a function of the significance of the residual terms of other currencies. If an insignificant residual is denoted as having zero informational content and a significant residual as having some arbitrary unit informational content, then the rate of information arrival will vary from zero, when none of the error terms is significant, to four, when all the error terms of the other currencies in the data are significant. Thus, there is, within this model, a mechanism which causes the rate of information arrival to vary. This results in the observed phenomena that the ARCH effects disappear when there are strong (significant at 1%) spillover effects. However, when spillover effects are nonexistent or weak, the ARCH effects become significant. This finding is, therefore, analogous to the results reported by Lamoureux and Lastrapes.

Results in Table III also show that the British pound and the Canadian dollar futures are more likely to be influenced by residuals from other currency futures. On the other hand, futures of Deutsche mark, Japanese yen, and Swiss franc are less influenced by volatility shocks from other currencies. That is, if the British pound and the Canadian dollar are considered to be the relatively softer currencies in the sample, then the significant spillover effects which persist over the longer period (1980–1989) are only to be found emanating from the futures of the stronger currencies—the Swiss franc, the Deutsche mark, and the Japanese yen. In fact, the spillover effect of the Swiss franc futures is the most pervasive in the long run affecting three of the other four currencies in the sample.[3]

Prior to February 25, 1985, daily price limits were in effect for all currency futures traded on the Chicago Mercantile Exchange. To study volatility spillover in the post price limit period, the model is applied to the data from after February 25, 1985. The model is again found to be well specified. The null hypothesis of normality for the raw returns is rejected by the Kolmogrov-Smirnov D statistic. The Box-Pierce Q test for autocorrelation on the raw and the squared raw returns shows clearly the presence of heteroscedasticity. There is no significant autocorrelation among the residuals leading to the conclusion that the AR(1) process results in the most parsimonious model for this data.[4]

Results in Table IV shows that for all the five currencies in the post–price limit period, the GARCH effects remain very strong in the returns generating process. The pattern of significant lagged squared error terms is somewhat different from the full data set (1980–1989), but remains consistent with the Lamoureux and Lastrapes explanation discussed earlier. The Canadian dollar and Japanese yen have neither ARCH nor spillover effects. The Deutsche mark has a highly significant ARCH effect and only a relatively weak spillover effect from the Swiss franc. The British pound and Swiss franc have spillover effects but no ARCH effects. The British pound has highly significant spillover effects from the Deutsche mark and Swiss franc. These are the same two currency futures which have a significant impact on the British pound when the full data set is used. The Swiss franc has a relatively weak spillover effect from the Deutsche mark. In short, similar to the results in Table III,

[3]During the period of January 1980 through December 1989, the British pound and the Canadian dollar depreciated by 27.7% and 0.6%, respectively, against the U.S. dollar in the spot market. During the same period, the Deutsche mark, the Swiss franc, and the Japanese yen appreciated against the U.S. dollar by 1.2%, 3.1%, and 66.7%, respectively.

[4]Tests of model specification with the truncated data are not reported but are available on request from the authors.

Table IV
THE GARCH ESTIMATION OF VOLATILITY TRANSMISSION AMONG FOREIGN CURRENCY FUTURES BETWEEN 1985 AND 1989

$$y_{i,t} = y_{i,t-1} + \varepsilon_{i,t}$$

$$(\varepsilon_{i,t}|\varepsilon_{i,t-1}, \varepsilon_{i,t-2}, \ldots) \sim \mathbb{N}(O, h_{i,t})$$

$$h_{i,t} = \omega_i + \beta_i h_{i,t-1} + \sum_{i=1}^{5} \alpha_i \varepsilon_{i,t-1}^2$$

WHERE y IS THE PRICE CHANGE MEASURED AS $\ln(\text{close}_t/\text{close}_{t-1})$ FOR EACH CURRENCY

Maximum Likelihood Estimates	BP	CD	DM	JY	SF
Intercept	0.0007	0.0020[a]	0.0036[b]	0.0065[b]	0.0104[a]
$h_{i,t-1}$	0.9923[a]	0.9763[a]	0.9937[a]	0.9851[a]	0.9971[a]
$\varepsilon_{bp,t-1}^2$	0.0010	0.0000[c]	0.0002	0.0003	0.0001
$\varepsilon_{cd,t-1}^2$	0.0035	0.0002	0.0001	0.0001	0.0001
$\varepsilon_{dm,t-1}^2$	0.0054[a]	0.0002	0.0025[a]	0.0006	0.0031[b]
$\varepsilon_{jy,t-1}^2$	0.0000[c]	0.0002	0.0000[c]	0.0001	0.0001
$\varepsilon_{sf,t-1}^2$	0.0050[a]	0.0001	0.0019[b]	0.0002	0.0001

[a] Significant at 1%.
[b] Significant at 5%.
[c] Numbers which are 0.0000 only suggest that they are less than 0.0001 and should not be interpreted as zeros.

it is found in the post–price limit period that stronger currencies such as Deutsche mark and Swiss franc are the ones that are involved in transmitting spillover effects.

Table V shows the inter-currency futures volatility transmission by year. Results are in general consistent with those reported earlier. Significant spillover effects in the currency futures market are observed. In general, the Deutsche mark tends to exert more influence than the other four currencies in the futures markets. Among the five currency futures, the British pound is most likely to be influenced by volatility surprises of other currencies. The Deutsche mark and Japanese yen futures are least affected by other currencies. It should be noted that the conditional variance of each currency futures is more likely to be affected by lagged squared residuals of other currencies than its own lagged squared residuals. This suggests that, for a given foreign currency, market makers are better able to gauge the informational content of the news as its affects that currency, but are unable to show the same insight for news affecting the other currencies. Based on conversations with a number of foreign currency dealers, this might be due to the fact that a lot of currency traders specialize in one or two currencies only. Also, most in-house traders of non–Wall Street related industries (e.g., import/export) may lack sufficient background knowledge of events that affect currencies other than the currencies they deal with directly. As a result, the informational content of events in countries, other than the ones of their currencies, is often misjudged and they continue to be surprised by shocks from these other currencies. The results in Table V also show that the intensity of spillover effects in the foreign exchange futures markets have subsided since 1987. This may be the result of the Louvre Accord of 1987 in which the Group of Five industrial countries pledged to support stability of exchange rates around their current levels. The commitment to intervention by the Central Banks and a change in market psychology, as noted by some authors,[5] may have contributed to the dampening of the spillover effects.

Forecasts of Volatility

The results of the GARCH model show that any realistic process for forecasting exchange rate returns in futures markets must allow for a high degree of dependence in conditional variances. Hence, to show the superiority in volatility forecasting when the impact of volatility transmission is considered, the volatility estimates of the GARCH model are compared to the historical average of volatility for the last 30 days of the sample. Historical average is the best forecast if the time series of returns are strictly white noise. The forecasts of 30 daily return variances estimated by the GARCH model of this study are compared to the historical estimates and both are compared to the actual ex post variances using MSE (mean squared error). Table VI shows clearly that the GARCH model forecasts are superior as shown by the smaller MSE values. Thus, the GARCH forecasts provide substantial improvement over historical estimates.

Table V
INTER-CURRENCY FUTURES VOLATILITY TRANSMISSION BY YEAR[a]

	Futures Contract				
	BP	**CD**	**DM**	**JY**	**SF**
1980	JY[d], SF[b]	CD[c]	SF[c]		
1981	DM[b]		CD[b], SF[b]	CD[b]	CD[b], SF[c]
1982	DM[b]				CD[c]
1983	SF[c]				
1984	CD[b], DM[b]	DM[b], JY[d]	JY[b]	DM[b], JY[b]	DM[d], JY[b]
1985	DM[b]	CD[b]	BP[c], DM[b]	DM[b]	
1986	CD[c], SF[b]	BP[b], CD[d]			
1987	DM[b], JY[b]	DM[c]	DM[b]	DM[b]	DM[b]
1988	DM[b], SF[b]				
1989	CD[d], DM[b] JY[b]				

[a] The results presented show that the conditional volatility of each currency futures is affected by past squared innovations of other currency futures.
[b] Significant at 1%.
[c] Significant at 5%.
[d] Significant at 10%.

[5] See, for example, Eiteman and Stonehill (1989).

Table VI
FORECASTS OF DAILY VARIANCE OF RETURNS ON CURRENCY FUTURES USING MSE[a]

	BP	CD	DM	JY	SF
Historical estimate	0.000258	0.000643	0.000434	0.000406	0.000012
GARCH forecast	0.000250	0.000597	0.000406	0.000324	0.000009

[a] Where: $MSE = 1/30 \sum_{i=1}^{30} E_i^2$

Note: $\text{Error}(E_i) = \text{forecast} - \text{actual}$.

CONCLUSION

This article investigates the contention of Harvey and Huang that information regarding a currency future may have impact on the volatility of other currency futures. Using a GARCH methodology, significant volatility transmissions are found both in the long and the short run. This implies that traders in one currency futures draw inferences about the shocks to one currency from observed price movements in other currencies. In the short run, the pattern of volatility spillover is very diverse. All currencies are involved at some periods in transmitting volatility to other currencies. Over the long run, the transmission of volatility pattern resolves into two distinct effects—an ARCH effect and a spillover effect. It is found that the ARCH effect and spillover effect do not exist simultaneously on average. This holds both in the full–and post–price limit periods. The mixture model is cited as a possible explanation for the phenomena. The results also indicate that, in the long run, volatility spillover emanate from stronger currencies such as the Deutsche mark and the Swiss franc. It is shown that GARCH models which consider volatility transmission have greater forecasting power than historical estimates.

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