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NEWS FROM THE U.S. AND JAPAN: WHICH MOVES THE YEN/DOLLAR EXCHANGE RATE?

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ABSTRACT

Intra-daily movements in the yen/dollar exchange rate were examined in four non-overlapping segments within each business day from January 1980 to September 1985. The empirical results yielded several conclusions. First, most depreciation of the yen (appreciation of the dollar) from late 1982 to early 1984 occurred in the New York market. The direction of the yen was mostly neutral in the Tokyo market. Also, the volatility of the exchange rate decreased considerably in the Tokyo market. The volatility in the New York market, on the other hand, did not decrease until very recently. Second, market efficiency was examined in terms of the random-walk behavior of short-run movements in the yen/dollar rate. Information on the preceding segments within a day was sometimes significant in predicting the exchange rate movement in a market. Third, there is evidence of the "profit-taking" behavior, or overshooting, in that a large jump (more than 3 absolute yen) in any market tends to be reversed by a fifth of the jump during the same day in the next market. Finally, the relative effects of news from the U.S. and Japan were examined explicitly both with respect to possible major events behind large jumps and the response of the yen/dollar rate to particular economic announcements in both countries. Over the entire sample period, news concerning the U.S. money stock had the only significant effects.

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I. INTRODUCTION

The pre-eminence of the efficient markets hypothesis has led to a number of studies on the effect of news on asset prices. Many of these studies further employ finely observed data, usually a change in an asset's price during a 24-hour period containing major "news." In this context, "news" refers to an unexpected change in a fundamental variable relevant to the asset's price determination. By examining the response to news, different hypotheses about an asset's price behavior can be evaluated. In contrast, the expected part of the announcement or development should not influence the asset's price since it is already taken into account before the announcement in an efficient market.

Among the recent studies examining the effect of news, the response of foreign exchange rates has received considerable attention. The response to the Federal Reserve's weekly money announcements is investigated by Cornell (1982, 1983), Frankel and Hardouvelis (1985), Engel and Frankel (1984), Hardouvelis (1984), and Roley (1985b), among others. Most of the evidence is consistent with the so-called policy-anticipations (or Keynesian) hypothesis in that a positive money announcement surprise causes dollar appreciation. Under this hypothesis, the observed positive response of U.S. interest rates to positive money announcement surprises represents a real interest-rate response, leading to an appreciation of the dollar in foreign exchange markets. The real rate rises due to the expectation of future tightening by the Federal Reserve as a reaction to the unanticipated increase in money.[1/]

The response of exchange rates to other economic announcements also has been considered. Batten and Thornton (1984) examine the

response to U.S. discount rate changes. They conclude that unexpected discount rate changes implemented with international considerations, most notably on November 1, 1978, are significant in explaining exchange rate movements. Hakkio and Pearce (1986) consider the response of exchange rates to U.S. announcements of inflation, industrial production, and the unemployment rate, in addition to weekly money announcements. Their results suggest that only money surprises affect exchange rates significantly.

While not focusing on economic announcements, Mussa (1979), Dornbusch (1980), and Frenkel (1981) also consider the effect of unanticipated changes in economic variables on exchange rates. Edwards (1982, 1983, 1984) and Longworth (1984) further attempt to formalize a method to explain the deviations between the forward rate and the realized spot rate using the unanticipated components of money, interest rates, and output. Since their data consist of monthly changes, the immediate responses of exchange rates to news announcements are not measured. A novelty of their approach, however, is to take into account foreign (non-U.S.) news as well as domestic (U.S.) news.

As is recognized in the literature on the response of asset prices to economic announcements, it is desirable to take the shortest interval possible around potential news since other shocks may dilute the estimated effect over one month. However, Edward's idea that exchange rates should respond to not only U.S. news but foreign news, implying correlated error terms in the various currency equations, is well taken. This point leads to the question of how to measure exchange rate responses to foreign (non-U.S.) news. Since an exchange rate is the relative price

of two assets (i.e., currencies), it is important to recognize that the rate could respond to domestic and/or foreign news. However, if exchange rate responses to domestic and foreign news are to be separated, a 24-hour segment, not to mention one month, as a data unit is not fine enough since it involves reactions to both domestic and foreign news.

Most studies investigating the effects of announcements measure the change in exchange rates over 24 hours (e.g., a change from a close to a close). In contrast, Hakkio and Pearce (1986) examine exchange rate responses in the New York market over two sub-intervals, but they do not consider exchange rate movements in the rest of the world. As noted above, it is important to recognize that not only domestic but also foreign news is very relevant in the determination of the exchange rate, and that the foreign exchange market is open almost continually somewhere in the world. Therefore, news analysis of the exchange rate needs to be carried out with respect to the other country's news as well as U.S. news.

This paper distinguishes itself in several aspects from the other studies mentioned above. Most advantages come from the data set, which consists of the opening and closing quotes of the yen/dollar exchange rate in the Tokyo market and the 9 A.M., noon, and 4:30 P.M. quotes in the New York market for each business day from January 1980 through September 1985. In addition, announcements of the money supply, industrial production, and wholesale (producers) prices are collected both for the U.S. and Japan.

The short time intervals between exchange rate observations along with the use of both foreign and domestic economic data allow a better understanding of the behavior of the yen/dollar rate for several reasons.

First, the responses of the exchange rate to U.S. and Japanese economic news can be differentiated. Because of the 14-hour (13-hour during daylight saving time) time difference between Tokyo and New York, the business hours of the two markets do not overlap. (See Appendix 1 for data sources and timing.) Since currency, as opposed to the U.S. Treasury bills or U.S. equities, is traded almost continuously around the clock somewhere in the world, any development in world news will be immediately reflected in the exchange rate.

Second, it can be assumed as a first approximation that U.S.-oriented news -- such as economic announcements, and political developments -- mainly hit the market during its business hours, and similarly for Japanese news. Because of non-overlapping business hours, exchange rate changes in the New York market (9 A.M. - 4:30 P.M.) can be regarded as responses to U.S. news, and the changes in the Tokyo market (9 A.M. - 3:30 P.M.) as responses to Japanese news. Since the exchange rate should reflect not only U.S. news but also Japanese news, it is very interesting, for example, to consider how Japanese money announcements compare with U.S. money announcements with respect to the exchange rate response.

Third, economic news in addition to money announcements is considered; namely, industrial production and wholesale (producers, in the U.S.) price index announcements every month. These announcements are decomposed into surprise and expected parts and tested against the efficient markets hypothesis. Using these data, the relative efficiency of the New York-Tokyo markets also can be compared.

Finally, the features of this investigation outlined above are extremely useful in addressing recent policy issues. By identifying

whether Japanese news or U.S. news influences the exchange rate more, and also by identifying what kind of news in each market moves the exchange rate, this analysis sheds light from a new angle on the controversy of the cause of the "overvalued dollar in the 1980s." If the "cause" of the strong dollar is tight monetary policy of the U.S., the exchange rate should exhibit relatively large responses to U.S. money announcement surprises. Alternatively, if the dollar's strength, particularly since 1982, is a reflection of the strength of the U.S. economy relative to that of Japan, then other kinds of news such as industrial production announcements in both countries should have significant effects on the exchange rate.

To analyze the effects of changes in policy and deregulation further, several possible break points are considered within the 1980-1985 sample. First, December 1980 should be noted for the sweeping deregulation that occurred with respect to Japanese capital controls both into and out of Japan.[2/] Second, in October 1982, the Federal Reserve announced the abandonment of its previous monetary-control procedure and also indicated that targets for the narrowly-defined money stock (M1) would be de-emphasized. Third, in February 1984, the Federal Reserve adopted a different reserve requirement system, and as a consequence the behavior of money and interest rates in the U.S. may have changed.[3/]

Following this introductory section, the second section examines the relative volatility of the yen/dollar rate in the New York and Tokyo markets. The relative contributions of these markets in determining longer-run movements also are considered. In the third section, the random-walk behavior of the yen/dollar rate is tested both within and across markets. The possibility of inertia over short intervals also

is tested. The role of news in explaining large exchange-rate movements is considered in the fourth section, along with tests of profit-taking behavior or "corrections" following large jumps. In the fifth section, the response of the yen/dollar rate to economic news announcements in both the U.S. and Japan is estimated. The main conclusions are summarized in the final section.

II. TREND AND VOLATILITY ANALYSIS

To compare movements of the yen/dollar exchange rate in different markets throughout the world, four major segments are considered within each day. (The timing of different markets is explained further in Appendix 1). First, exchange rate movements from the opening (9 A.M.), TKO, to the close (3:30 P.M.), TKC, of the Tokyo market mainly reflect traders' responses to news originating in Japan. Both the London and New York markets are closed during business hours in Tokyo. This segment is denoted as the "Tokyo" segment of the day. Second, from the close of Tokyo market to the opening of the New York market, news and actions in the European markets are thought to be responsible for the changes in the yen/dollar exchange rate through cross arbitrage with European currencies. This segment is referred to as "Europe." Third, changes of the yen/dollar rate from 9 A.M., NYO, to 4:30 P.M., NYC, in the New York market mainly reflect the effects of U.S. news, although the London market is still open concurrently at the very beginning hours of New York market trading. This segment is denoted as "New York." The fourth segment of the day differs from the others. In particular, there is no major market between New York and Tokyo. For 3½ hours (2½ during

daylight saving time), most of the Japanese, American and European market participants are not trading. For convenience, this period is referred to as the "Pacific" market.

A summary of yen/dollar exchange rate movements for each market is presented in Table 1. This table indicates which market was most influential in determining exchange rate changes and volatility. Several stylized facts are apparent in this table. First, the exchange rate at the end of the sample, September 20, 1985, happened to be about the same as that of the start of the sample period, January 1, 1980. That is, total net changes summed over all markets for the entire sample period are less than one yen. However, when they are decomposed into separate markets, differences are apparent. In particular, accumulated changes in the New York market during the second subperiod reflect yen depreciation, and those for Europe in the first, second, and third subperiods reflect yen appreciation. The drift of the exchange rate in the Tokyo market appears to be "trendless" except for a mild depreciation in the second subperiod. The data suggest that U.S. economic activity and policies led toward an "overvalued" dollar, while the European markets recorded opposite effects. This finding is consistent with the assertion that the U.S. fiscal and monetary policy mix in 1981-1982 caused "surprisingly" high real interest rates, considering the on-going recession, which in turn attracted foreign (Japanese especially) capital into the U.S. In turn, the exchange rate responded to the capital account movement rather than the current account. Moreover, this effect was sufficiently strong such that counter measures (keeping the interest rate higher than expected) by European countries could not overturn the tide.

Since theory often predicts that asset prices exhibit a random walk property, it is of interest to examine whether an expected daily change was statistically different from zero in any market during any subperiod. As indicated in Table 1, the daily exchange rate movement in the New York market during the subperiod II (464 observations) was not a random walk in the sense that the hypothesis that the expected change is equal to zero is rejected at the 1 percent significance level. Similarly, in the European market during the subperiods I and III, daily movements were predictable at the 5 percent significance level. However, the mean change is slightly more than 1/10 of one yen. Considering the bid-ask spread, which is about 1/20 to 1/10 of one yen, the statistical "predictability" does not mean that there were unexploited profit opportunities in the market. The conditional prediction depending on movements in the preceding markets are examined in section III.

The volatility of the exchange rate measured by variances and mean absolute changes also is reported in Table 1. The Pacific market consistently had low volatility, about a half to a third that of any other market in terms of mean absolute changes. As is shown below, this result is robust even when correcting for the different number of hours in the segments.

The volatilities of the Tokyo and New York markets changed significantly over the sample. In the first subperiod, the Tokyo market was slightly more volatile than both the New York and European markets. However, the New York market was most volatile from the second to the fourth subperiods. Since October 1982, the New York market has been about twice as volatile as the Tokyo market in terms of the variances, due mainly to

the major decline in the Tokyo market's volatility. In terms of variances, the volatility of the third subperiod is a half of the first period in the Tokyo market, and the fourth period's volatility is again half that of the third period.

The decline in the volatility in the Tokyo market can be explained by two factors: news and institutions.[4/] First, the Japanese economy was highly volatile after the second oil crisis in 1980. The Bank of Japan was attempting to avoid both inflation and yen depreciation in the spring, and then trying to stimulate the economy after the summer. For example, the official discount rate was raised from 6.25 to 7.25 percent in February and again to 9 percent in March. The rate was decreased to 8.25 percent in August and to 7.25 percent in November. Some of the actions taken by the Bank most likely added to the uncertainty in the market.[5/] Second, most of the capital controls on flows into and out of Japan were eliminated on December 1, 1980. In addition, the so-called "real demand principle" was eliminated on April 1, 1984. Prior to that date, positions in the forward market without "real demands" were prohibited. Both measures contributed to the broadening of the Tokyo market, which in turn may have increased its stability.

The above explanations are not entirely free from criticism. For example, U.S. interest rates rose in the spring of 1980 and then declined during the summer and fall, similar to Japan, but with a larger magnitude. Despite the similar interest rate patterns, the volatility of the exchange rate differed in the two markets.

A. Volatility Per Hour

In the preceding subsection, the difference in the number of hours for different segments was ignored. If one segment is longer than

another, its apparent volatility may be artificially high. To correct for the difference in segment hours, "per hour" variances are calculated below.[6/] The market hours in Tokyo and New York are constant for all observations. The hours between two markets, however, vary depending on whether the U.S. is on the daylight saving time. In addition, the Pacific segment, hours from New York closing to Tokyo opening, includes a weekend (an extra 48 hours) once every five observations.

Table 2 shows per hour variances calculated from the volatility measures reported in Table 1. Even on a per hour basis, the volatility ranking between Tokyo and New York does not change. The Tokyo market was more volatile in 1980, while the New York market was more volatile than Tokyo beginning in the second subperiod.

Turning to the Pacific segment, volatility per hour is expected to be very small since all major markets in the world are closed during these hours. Moreover, if this segment contains a weekend, it extends more than 50 hours without trading activities. As indicated in Table 2, the per hour variance of the weekday Pacific segment is a third to a half that of its New York counterpart as expected.[7/]

The low per hour volatility of the Pacific market may be interpreted as evidence for the lack of news. To examine this hypothesis further, the Pacific segment of the day can be compared to the most "active" segment of the day, namely 9 A.M. - 12 Noon in the New York market. The London market is still open during some part of the New York morning session. The three hours which would reflect New York and European news are obviously more volatile than the comparable hours in the Pacific segment of the day.[8/]

An alternative explanation of the lower volatility during the Pacific segment could be its lack of "self-generating" trading rather than the lack of news. French and Roll (1984) propose that trades self-generate volatility based on evidence that when the stock market is closed during regular business hours, the volatility between closing and opening quotes is significantly less than during other times. Unfortunately, because the foreign exchange market is almost always (except the Pacific segment) open somewhere in the world and ready to process relevant news, the maintained hypothesis that it is news which determines volatility cannot be differentiated from an alternative hypothesis that the mere existence of trading generates the volatility.

III. RANDOM WALK HYPOTHESIS

In this section, the random walk hypothesis that changes in the exchange rate are unpredictable is tested. Under this hypothesis, all information concerning the exchange rate is processed instantly. The New York closing rate, for example, should be the expected level of the Tokyo opening. Similarly, the expected closing rate in the New York market as of 9:01 A.M. should be the opening (9 A.M.) rate in the New York market. The random walk hypothesis is tested by regressing a change in a segment's rate on the aggregated change during the three preceding segments:

$$(3.1) \qquad TKO_t - NYC_{t-1} = a + b_1(NYC_{t-1} - TKO_{t-1}) + e_t$$

$$(3.2) \qquad TKC_t - TKO_t = a + b_1(TKO_t - TKC_{t-1}) + e_t$$

$$(3.3) \qquad NYO_t - TKC_t = a + b_1(TKC_t - NYO_{t-1}) + e_t$$

$$(3.4) \qquad NYC_t - NYO_t = a + b_1(NYO_t - NYC_{t-1}) + e_t$$

where the random error term in each equation is represented by e_t for simplicity. The random walk hypothesis is that $b_1 = 0$ in each equation.[9/]

The above equations can be generalized slightly to consider additional alternative hypotheses. The movement in European markets, for example, captured by $(NYO_t - TKC_t)$, may have an "inertia" effect on the within-the-market change in New York. This hypothesis may not be refuted by equation (3.4) if the movement in European markets is dominated by the movement in the rest of the world. In general, the following equations allow tests of whether any of the preceding three segments of the day has a special effect on the change during the upcoming segment:

$$(3.5)\quad TKO_t - NYC_{t-1} = a + b_1(NYC_{t-1} - NYO_{t-1}) + b_2(NYO_{t-1} - TKC_{t-1}) + b_3(TKC_{t-1} - TKO_{t-1}) + e_t$$

$$(3.6)\quad TKC_t - TKO_t = a + b_1(TKO_t - NYC_{t-1}) + b_2(NYC_{t-1} - NYO_{t-1}) + b_3(NYO_{t-1} - TKC_{t-1}) + e_t$$

$$(3.7)\quad NYO_t - TKC_t = a + b_1(TKC_t - TKO_t) + b_2(TKO_t - NYC_{t-1}) + b_3(NYC_{t-1} - NYO_{t-1}) + e_t$$

$$(3.8)\quad NYC_t - NYO_t = a + b_1(NYO_t - TKC_t) + b_2(TKC_t - TKO_t) + b_3(TKO_t - NYC_{t-1}) + e_t$$

The random walk hypothesis is described as $b_1 = b_2 = b_3 = 0$.

The estimation and test results of equations (3.1) - (3.8) are summarized in Table 3. The equations are estimated over the entire sample and selected subsamples corresponding to possible policy regimes and deregulation.[10/] In two of the first four equations, (3.2) and (3.3), the random-walk hypothesis can be rejected at the 5 percent level for the entire sample period. The results indicate that the opening Tokyo quote

is not an unbiased predictor of the closing Tokyo quote, and similarly that the closing Tokyo quote is biased in forecasting the opening New York yen/dollar rate. In contrast, the closing New York rate in the previous day is an unbiased predictor of the opening rate in Tokyo, and the opening and closing rates in New York do not exhibit any significant bias. On the basis of these results, the rationality of the closing quote in Tokyo may be questioned.

For the entire sample period, the random walk hypothesis cannot be rejected in equations (3.1) and (3.5), indicating that the exchange rate movement in the Pacific market is indeed a random walk. The movements in the preceding three segments of the day, whether aggregated or separate, do not contribute in predicting the change in the Pacific market. In contrast, equation (3.8) shows that the movement in the New York market is predictable using changes in the three preceding segments, but it is not predictable when these segments are aggregated.

The rejection of the random walk hypothesis is most definite in the second subperiod. The number of rejections decreases in the third subperiod and again in the fourth subperiod.[11/] One explanation is based on the notion that "large jumps" and "small trembles" are caused by different factors and that a large jump in one period would predict movements in the following segments. As large jumps become less frequent in later periods (as will be evident in Table 4), it may become difficult to reject the random walk hypothesis. Alternatively, the results may be interpreted as support for the assertion that as the market becomes large and more traders (speculators) participate in it, the price movement follows the theoretically-predicted random walk behavior.

The rejection of the random walk hypothesis does not necessarily mean an unexploited profit opportunity. In fact, the typical size of the predicted change in a segment is typically well under the bid-ask spread.[12/] Nevertheless, important insights about the conditional predictability of intra-daily movements of the exchange rate are apparent in the table.[13/]

IV. NEWS ANALYSIS AND PROFIT-TAKING BEHAVIOR

In the previous section, the random walk hypothesis was analyzed in the sense that information about yen/dollar rate movements during the past 24 hours should not be helpful in predicting the current segment's rate. The estimation procedure implicitly assumed that each day in the sample is qualitatively the same. However, newspaper headings are constantly encountered such as the price (exchange rate) declined because of "profit-taking" after a sharp rise. There seems to be a view, at least in the news media, that any large change in an asset's price is followed by a movement in the opposite direction. There also is a view, which is not mutually exclusive, that sharp changes in the price reflect the last stage of a bubble (or a bandwagon effect) in which the bubble bursts. These views predict that days of large price changes should be treated separately from other days and be tested for predictability of subsequent price movements.

A large change by itself is not evidence of a bubble. It may be reflecting some major news in the world, a sudden death of a political leader, or an initiation of war in the Middle East. If all large changes

are attributable to major news, factors which traders think are most important in the determination of the yen/dollar exchange rate can potentially be ascertained. If many large changes occur without any apparent major news items, the existence of a bubble or a bandwagon effect in the market may be suspected. To examine these hypotheses, a set of selected days with large jumps is used.

A. Is There Always Major News Behind a Large Jump in the Rate?

Days in which a large change in the exchange rate occurred are examined closely below. Table 4 lists the number of days in which the yen jumped by more than 3 absolute yen. From Table 1, a change of three yen is more than two standard deviations. This classification scheme reconfirms the findings in Section II about which market was more volatile. By selecting the infrequent days with jumps of more than 3 yen, special characteristics are examined.

A jump in the exchange rate is supposedly triggered by some economic or political news. Newspapers relevant to the days of large changes (more than 3 absolute yen per segment) were examined in an attempt to identify major news items. This exercise is summarized in Appendix 2. After possible causes for large jumps were reviewed, it appears that not all jumps can be associated with major news.

B. Tests of Bubbles and Profit-Taking

Since news responsible for all large jumps could not be identified, an alternative hypothesis is considered. In particular, suppose that the exchange rate could deviate from an otherwise stationary stochastic process for a short period of time. A "rational" bubble could

then emerge and burst occasionally. That is, this bubble hypothesis for a large change within a day is that the jump is caused by the final stage of a bubble or a bandwagon effect. A large jump can then be interpreted as a sudden correction to the "natural" (equilibrium) level from an exploding bubble process. This interpretation predicts that the large jump is preceded by a significant change in the opposite direction. Formally,

(4.1) Jump = a + b(change in the previous segment) + e, $b < 0$.

In addition, it can be loosely hypothesized that a large jump (3 yen or more) is followed by profit-taking behavior. Under this hypothesis, the subsequent movement if not necessarily large, but it is in the opposite direction regardless of the reason for the jump. This behavior can be represented as

(4.2) (Change in the subsequent segment) = a + b(Jump) + e, $b < 0$.

The empirical results for days with large jumps are summarized in the bottom part of Table 4. The results for equation (4.1) indicate that there is no evidence that large jumps are preceded by changes in the opposite direction.[14/] Large jumps, therefore, cannot be identified as the popping of a bubble. In contrast, there is clear evidence that "profit-taking" occurred after a large jump.[15/] For a positive jump of 3 yen, for example, the results indicate that during the next segment of the day the yen/dollar rate falls by 0.5 yen. In an efficient market, it is difficult to rationalize such behavior.

V. RESPONSES TO ECONOMIC NEWS ANNOUNCEMENTS

In this section, the response of the yen/dollar exchange rate to announcements of important economic news is examined. Announcements of the money supply, industrial production, and producers (wholesale, in Japan) prices are considered for both the U.S. and Japan. Previous research in this area is extended in at least two ways. First, by considering foreign exchange trading each day in several segments throughout the world, competing hypotheses about factors which determine the exchange rate (critical fundamentals) can be better differentiated. Second, Japanese announcements are analyzed in parallel with U.S. announcements. Since the exchange rate could be influenced by either economy, parallel effects from Japanese news announcements might be expected. However, due to the differences in monetary policy rules, regulations, institutions, and economic structures, announcement effects may not be symmetric between the two countries.

The usual efficient markets model is used to estimate the response of the yen/dollar exchange rate to economic news announcements. This model may be represented as

$$X(k) = a(k) + b_1(k) \cdot SA + b_2(k) \cdot EA + e \tag{5.1}$$

where $X(k)$ = change in the yen/dollar rate in the k^{th} segment after the announcement

SA = surprise part of the announcement

EA = expected part of the announcement.

Under the null hypothesis of market efficiency, both the coefficient on the expected announced value, $b_2(k)$, and the constant should equal zero. Moreover, if the market incorporates news rapidly, the coefficient on

the surprise component of the announcement, $b_1(k)$, should equal zero in segments following that of the announcement (k=1,2,...). Alternatively, if one segment of the market either over-or-under-reacts to news, subsequent segments may exhibit significant responses.

The announcement data are defined in Appendix 1. Expected values of announcements differ depending on the country. For the U.S., expected announced values are constructed using the survey compiled by Money Market Services, Inc. In general, these survey data exhibit desirable properties in terms of their conformance with rational expectations (e.g., Pearce and Roley, 1985). For Japan, a similar survey is not available. As an alternative, a rolling vector autoregression is used, including money, industrial production, wholesale prices, and the Gensaki interest rate. The announcement surprises generated by this model are confirmed to have means insignificantly different from zero and no significant serial correlation.[16/]

A. Money Announcements

The estimated response of the yen/dollar exchange rate to weekly U.S. money announcement surprises is reported in Table 5. The response is estimated over the entire 1980-85 sample as well as several subsamples corresponding to possible changes in policy regimes in both the U.S. and Japan. In all cases, the response is estimated using equation (5.1) despite the absence of both estimated intercepts and the effects of expected money in the table. While similar estimates of the initial response in the New York market (k=0) are reported elsewhere, the results in Table 5 are obtained both for a more recent sample and for more highly disaggregated segments within a 24-hour period.

The initial response to U.S. money announcement surprises in the New York market is positive and statistically significant at the 5 percent level for the overall sample and in two of the four subsamples. In these instances, the response is consistent with the expectation of higher real interest rates in the U.S., for example, as the Federal Reserve attempts to offset a positive money surprise. The estimated response is not significant at even the 10 percent level in the February 1984 - September 1985 period, corresponding to the adoption of contemporaneous reserve requirements by the Federal Reserve. Roley (1985a) finds that the response of the 3-month Treasury bill yield also is insignificantly different from zero in the post-February 1984 period. As a consequence, it is not surprising that the response of the yen/dollar exchange rate is insignificant.

Similar to the response in the New York market, the response in the Pacific segment is statistically significant in two subsamples. These results, which have not been reported previously, indicate that the yen/dollar exchange rate does not adjust fully by 4:30 P.M. New York time to the 4:10 P.M. announcement. Instead, a response of almost equal magnitude is incorporated in the opening Tokyo quote as reflected by the response in the Pacific segment. U.S. money announcement surprises have no further effects in the subsequent Tokyo and Europe segments.

As a whole, these results suggest that U.S. monetary information has affected the yen/dollar exchange rate significantly. News from U.S. money announcements also is incorporated within three to four hours following an announcement. Moreover, constant terms are uniformly insignificant in the estimated equations, and expected money is statistically significant at the 5 percent level in only one equation. Thus, the results are broadly consistent with market efficiency.

If the Bank of Japan operates under the same policy rule as the Federal Reserve, a symmetric effect to Japanese money announcements would be expected. However, it is widely suspected that the Bank of Japan does not emphasize the money supply as its policy target. Thus, Japanese money announcements may influence the exchange rate differently.

In contrast to the U.S., money announcements are made monthly in Japan. In particular, the Bank of Japan announces every month the growth rate of the money supply for 12 months ending in the month preceding the announcement. The monthly average of M2 + CD is used for the definition of money supply.

The response of the yen/dollar exchange rate to Japanese money announcement surprises is summarized in the right-hand side of Table 5. Similar to the estimates for U.S. money announcements, intercepts and the effects of expected money are insignificant in all but one instance, consistent with efficient markets. A further question of interest is whether the coefficient on the surprise part of announcement is significant as is the case for the U.S. As is apparent in the table, a significant response of the exchange rate after the money announcement is not detected. The results therefore suggest that money announcements in Japan do not have any information value for traders about the future course of the economy or economic policies. Traders must believe that the Bank of Japan does not respond to any surprise increase or decrease in the money supply (growth rate). Thus, the money supply is apparently not a primary or intermediate target of the Bank of Japan.

B. Industrial Production Announcements

The unanticipated component of industrial production announcements could affect exchange rates through at least two channels. First,

the announcement may embody information about the future course of the economy. A surprise increase in industrial production, for example, may indicate that the future growth of the economy will be stronger than previously expected. In turn, expectations about real interest rates and capital inflows will be revised upward. As a consequence, the surprise increase would induce an appreciation of this country's currency. Moreover, the monetary or fiscal authorities may react to the industrial production surprise by implementing countercyclical policies. Under these circumstances, the effect on the exchange rate would be reinforced.

Second, a surprise increase in industrial production may imply higher future inflation which should have a depreciating effect on a country's currency. If traders think this scenario is possible, the exchange rate should depreciate at the time of the announcement.

The estimated response of the yen/dollar exchange rate to U.S. industrial production announcement surprises is exhibited on the left-hand side of Table 6.[17/] The response again is estimated using equation (5.1). Because U.S. industrial production announcements were made at either 8:30 or 9:00 A.M., the segments differ somewhat from those reported for money announcements. In particular, the initial segment in the New York market (k=0) is measured from the closing quote in the Tokyo market to the 12:00 Noon quote in the New York market. The second segment (k=1) allows for any further response in the New York market from 12:00 Noon to 4:30 P.M. The other segments are as defined previously.

During the segment in which the U.S. announcement is made, the estimated response is insignificantly different from zero at the 5 percent level. In the afternoon following the announcement, however, there

is some evidence that the dollar depreciates in response to a positive surprise, perhaps reflecting traders' assessments of increased inflation. The estimated response since February 1984 contributes significantly to this result. Nevertheless, combining the point estimates for both segments in the New York market (k=0,1), the overall response is not statistically significant. It is somewhat disconcerting, however, that the only significant response occurs at least three hours after the announcement.

Turning to industrial production announcements in Japan, the estimated response of the yen/dollar exchange rate is reported on the right-hand side of Table 6. The yen appreciates significantly in response to positive industrial production surprises in one subsample. This estimated response is consistent with traders' assessments of a stronger economy and higher real interest rates, which leads to appreciation of the yen. This behavior appears to be reasonable given the popular belief in Japan that the economic growth rate is an important policy target. The expected part of the announcement is uniformly insignificant.

C. Inflation Announcements

As was the case for money announcements, these are two main competing hypotheses concerning the response of exchange rates to a surprise in an inflation announcement. Suppose that traders believe that a surprise increase in prices is a signal of future inflation, then it has a depreciating effect on the exchange rate through Purchasing Power Parity. Alternatively, if traders think that the central bank will tighten its policy in response to a surprise price increase, the exchange rate could appreciate due to higher real interest rates and an increased inflow of capital.

The response of the yen/dollar exchange rate to inflation surprises is exhibited in Table 7. Results using producer (wholesale) prices are reported for both the U.S. and Japan in the table. Movements in producer prices are generally considered to provide more relevant information about future inflation than observed movements in consumer prices. The estimation results as a whole are broadly consistent with the efficient markets hypothesis, as the expected announced value of producer prices is significant in only one regression.

For surprises in U.S. producer prices, which again are announced at either 8:30 or 9:00 A.M., the response of the yen/dollar rate is significant at the 5 percent level in one case. In particular, the response is significantly positive in the post-February 1984 sample. It is interesting to note that this period is unique in that U.S. industrial production surprises also have significant effects, while the response to U.S. money announcement surprises is insignificant. The results suggest that both the Federal Reserve and traders shifted their focus away from the money supply and toward measures of inflation and economic activity.

For surprises in Japanese producer prices, the response of the yen/dollar rate is uniformly insignificant at the 5 percent level. This non-reaction is possible if traders think that the Bank of Japan tries to target real interest rates and/or the exchange rate. The Bank of Japan in fact appears to be more sensitive to the level of the exchange rate than the Federal Reserve. Japanese officials state quite frequently that they closely monitor the level of the yen in the foreign exchange market. The lack of response of the yen/dollar rate to money or inflation announcements therefore appears to be plausible.

VI. SUMMARY OF CONCLUSIONS

This paper examined yen/dollar exchange rate movements from a new perspective. In particular, movements in the yen/dollar rate were examined in four disaggregated segments within each business day from 1980 through 1985. This disaggregation allowed within-day movements in New York and Tokyo to be considered separately. In investigating the behavior of the yen/dollar rate during these segments, several factors were considered. First, both the volatility of the markets and the contributions of the respective markets in determining longer-run exchange rate movements were compared. Second, market efficiency was examined in terms of the random-walk behavior of very short-run movements in the yen/dollar rate. The behavior of the exchange rate immediately before and after large jumps also was investigated. Third, the relative effects of news from the U.S. and Japan were examined explicitly both with respect to possible major events behind large jumps and the response of the yen/dollar rate to particular economic announcements in both countries.

The empirical results yielded several conclusions. First, in terms of the general characteristics of daily yen/dollar movements, the data indicated that the New York market was typically more volatile, perhaps reflecting a greater presence of relevant news. Moreover, the volatility in the Tokyo market has been dramatically decreasing. Also, in the first half of the 1980s, the dollar tended to appreciate in the New York market and depreciate in the European market (Tokyo close to New York opening). In three of the four subperiods considered, the Tokyo market made virtually no contribution to annual yen/dollar rate movements.

Second, the random-walk hypothesis could be rejected in most cases. Moreover, contrary to a related hypothesis also based on efficient markets, large jumps of three yen or more were followed by significant movements in the opposite direction, indicating the presence of so-called profit-taking behavior or overshooting. Large jumps additionally could not be related to major news items in many cases.

Finally, among the economic announcements considered, U.S. money announcement surprises had the most consistent effects, at least prior to February 1984. Positive surprises were found to result in dollar appreciation. Other U.S. announcements had effects only in the post-February 1984 period, which could coincide with a change in emphasis by both traders and policymakers from money to inflation and economic activity. For Japanese economic announcements, only industrial production announcements in one subperiod exhibited significant effects on the yen/dollar rate.

As a whole, the results indicate that the source of the dollar's strength relative to the yen during the 1980-1984 period eminated from the New York market. In turn, information related to U.S. monetary policy appears to be a significant factor. European markets, however, tended to reverse the longer-run effects originating in New York. The evidence is nevertheless suggestive that U.S. economic policies and the behavior of the U.S. economy were largely responsible for the behavior of the yen/dollar rate over this period.

APPENDIX 1

Data Definitions and Sources

A. Exchange Rate Quotes

TKO = 9 A.M. quote in the Tokyo foreign exchange market

TKC = 3:30 P.M. quote in the Tokyo foreign exchange market

NYO = 9 A.M. quote in the New York foreign exchange market

NYN = 12 Noon quote in the New York foreign exchange market

NYC = 4:30 P.M. quote in the New York foreign exchange market

All quotes are in yen/dollar. Tokyo quotes were collected from a daily newspaper, Nihon Keizai Shinbun. New York quotes were obtained from the Federal Reserve Bank of New York.

B. Data Timing

Tokyo		New York		
Day	Time	Day	EST	EDT
T	9:00 A.M.(opening),TKO	T-1	7:00 P.M.(closed)	8:00 P.M.(closed)
T	3:30 P.M.(closing), TKC	T	1:30 A.M.(closed)	2:30 A.M.(closed)
T	10:00 P.M.(closed)	T	8:00 A.M.(closed)	9:00 A.M.(opening), NYO
T	11:00 P.M.(closed)	T	9:00 A.M.(opening),NYO	10:00 A.M.(open)
T+1	5:30 A.M.(closed)	T	3:30 P.M.(open)	4:30 P.M.(closing), NYC
T+1	6:30 A.M.(closed)	T	4:30 P.M.(closing),NYC	5:30 P.M.(closed)
T+1	9:00 A.M.(opening), TKO	T	7:00 P.M.(closed)	8:00 P.M.(closed)

Appendix 1 (continued)

The New York foreign exchange market, unlike its Tokyo counterpart, does not have well-defined business hours. Therefore, 9 A.M. and 4:30 P.M. quotes are only approximations of the opening and closing rates for the day.

The number of hours between opening (O) and closing (C) quotes is the following:

Tokyo (O) - Tokyo (C): 6.5 hours (with 1.5 hour lunch break)

Tokyo (C) - N.Y. (O): 7.5 hours (EST)/6.5 hours (EDT)

N.Y. (O) - N.Y. (C): 7.5 hours

N.Y. (C) - Tokyo (O): 2.5 hours (EST)/3.5 hours (EDT)

C. Japanese Announcement and Surprise Data

M2 + CD: growth rate of the monthly average of M2 + CD over the past 12 months ending two months before the announcement month. The announcement is usually made on Tuesday or Friday of the first or second week. (Source: Bank of Japan, reported in Nihon Keizai Shinbun)

IP: percentage change in the industrial production index, seasonally adjusted, for one month before the announcement month. The announcement is usually made sometime toward the end of the month. (Source: Ministry of Industry and International Trade, reported in Nihon Keizai Shinbun)

WPI: percentage change in the wholesale price index, seasonally adjusted, for one month before the announcement month. The announcement is made during the second or third week. (Source: Bank of Japan, reported in Nihon Keizai Shinbun)

The base year for WPI and IP changed during the sample period. Announced values during the old base year samples are deflated by the ratio of the new series to the old series.

Expected Values

A rolling vector autoregression model, including M2 + CD, IP, and WPI and the end of month Gensaki interest rate (3-month repurchase agreement) is used to create one-step (month) ahead predictions (expected values). The information set contains a constant and three lagged endogenous values which are available at the time of prediction. The deviations of expected values from realized values are confirmed to have zero means and no serial correlation.

D. U.S. Announcement and Surprise Data

M1: weekly change in the narrowly defined money stock, seasonally adjusted, in billions of dollars. The data are for the statement week ended about 1½ weeks previously. Each week's announcement was typically made on a Thursday or Friday. (Source: Board of Governors of the Federal Reserve System, H.6.)

IP: percentage change in the industrial production index, seasonally adjusted, for the month before the announcement month. (Source: Board of Governors of the Federal Reserve System, the Federal Reserve Bulletin.)

Appendix 1 (continued)

PPI: percentage change in the producer price index, seasonally adjusted, for the month before the announcement month. (Source: Bureau of Labor Statistics.)

Expected Values

Expectations are measured using the medians of the weekly market survey conducted by Money Market Services, Inc. The change in the 3-month Treasury bill yield during the five business days prior to an announcement is used to update the survey measure. See Roley (1983, 1985b).

APPENDIX 2

Days of Large Changes

Date	Market	Change (Yen/dollar)	Explanations Given in Newspapers
1980			
4/1	Tokyo	+3.6	Feeling of too strong yen compared with European currencies.
4/9	Europe	-6.6	Sharp decline in the dollar due to the anticipation of the peak of the U.S. interest rate.
4/10	New York	-3.8	Anticipation of the interest rate peak in the U.S. BundesBank is rumored to tighten monetary policy.
4/11	Tokyo	3.5	?
4/16	New York	-3.8	Chase Manhattan lowered the prime.
4/23	New York	-3.9	Chase Manhattan lowered the prime rate, again.
5/6	Tokyo	-3.2	Declines in the interest rates in the U.S.
5/12	Europe	-3.7	?
5/16	Europe	4.1	Ohira Cabinet, Vote of non-confidence passed in the Diet.
5/28	Tokyo	3.1	The Eurodollar interest rate bottomed. The U.S. trade deficit shrank.
12/30	Europe	-3.3	Prime rate declined in the U.S.
1981			
3/2	New York	-3.05	Reagan's tight budget address.
3/2	Pacific	3.35	(profit-taking) ??
8/4	Tokyo	-4.3	Reaction to the strengthening dollar in recent days due to an expectation of continued high U.S. interest rates. Intervention by the Bank of Japan.

Appendix 2 (continued)

Date	Market	Change (Yen/dollar)	Explanations Given in Newspapers
1981			
8/4	Europe	3.2	(profit-taking) ??
8/7	New York	-3.2	?
8/17	New York	-3.15	Unexpected increase in the U.S. Money Supply. Uncertainty about the future of the U.S. interest rate.
12/11	Pacific	3.3	Bank of Japan lowered the official discount rate. (However, the announcement came on 12/10 in the Tokyo market.) This change is over the weekend (12/11 NYC to 12/14 TYO) after the announcement. It takes 4 days to have an effect?
1982			
7/16	New York	-3.2	U.S. interest rates declined further. M1 announcement was lower than expected.
8/18	New York	3.25	Reaction (profit-taking) to the yen appreciation in the Tokyo market (+2.7) and Europe market (+2.6)? Increased likelihood of Mexican default.
8/27	Europe	4.9	Cross-arbitrage with a strengthening D. Mark.
10/7	New York	-4.4	Federal Reserve announces the relaxation of monetary policy. The monetary regime change.
11/16	Europe	-4.25	The OPEC countries investment in yen.
1983			
1/11	New York	4.0	The "Chicago speculators" sold yen.
1/24	Tokyo	3.0	Expectation about further easing of U.S. monetary policy is not materializing. (?)

Appendix 2 (continued)

Date	Market	Change (Yen/dollar)	Explanations Given in Newspapers
1983			
1/26	Tokyo	-3.0	The OPEC meeting could not produce a result (oil price increase).
2/8	New York	3.05	??
2/22	New York	3.3	Nigeria decreased its oil price more than expected. (Oil price decrease usually works as yen appreciation. Why depreciation ?)
1984			
3/2	New York	-4.5	??
1985			
2/18	Europe	5.15	??
3/19	New York	-4.55	Ohio banking crisis
3/19	Pacific	3.30	(Profit-taking)??

Footnotes

1. For discussions of both the policy anticipations and expected inflation hypotheses, see Urich and Wachtel (1981), Cornell (1983), and Roley and Walsh (1985).

2. See Ito (1986) for the effect of the December 1980 changes on covered interest parity.

3. The effects of these changes in Federal Reserve policy are considered in detail by Roley (1985a). The response of interest rates to money announcement surprises is found to change significantly over the different regimes.

4. Three more reasons for the volatility differences have been suggested to us by the Japanese traders. First, Japanese traders are on salaries, while U.S. traders are on commissions. This, however, does not explain why Japanese volatility has been decreasing. Second, the Tokyo market has a higher proportion of "real demands" than the New York market. The buy and sell orders based on real demands, that is leads and lags, may occur with the change in the level and be stabilizing, while speculative demands could be destabilizing. This explanation is at odds with the fact that the volatility has been decreasing since the abolition of the "real demand principle" in the forward market. Third, traders have self-fulfilling expectations that Tokyo is stable and New York is volatile. If the market is thought to be stable, profit-taking (and squaring the position) occurs with a small change, and loss-taking (and squaring the position) does not occur until the change becomes large. Both actions would stabilize the market. This explanation cannot, however, account for the changes which occurred over time in both of the markets.

5. This was the first time that the Japanese official discount rate was changed in February. Changes in the rate in January or February had been avoided because the budget for the next fiscal year is being formulated, and the change in the rate would jeopardize the government budget calculation.

6. French and Roll (1984) discuss the use of "per hour" volatility in the context of stock prices.

7. In fact, the variance before the per-hour correction is similar for the weekday and weekend segments. The per hour variance of the weekend segment is, therefore, about 15 to 20 times less than that of the weekday segment.

8. Since both segments extend about three hours, the comparison is immune from a possible bias from per hour correction.

9. This test is actually somewhat weaker than that implied by the random walk hypothesis in that the test does not include a = 0.

10. Observations involving national holidays in each country are deleted, but observations spanning weekends are included.

11. It might be noted that the random walk hypothesis is rejected in the Pacific market in the third and fourth subperiods, when the other markets become random walks. Combining this with the observation that the Pacific market is a random walk over the entire sample period, the result is somewhat puzzling. However, the rejection in the Pacific market in the fourth subperiod is a result of one particular outlier: March 19, 1985, when a large yen appreciation (4.55 yen) in the New York market was reversed in the Pacific market (a depreciation of 3.30 yen). (See Appendix 2.) Without this outlier, the random walk hypothesis is not rejected in the Pacific market.

12. The typical size of a predicted change can be calculated from Tables 1 and 3. Substituting the sample mean or absolute mean (Table 1) for the right-hand side variables in each of the equations (3.5) to (3.8), and using the estimated b_1, b_2, and b_3. (Table 3), the predicted changes can be calculated. The largest predicted change is -.143 for equation (3.6) in subperiod 1, using mean absolute changes.

13. The interest rate differential could be an additional factor in predicting exchange rate movements. Under the hypothesis of uncovered interest parity, the interest differential predicts the future spot rate. See Ito (1984) for the support of uncovered interest parity for the case of yen. The three-month dollar-denominated and yen-denominated interest rates were most disparate in mid-1981, at 12 percent. At a level of 230 yen, which was the case then, the interest differential predicts 0.0756 yen appreciation each day, or 0.019 yen per one segment of the day. This does not appear to be a large factor in explaining the mean absolute change of 0.7 in the second subperiod.

14. Additional segments also were included in the tests, and the same result emerged.

15. This could also be viewed as evidence of "overshooting" or "overreaction" in the market within a day.

16. Results reported in Tables 5 through 7 are robust with respect to several modifications in the data set: a change in lag length, the deletion of the Gensaki rate, or the addition of the exchange rate.

17. For both the U.S. and Japan, surprises in industrial production and producer (wholesale) prices are calculated from announced percentage changes.

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TABLE 1

Summary of Yen/Dollar Exchange Rate Movements in Four Markets

	Tokyo	Europe	New York	Pacific	Total
Entire Sample: January 1, 1980 - September 20, 1985					
Accumulated Change	14.16	-72.12	70.92	-4.65	0.60
Mean	0.00992	- 0.05447	0.04946	-0.00338	
Variance	0.63625	0.70969	0.96987	0.16079	
Mean Absolute Change	0.55923	0.59154	0.72035	0.25552	
Standard Error (Mean)	0.02111	0.02269	0.02601	0.01082	
t-statistic (Mean=0)	0.47	- 2.40*	1.90	-0.31	
Period I: January 1, 1980 - November 30, 1980					
Accumulated Change	-3.40	-29.41	1.75	10.06	-21.40
Mean	-0.01504	- 0.13553	0.00764	0.04615	
Variance	1.01821	0.88533	0.85011	0.11837	
Mean Absolute Change	0.71584	0.61544	0.62450	0.23670	
Standard Error (Mean)	0.06712	0.06387	0.06093	0.02330	
t-statistic (Mean=0)	-0.22	- 2.12*	0.12	1.98*	
Period II: December 1, 1980 - October 4, 1982					
Accumulated Change	20.42	-21.81	60.69	-4.05	56.95
Mean	0.04430	- 0.04879	0.13079	-0.00910	
Variance	0.88640	0.85735	1.15799	0.17612	
Mean Absolute Change	0.71037	0.68387	0.84356	0.25638	
Standard Error (Mean)	0.04385	0.04380	0.04996	0.01989	
t-statistic (Mean=0)	1.01	- 1.11	2.62**	-0.46	
Period III: October 5, 1982 - January 31, 1984					
Accumulated Change	-2.89	-32.47	4.33	0.13	-39.60
Mean	-0.00878	- 0.10211	0.01304	0.00041	
Variance	0.50246	0.64401	1.17537	0.17180	
Mean Absolute Change	0.50009	0.59223	0.80883	0.26912	
Standard Error (Mean)	0.03908	0.04500	0.05950	0.02395	
t-statistic (Mean=0)	-0.22	2.27*	0.22	0.02	
Period IV: February 1, 1984 - September 20, 1985					
Accumulated Change	0.03	8.57	4.15	-10.79	4.35
Mean	0.00007	0.02159	0.01015	- 0.02739	
Variance	0.25656	0.49428	0.65259	0.14925	
Mean Absolute Change	0.35143	0.47408	0.56242	0.25404	
Standard Error (Mean)	0.02495	0.03529	0.03994	0.01946	
t-statistic (Mean=0)	0.00	0.61	0.25	-1.41	

Notes: Accumulated changes are sums of all observed daily changes in the respective markets for the specified period. Because of occasional missing observations due to holidays in both countries, accumulated changes for the four markets do not necessarily add up to the total changes. If one market is closed because of a holiday, then not only that market but also the adjacent markets become missing observations. For the same reason, the numbers of observations in each segment are different even for the same subperiod. The number of observations can be calculated by dividing the accumulated change by the mean for a particular market for a particular sub-period.

* Significant at the 5 percent level. ** Significant at the 1 percent level.

TABLE 2

Volatility Per Hour

Period	Market					
			New York		Pacific	
	Tokyo	Europe	all day	9-12 only	weekday	weekend
Jan. 1, 1980 - Nov. 30, 1980	0.1476	0.1212	0.1119	0.1828	0.0519	0.0039
Dec. 1, 1980 - Oct. 4, 1982	0.1364	0.1201	0.1553	0.2063	0.0397	0.0087
Oct. 5, 1982 - Jan. 31, 1984	0.0780	0.0952	0.1579	0.1813	0.0543	0.0073
Feb. 1, 1984 - Sept. 20, 1985	0.0396	0.0716	0.0873	0.0919	0.0474	0.0036

Notes:

Variances divided by the number of hours of the respective market. The number of hours for both Europe and Pacific is different from the last Sunday in April to the last Sunday in October due to daylight savings time in the New York market. (See Appendix 1.) The reported numbers are adjusted for the difference due to daylight savings time by taking a weighted average, with the weights being the number of observations for the summer and winter, respectively.

TABLE 3

Random Walk Hypothesis

Equation	a	b_1	b_2	b_3	F/p-value
Entire Sample: January 1, 1980 - September 20, 1985					
(3.1)	-0.0084 (-0.755)	-0.0050 (-0.707)			0.499 (0.480)
(3.2)	0.0156 (0.725)	-0.0497 (-2.985)			8.912 (0.003)**
(3.3)	-0.0596 (-2.593)	0.1027 (5.411)			29.282 ($.1\times10^{-6}$)**
(3.4)	0.0359 (1.325)	0.0036 (0.162)			0.026 (0.871)
(3.5)	-0.0080 (-0.718)	-0.0221 (-1.930)	-0.0097 (-0.0731)	-0.0212 (1.513)	1.866 (0.1334)
(3.6)	0.0227 (1.070)	-0.2395 (-4.577)	-0.1086 (-5.025)	0.0722 (2.879)	18.475 ($.1\times10^{-10}$)**
(3.7)	-0.0634 (-2.780)	0.0558 (1.914)	-0.1105 (-1.936)	0.1564 (6.720)	17.427 ($.4\times10^{-7}$)**
(3.8)	0.0297 (1.112)	-0.0958 (-2.871)	0.1508 (4.486)	-0.2339 (-3.510)	14.294 ($.4\times10^{-8}$)**
Period I: January 1, 1980 - November 30, 1980					
(3.1)	0.0371 (1.542)	-0.1915 (-1.465)			2.145 (0.145)
(3.2)	-0.0053 (-0.078)	-0.0648 (-1.166)			1.359 (0.245)
(3.3)	-0.1425 (-2.214)	0.1925 (3.537)			12.507 (0.001)**
(3.4)	0.0108 (0.169)	0.1131 (2.553)			6.518 (0.011)*
(3.5)	0.0356 (1.501)	-0.0958 (-3.457)	-0.0398 (-1.566)	0.0526 (2.048)	4.4734 (0.005)**
(3.6)	0.0269 (0.385)	-0.3846 (-1.966)	-0.2128 (-2.900)	0.0870 (1.223)	4.4765 (0.005)**
(3.7)	-0.1372 (-2.120)	0.1455 (2.181)	-0.0365 (-0.191)	0.2632 (3.597)	5.3737 (0.001)**
(3.8)	-0.0015 (-0.025)	-0.1502 (-2.411)	0.3776 (6.293)	-0.2084 (-1.210)	15.3692 ($.5\times10^{-8}$)**

Period II: December 1, 1980 - October 4, 1982					
(3.1)	-0.0188	0.0371			9.157
	(0.923)	(3.026)			(0.003)**
(3.2)	0.0542	-0.0685			4.858
	(1.204)	(-2.204)			(0.028)*
(3.3)	-0.0643	0.0845			6.993
	(-1.447)	(2.644)			(0.009)**
(3.4)	0.1082	-0.0790			4.321
	(2.102)	(-2.078)			(0.038)*
(3.5)	-0.0153	0.0285	0.0708	0.0204	4.208
	(-0.749)	(1.497)	(3.229)	(0.957)	(0.006)**
(3.6)	0.0684	-0.1302	-0.1418	0.0479	5.046
	(1.523)	(-1.220)	(-3.373)	(0.981)	(0.002)**
(3.7)	-0.0734	0.0300	-0.1161	0.1549	5.082
	(-1.658)	(0.635)	(-1.113)	(3.796)	(0.002)**
(3.8)	0.0971	-0.1432	0.0363	-0.4294	6.486
	(1.910)	(-2.600)	(0.675)	(-3.552)	(0.0003)**
Period III: October 5, 1982 - January 31, 1984					
(3.1)	-0.0066	-0.0260			2.800
	(-0.269)	(-1.673)			(0.095)
(3.2)	-0.0029	-0.0445			2.382
	(-0.073)	(-1.544)			(0.124)
(3.3)	-0.0982	0.1102			10.113
	(-2.181)	(3.180)			(0.002)**
(3.4)	0.0051	0.0298			0.279
	(0.084)	(0.528)			(0.598)
(3.5)	-0.0159	0.0086	-0.1163	-0.0018	5.025
	(-0.653)	(0.383)	(-3.849)	(-0.053)	(0.002)**
(3.6)	0.0058	-0.3153	-0.0604	0.0500	6.157
	(0.150)	(-3.443)	(-1.709)	(1.020)	(0.0004)**
(3.7)	-0.1023	0.0062	-0.1645	0.1784	7.161
	(-2.302)	(0.098)	(-1.558)	(4.374)	(0.0001)**
(3.8)	0.0054	-0.0107	0.1363	-0.2143	1.939
	(0.089)	(0.141)	(1.577)	(-1.487)	(0.123)

Period IV: February 1, 1984 - September 20, 1985

(3.1)	-0.0299 (-1.508)	-0.0426 (-2.641)			6.975 (0.009)**
(3.2)	-0.0011 (-0.044)	-0.0100 (-0.410)			0.168 (0.682)
(3.3)	0.0219 (0.601)	0.0608 (1.488)			2.213 (0.138)
(3.4)	0.0006 (0.014)	0.0255 (0.556)			0.310 (0.578)
(3.5)	-0.0307 (-1.573)	-0.1112 (-4.524)	-0.0210 (-0.758)	0.0620 (1.617)	7.328 (0.0001)**
(3.6)	-0.0116 (-0.460)	-0.2467 (-3.725)	-0.0602 (-1.864)	0.0869 (2.430)	7.233 (0.0001)**
(3.7)	0.0177 (0.485)	0.0754 (1.027)	-0.0804 (-0.818)	0.0676 (1.435)	1.578 (0.194)
(3.8)	0.0014 (0.034)	-0.0336 (-0.567)	0.1542 (1.822)	0.0135 (0.122)	1.191 (0.313)

Notes: Equation numbers correspond to those in the text. Numbers in parentheses below the coefficient estimates are t-statistics.

* Significant at 5 percent level.
** Significant at 10 percent level.

F = F-statistic, $H_0 : b_1 = b_2 = b_3 = 0$.

TABLE 4

Jumps, Bubbles, and Profit-Taking

Number of Days with More than 3 yen Absolute Change

	Tokyo	Europe	New York	Pacific
Jan. 1, 1980 - Sept. 20, 1985	7	8	14	3
Jan. 1, 1980 - Nov. 30, 1980	4	3	3	0
Dec. 1, 1980 - Oct. 4, 1984	1	3	5	2
Oct. 5, 1984 - Jan. 31, 1984	2	1	4	0
Feb. 1, 1984 - Sept. 20, 1985	0	1	2	1

Estimation Results

	Coefficient Estimates		Summary Statistics		
Equation	a	b	$\bar{R}^2$	SER	DW
(4.1)	-0.566 (-0.790)	-0.422 (0.950)	0.003	3.87	2.53
(4.2)	0.143 (0.691)	-0.169** (-3.128)	.221	1.16	1.90

Notes: See the notes in Table 3.

DW = Durbin-Watson statistic.

SER = standard error.

$\bar{R}^2$ = multiple correlation coefficient corrected for degrees of freedom.

TABLE 5

Response to Money Announcement Surprises

Response Coefficient $b_1(k)$ Estimates

	U.S.				Japan			
Sample	k=0 New York	k=1 Pacific	k=2 Tokyo	k-3 Europe	k=0 Tokyo	k=1 Europe	k=2 New York	k=3 Pacific
80:1 - 85:9	0.11* (6.22)	0.08* (5.05)	0.01 (0.23)	-0.02 (-0.82)	0.05 (0.35)	-0.06 (-0.33)	0.02 (0.11)	-0.03 (-0.23)
80:1 - 80:11	0.05 (1.57)	0.02 (0.50)	0.06 (0.78)	0.08 (1.31)	-0.77 (-1.01)	-0.22 (-0.34)	0.59 (0.61)	0.30 (1.02)
80:12- 82:10	0.14* (4.93)	0.12* (4.07)	0.01 (0.18)	-0.04 (-1.01)	0.12 (0.77)	-0.10 (-0.38)	-0.12 (-0.44)	-0.08 (-0.82)
82:10- 84:1	0.14* (3.22)	0.10* (3.04)	-0.03 (-0.61)	-0.09 (-1.48)	1.14 (1.65)	0.19 (0.24)	0.84 (0.82)	-0.44 (-0.52)
84:2 - 85:9	0.05 (1.49)	0.01 (0.67)	-0.00 (-0.02)	-0.00 (-0.09)	-0.52 (-1.00)	-0.21 (-0.31)	-0.38 (-0.82)	0.45 (1.13)

Notes: See the notes in Table 3. Equation (5.1) is used to obtain response coefficient estimates. For U.S. money announcements, the response in the New York market is measured from 12:00 Noon to 4:30 P.M. For Japanese money announcements, the response in the New York market is measured from 9:00 A.M. to 4:30 P.M.

TABLE 6

Response to Industrial Production Announcement Surprises

	Response Coefficient $b_1(k)$ Estimates								
	U.S.					Japan			
Sample	k=0 New York	k=1 New York	k=2 Pacific	k=3 Tokyo	k=4 Europe	k=0 Tokyo	k=1 Europe	k=2 New York	k=3 Pacific
80:1 - 85:9	0.50 (1.37)	-0.40* (-2.18)	0.18 (1.43)	0.14 (0.62)	0.63 (1.93	-0.05 (-0.79)	0.01 (0.11)	0.07 (0.62)	0.06 (1.93)
80:1 - 80:11	-0.80 (-1.14)	-0.04 (-0.13)	0.00 (0.00)	0.60 (1.27)	0.02 (0.05)	-0.09 (-0.60)	-0.02 (-0.17)	-0.04 (-0.29)	0.06 (1.95)
80:12- 82:10	0.71 (1.47)	-0.43 (-1.45)	0.13 (1.34)	0.04 (0.11)	0.73* (2.40)	0.04 (0.28)	0.16 (0.61)	0.28 (1.28)	0.05 (0.90)
82:10- 84:1	0.21 (0.18)	0.11 (0.24)	0.58 (1.29)	-0.05 (-0.12)	0.04 (0.05)	-0.31 (-3.33)*	-0.01 (-0.04)	0.07 (0.23)	0.15 (1.74)
84:2 - 85:9	1.14 (1.25)	-1.36* (-3.08)	0.06 (0.21)	0.61 (1.29)	1.47 (1.20)	0.09 (0.65)	-0.03 (-0.29)	0.09 (0.48)	0.02 (0.21)

Notes: See the notes in Table 3. Equation (5.1) is used to obtain response coefficient estimates. For U.S. announcements, the initial response in the New York market (k=0) is measured from the closing quote in Tokyo to the 12:00 Noon quote in New York. The response in the subsequent segment (k=1) is measured from 12:00 Noon to 4:30 P.M. in New York. For Japanese announcements, the response in the New York market is measured from 9:00 A.M. to 4:30 P.M.

TABLE 7

Response to Inflation Announcement Surprises

	Response Coefficient $b_1(k)$ Estimates								
	U.S.					Japan			
Sample	k=0 New York	k=1 New York	k=2 Pacific	k=3 Tokyo	k=4 Europe	k=0 Tokyo	k=1 Europe	k=2 New York	k=3 Pacific
80:1 - 85:9	0.21 (0.48)	-0.24 (-0.87)	0.09 (0.49)	0.45 (1.47)	-0.00 (-0.00)	-0.58 (-0.46)	-0.37 (-1.79)	-0.07 (-0.35)	-1.00 (-0.74)
80:1 - 80:11	0.07 (0.11)	0.03 (0.08)	0.15 (0.65)	0.11 (0.17)	0.42 (1.68)	-0.14 (-0.41)	-0.27 (-0.95)	-0.15 (-0.93)	0.04 (0.33)
80:12- 82:10	0.31 (0.30)	0.32 (0.60)	0.12 (0.23)	0.49 (0.74)	0.30 (0.28)	0.15 (0.45)	-0.41 (-1.44)	-0.37 (-0.65)	-0.42 (-1.08)
82:10- 84:1	-0.86 (-0.86)	-1.00 (-1.24)	0.08 (0.27)	1.27 (1.33)	-1.80 (-1.23)	-0.03 (-0.12)	-0.96 (-1.53)	-0.02 (-0.03)	-0.13 (-0.48)
84:2 - 85:9	1.38* (1.98)	-0.42 (-0.94)	0.04 (0.09)	0.23 (0.58)	-0.51 (-0.35)	-0.12 (-0.31)	-0.62 (-0.67)	-0.01 (-0.02)	0.42 (1.03)

Notes: See the notes in Table 6.