Journal of Economic Integration
17(3), September 2002; 449-473

Empirical Analysis of the Psychological Hypothesis on Exchange Rate Determination and Testing Its Forecastability: The Korean Experience

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Abstract

The role of psychological impact is examined by investigating the determination of exchange rates, especially the U.S. Dollar. It has been applied to the Korean economic crisis which occurred between January 1997 and June 1999. The basic idea is that psychological information can be used in generating rational expectation, and accordingly, it would induce exchange market clearance. While psychological hypothesis is weakly supported, results reveal that the U.S. Dollar can be determined by psychological impact. The ex-post simulation process also proves it. The understanding of psychological impact is necessary for the implementation of foreign exchange policies.

• **JEL Classifications:** C32, F41

• **Key Words:** Market Sentiment, Psychological Hypothesis, GARCH-M Model

I. Introduction

As the world economy continuously moves toward on open system, the exchange rate plays an important role along with fundamental economic variables such as income, price, unemployment and trade balance in describing and analyzing the macroeconomic system. A number of economists has thoroughly investigated foreign exchange rates. In the original research, the exchange rate was determined by using the real sector which is based upon the trade balance, and

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concluded that the terms of trade are a key factor in determining exchange rates. This was because the real sector was more heavily weighted than the financial sector in this era. It reflected that the real sector which is connected to trade balance dominated international trade flow. Accordingly, purchasing power parity has long been adopted for exchange rate determination. Since purchasing power parity is calculated by the differences in general price level which comes from the real sector, usually non-tradable goods, it seems to be in line with the traditional approach.

As the share of the financial sector is gradually more weighted, the exchange rate is influenced by the interest rate parity, and it is developed to the portfolio balance approach. Foreign currency becomes a part of the assets, and it is allocated with other assets. In this case, fundamental macroeconomic variables such as money stock, interest rates, and real income influence the determination of exchange rates. Therefore, the investor is trying to maximize the return by optimally allocating investor's assets. Depending upon this approach, the analysis and forecasting of the exchange rates could not be possible without understanding the fundamental macroeconomic variables. All the previous works in this literature, however, mainly deal with long-run analysis. While the overshooting model induced an expected change in the exchange rate determination, it attempted to evaluate short-run and long-run path, simultaneously. However, the overshooting model does not provide sufficient ways to evaluate short-run analysis in exchange rate determination.

Many economists tried to find a formula to overcome it by using non-economic factors. This is completely understandable due to the fact that the exchange market is so sensitive and easily affected by non-economic fundamental variables. The economic news model is chosen as an alternative. But, such an attempt has not fulfilled the forecasting of the exchange rate determination in the short-run either. In light of this, market sentiment is emphasized in this literature. As most economists acknowledged, Asian foreign exchange markets, including Korea, suffered from a severe disequilibrium a few years ago. Such a situation provided an excellent opportunity for the evaluation of the market sentiment because the psychological impact was dramatically apparent in the foreign exchange markets of Asian countries during this period. The research covers materials from January 1997 to June 1999 and reflects the economic crisis which happened in the second half of 1997. This paper consists of the following sections. Section II is a review of literature concerning economic analysis and psychology. Section III provides a

theoretical background, and Section IV discusses empirical results. The conclusion and its policy implication are in Section V.

II. Literature Reviews

Many economists have researched the psychological impact on economic behavior, and some of them have been quite successful in developing stylized fact of models by using a number of theoretical works. They are based on in consumer's behavior, decision making and investment decision. Lewin (1996), Rabin (1998), Earl (1990), Hogarth and Reder (1986) reviewed the relationship between economics and psychology. Lewin (1996) insisted that psychologists and institutionalist economists attacked the unscientific nature of economics due to the lack of psychological influences in economic analysis. Rabin (1998) concluded that psychology systematically explores human judgment, behavior, and well-being, and it can teach us an important lesson about how humans differ from the way they are traditionally described by economists. Standard economics assumes that each person maximizes stable and coherent preferences given rationally formed probabilistic beliefs, but psychological research teaches us ways to describe preferences more realistically about biases in belief formation and about ways it is misleading to conceptualize people as attempting to maximize stable, coherent, and accurately perceived preferences. Earl (1990) reviewed recent literature that integrates economics and psychology, contrasting economists' views of rationality with psychologists' research on how expectations and actions are affected by problems of cognition. The discussion of the relevance of motivational theories follows a review of literature on decision procedures used for evaluating alternatives in situations of complexity. Hogarth and Reder (1986) explained that the paradigm of rational choice provides economics with a unity that is lacking in psychology. In the study of choice behavior, the two disciplines differ concerning scope of phenomena, object of study, and data considered relevant. Psychologists are interested in different types of individual process data. Despite these differences, the study indicated that each discipline could benefit from considering the alternative perspective.

Simon (1986) and Smith (1991) revealed the relationship between rationality and psychology. Simon (1986) asserted that the assumption that an individual maximizes subjective economic rationality provides only a small part of the premise in economic reasoning, and often not the essential part. The remainder of

the premise is auxiliary empirical assumptions about individual's utilities, beliefs, expectations, and the like. Making these assumptions correctly requires an empirically founded theory of choice that specifies what information decision makers use and how they actually process it. This behavioral empirical base is largely lacking in contemporary economic analysis, and formulating it is essential for enhancing the explanatory and predictive power of economics. Smith (1991) believed a problem existed between economic theory and the falsifying evidence of psychology. Most standard theory provides a correct first approximation in predicting motivated behavior in laboratory experimental markets, but the theory is incomplete, particularly in articulating convergence processes in time and in ignoring decision cost. Furthermore, Anderson and Goldsmith (1994) dealt with the forecasting based on a psychological variable. Aftalion was the pioneer in using psychological factors in exchange rate determination (Baudin (1957)). Aftalion was the first to pay attention to the psychological impact in the foreign exchange market. However, no further empirical research has been done due to the fact that the quantifying of qualitative data is not easily feasible. Hopper (1997) described the importance of psychological impact in economic analysis. Hopper (1997) minutely analyzed market sentiment in the exchange rate determination. The news about the fundamentals can be defined as the difference between what market participants expect the fundamentals to be and what the fundamentals actually are once their values are announced. Hopper (1997) insisted that the alternative view is that exchange rates are determined, at least in the short-run period of less than two years, by the market sentiment. Under this view, the exchange rate is the result of a self-fulfilling prophecy. The participants in the foreign exchange market expect a currency to be a certain level in the future. When they act on their expectations, it ends up at the predicted level confirming their expectations. So it seems reasonable to try to understand the psychology of the foreign exchange market to improve forecasts of the short-run exchange rate determination.

III. Theoretical Background

A. Forming Psychological Variable

The basic idea in analyzing the psychological impact of the exchange rate determination is the transformation of qualitative data to a quantitative one. Frey and Eichenberger (1991) are the pioneers in this field of study. Frey and Eichenberger (1991) insist that cognitive psychology and experimental economics

indicate that under identifiable conditions individuals do not act in an economically rational way. Also, economic markets do not fully eliminate anomalies in the aggregation process. Moreover, institutions can partially be interpreted as endogenously emerging as a result of individuals demands to cope with anomalies. According to Frey and Eichenberger (1991), psychological impact is shown in through diversified aspect. Such as reference point effect, sunk cost effect, endowment effect, framing effect, availability bias, representativeness bias, opportunity cost effect, and certainty effect. Based upon this, Fishbein and Ajzen (1975) developed the detailed formula of equation (1), and it enables to empirical analysis in this field.

$$B \fallingdotseq BI = \left(\sum_{i=1}^{n} b_i e_i \right) w_i + \left(\sum_{j=1}^{N} NB_j MC_j \right) w_j \qquad (1)$$

where, B: overt behavior

BI: behavioral intentions

The equation (1) consists of a few coefficients. The b_i is the consumer's view of the likelihood that performing the activity will result in the consequence i. The e_i is the consumer's evaluation of outcome i's goodness or badness. The NB_j is the person's assessment of whether referent j thinks it should chose to undertake the activity. The MC_j is the person's motivation to comply with referent j's opinion. The n is the number of salient beliefs the person holds about performing the activity. As Miller (1956) asserted, the major group i in forming BI is usually assumed to be 7±2. The N is the number of other people whose opinions matter to the decision maker in the context question. The w_i and w_j are the weights that the analysis may estimate empirically using regression techniques, respectively.

B. Application to Exchange Rate Determination

The key exchange rate in the foreign exchange market in Korea is, of course, the U.S. Dollar. Therefore, understanding the determination of the U.S. Dollar is necessary to figure out the Korean foreign exchange market. Equation (1) can be modified to comply with exchange rate determination. PSY_t in equation (2) is an information matrix which captures the psychological impact of the U.S. Dollar on the foreign exchange market. The b_i in equation (1) can be replaced by $D \cdot \Delta EX_i$, where D is a dummy variable obtained from the news about economic fundamentals, and ΔEX_i is the first-differenced variable of the exchange rate in major group i. The e_i

could be set to 1 because the goodness or badness of the news is already reflected in the direction of its volatility. Also, NB_jMC_j in equation (1) can be replaced by $D \cdot \Delta EX_i$, the first-differenced variable of the exchange rate in minor group *j*, in forming a psychological variable. The weights w_i and w_j can be replaced by the correlation between the U.S. Dollar and the first-differenced exchange rates. The weighted average is used by the $\overline{X_w} = \frac{\Sigma w_i X_i}{\Sigma w_i}$ scheme. Following Miller (1956), the number of *n* is 5, 7, and 9, respectively. It may provide an optimal number of major group. Equation (1) is reorganized as

$$PSY_t = \left(\sum_{i=1}^{n} D \cdot \Delta EX_{it} \right) w_i + \left(\sum_{j=1}^{N} D \cdot \Delta EX_{jt} \right) w_j \qquad (2)$$

In equation (2) all the behavior for psychological impact created in the foreign exchange market toward the U.S. Dollar are included in the formula.

1) Non-Economic Fundamental Factor

To formulate a dummy variable which induces psychological impact, news about economic fundamentals that is not directly related to fundamental macroeconomic variables is used. The dummy variable comes from news about economic fundamentals which has sufficient impact to generate psychological information. The number of news items is summarized in Table 1. The number of news items from January 1997 to June 1997 is comparatively low. But, it has sharply increased since then, and it reached a high of 10 items in November 1997. The number of news items about economic fundamentals is concentrated after July 1997. This is because the economic crisis was initiated at this time.

Table 1. Number of news items about economic fundamentals

Month	No. of Events	Month	No. of Events	Month	No. of Events
1997. 1	4	1997. 11	10	1998. 9	6
1997. 2	0	1997. 12	8	1998. 10	5
1997. 3	4	1998. 1	9	1998. 11	6
1997. 4	0	1998. 2	8	1998. 12	5
1997. 5	4	1998. 3	6	1999. 1	5
1997. 6	1	1998. 4	3	1999. 2	7
1997. 7	5	1998. 5	8	1999. 3	6
1997. 8	4	1998. 6	6	1999. 4	6
1997. 9	4	1998. 7	7	1999. 5	4
1997. 10	5	1998. 8	7	1999. 6	8

2) Selecting Exchange Rates

The number of officially transacting foreign exchange rates is 29, including the U.S. Dollar, in Korea. Except for the U.S. Dollar, 28 of the first-differenced exchange rates are counted in forming a psychological information matrix. Depending upon the degree of correlation between the U.S. Dollar and the major group i is selected. The correlations are calculated by the first-differenced variables. In general, substitution among the exchange rate existed. The correlation can be replaced as a substitution factor. The weights ω_i and ω_j are replaced by using the correlation with the first-differenced U.S. Dollar. Daily data will be used for this analysis, and the source of the data is the Bank of Korea.

3) Exchange Market Clearance and Psychological Hypothesis

To evaluate psychological hypothesis in the foreign exchange market, rational expectation could be adopted to identify the foreign exchange market clearance. In this framework, it can be assumed that the psychological impact enables it to clear the market. It implies that the deviation will disappear or be taken care of by the psychological impact. It is assumed that the U.S. Dollar in the foreign exchange market is solely cleared by the psychological variable. According to Maddala (1992), rational expectation can be illustrated as follows.

$$y_t^* - y_{t-1}^* = \lambda(y_{t-1} - y_{t-1}^*) \tag{3}$$

where, y_t^* : variable with rational expectation
y_{t-1}^* : the first-differenced variable of observations
λ : speed of adjustment

In equation (3), the λ is in a range of $0 < \lambda < 1$. It gets a higher value if y_t^* and y_{t-1} approach faster. Also, prediction error can be expressed like equation (4). Statistical characteristics of define the rational expectation.

$$\varepsilon_t = y_t - y_t^*$$

$$E[e_t] = 0 \tag{4}$$

Empirically, the rational expectation is characterized by the estimated coefficient $\hat{\alpha}$ and statistical characteristics of ε_t in equation (5). If the market is sufficiently satisfied with the rational expectation, then $\hat{\alpha}$ approached to a unity, and ε_t is applicable to identically independently distributed or Gaussian white noise.

$$y_t = \alpha y_t^* + \varepsilon_t \tag{5}$$

The most crucial factor is the definition of y_t^* in the following equation (6). Here, I_t is an information matrix which contains all the information to generate the rational expectation value, y_t^*. To generate y_t^* or expected value, conditional probability of y_t is conditioned by lagged information matrix. Equation (2) could be a psychological information matrix generating the expected value of the key exchange rate, in this case, the U.S. Dollar.

$$y_t^* = E[y_t | I_{t-1}] \tag{6}$$

4) Econometric Methodology

The data obtained from the foreign exchange market is commonly has heteroscedasticity in it. It implies that the information at t-n period in the data is easily transferred to the next period. Also, uncertainty in the market is highly observed. The ARCH (Autoregressive Conditional Heteroscedasticity) model was introduced into econometric literature by Engle (1982) and was subsequently generalized by Bollerslev (1986) who proposed the generalized ARCH or GARCH (Generalized Autoregressive Conditional Heteroscedasticity) model. The development of the ARCH model by Engle (1982) and the GARCH model by Bollerslev (1986) enabled economists to figure out the foreign exchange market. The GARCH model incorporated infinite lagged variables in the analysis. Also, the GARCH-M model explains that conditional heteroscedasticity is generated based upon the mean. It implies that the model assumes a non-zero mean of the data.

Other related models, where the conditional variance of ε_t is used as one of the regressors explaining the conditional mean of y_t, have also been suggested in the literature and are known as ARCH-M or GARCH-M model (Engle *et al.* (1987) and Bollerslev *et al.* (1992)). The various members of the GARCH and GARCH-M models can be written as follows.

$$y_t = \beta' x_t + \gamma h_t^2 + \varepsilon_t \tag{7}$$

where,

$$h_t^2 = V[\varepsilon_t | \Omega_{t-1}] = E[\varepsilon_t^2 | \Omega_{t-1}] = \alpha_0 + \sum_{i-1}^{a} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_i h_{t-j}^2 \tag{8}$$

and Ω_{t-1} is the information set at time $t-1$, containing at least the observations of

x_t and on lagged values of y_t and x_t. Namely Ω_{t-1} is equal to $(x_t, x_{t-1}, x_{t-2}, ..., y_{t-1}, y_{t-2}, \dots)$. The unconditional variance of ε_t is constant because $V[\varepsilon_t] = \lim_{s \to \infty} E[e_{t+s}^2 \mid \Omega_{t-1}]$ and is formulated by

$$V[\varepsilon_t] = \sigma^2 = \frac{a_0}{1 - \sum_{i=1}^{q} \alpha_i - \sum_{j=1}^{p} \beta_i} > 0 \tag{9}$$

and the necessary condition for equation (7) to have a stationary covariance is given by

$$\sum_{i=1}^{q} \alpha_i + \sum_{j=1}^{p} \beta_i < 1 \tag{10}$$

In addition to the restrictions in equations (9) and (10), Bollerslev (1986) also assumes $\alpha_i \geq 0$, i=1, 2,..., q and $\beta_i \geq 0$, i=1, 2,..., p. Although these additional restrictions are sufficient for the conditional variance to be positive, they are not necessary (Nelson and Cao (1992)). It also has to be satisfied that other variables could influence h_t^2.

$$h_t^2 = \omega + \sum_{i-1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_i h_{t-j}^2 + \mu_i \tag{11}$$

The μ_t is a vector of covariance with stationary variables in Ω_{t-1}.

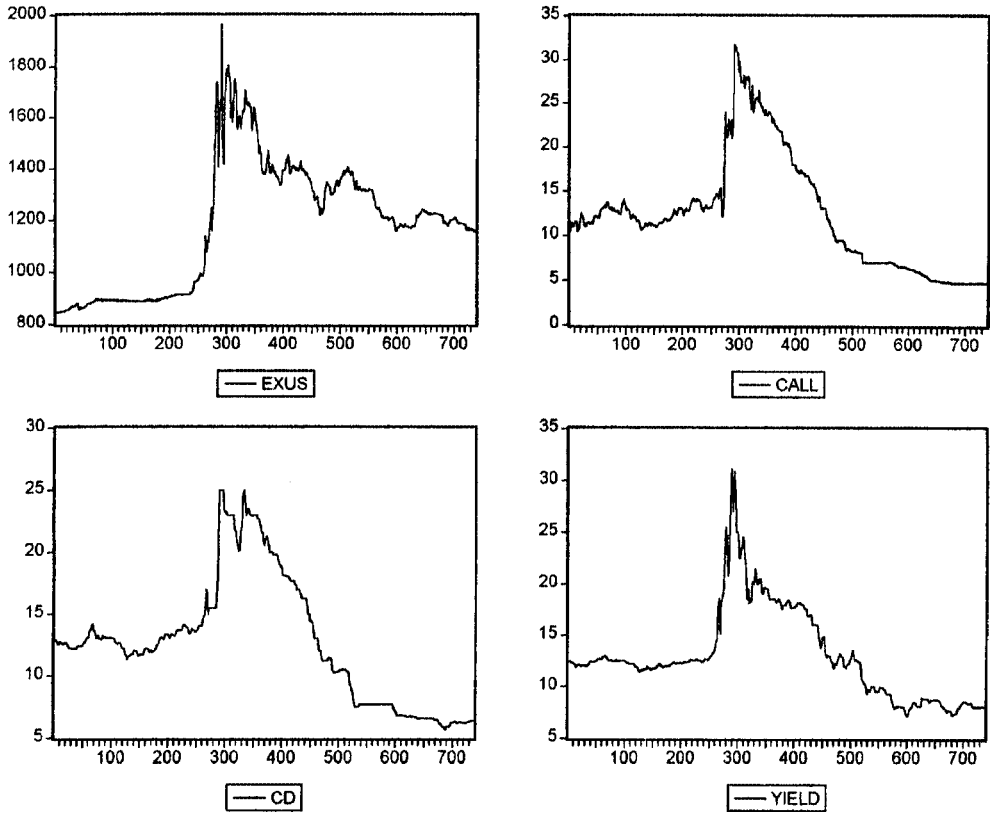
IV. Empirical Results

A. Bubble or Psychology?

As long as economic variables deviate from their fundamental values, it has to be defined whether the source of the deviation comes from a bubble or any other factor, such as psychological impact. The analysis on the bubbles in economic variables was performed by Ohanian (1996), Diba and Grossman (1988). Ohanian (1996) presented an analysis of the volatility of security prices to identify the bubbles. The research looked at whether movements in asset prices reflect changes in the fundamental value of the assets or whether these extreme price changes might be associated with changes in market psychology that may not be related to business conditions. The bubbles are defined as any deviation of the asset price from its fundamental value. However, certain types of bubbles can be difficult to

explain in a sensible way because they are similar to Ponzi schemes. Ohanian (1996) introduced variance bounds tests which were originally developed by Shiller (1989). The test compares the volatility of the observed security price with the volatility of the fundamental price. Ohanian (1996) even suggested the test could be applicable to bond and foreign exchange markets. However, this practice leads to difficulties in evaluating whether market fundamentals are consistent with prices. On the other hand, Diba and Grossman (1988) insisted that the growth rate trend should be counted. First of all, the revealed deviation from the fundamental values in the exchange market has to be characterized because the bubbles and the psychological impact are shown as the same format. Depending upon the daily data availability, the interest rate is selected as a representative variable of the fundamental ones. If there exists any relationship in the long-run, the bubble hypothesis can be tentatively excluded, and the deviation should be counted as psychological impact. To identify it, Figure 1 and 2 depict the trend of level and

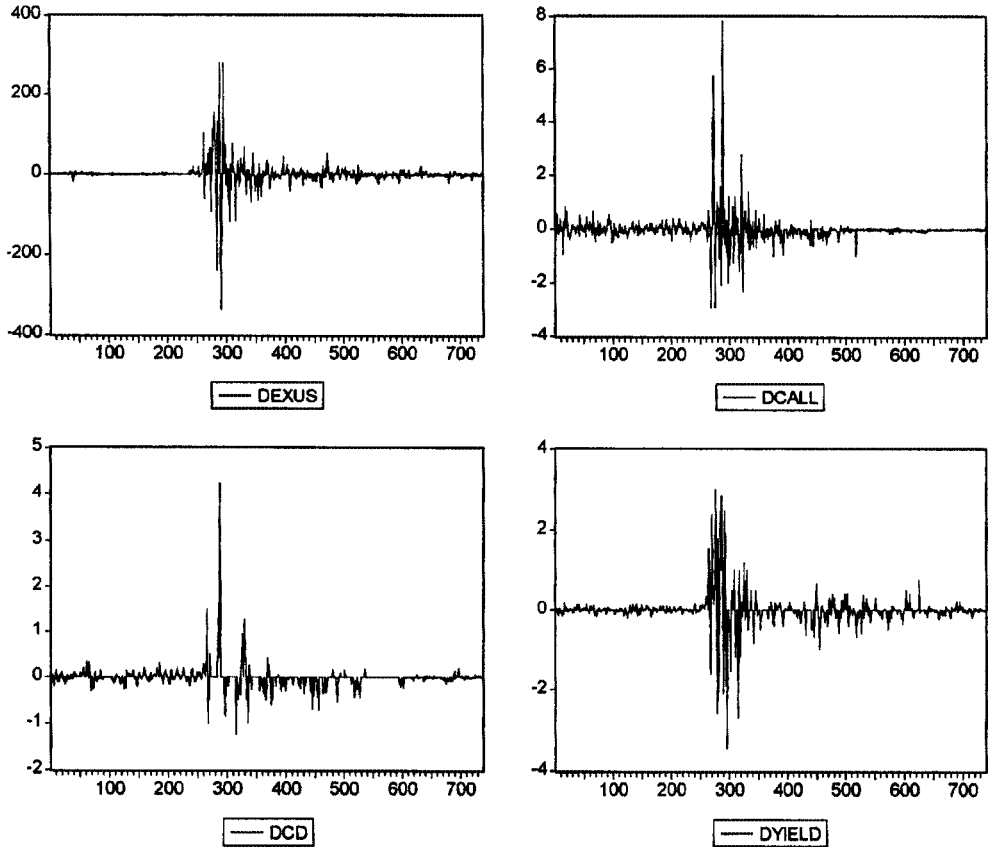
Figure 1. Trend of the U.S. Dollar and Interest Rates (Level).



the first-differenced of Won per the U.S. Dollar, and short-run (call market), mid-run (CD), and long-run (yield on equity) interest rates, respectively.

Figure 1 depicts the trend of the level, and Figure 2 shows the trend of the first-differenced. As shown in Figures 1 and 2, all the trends have the same shapes. It indicates that the exchange rate moves upward as interest rates go up and vice versa. In other words, the exchange rate is depreciated when interest rates are rising up. Following the monetary approach on exchange rate determination, the exchange rate has to be appreciated when the interest rate goes up. Once this happens, the capital inflows to the home country to get the benefit from the increasing in the interest rate, and accordingly the home currency changes to a strong money. The Korean case seems to be opposite of this proposition. The Keynesian approach explains that if the exchange rate goes up, the economic activities in the domestic market slowdown because of reduced investment due to

Figure 2. Trend of the U.S. Dollar and Interest Rates (First Differenced).



higher capital cost. The loss of competitiveness of the home country's products follows and, tentatively the home currency is depreciated. Brief review concludes that the Korean exchange market closely followed the Keynesian proposition, regardless of the short-run, mid-run, and long-run.[1] Therefore, it can be concluded that there does not exist the bubbles in the Korean foreign exchange market because the exchange rate has a steady relationship with fundamental macro-economic variables. If the deviation exists, it comes from another factor and not bubbles. Also, it allowed the study to focus on the psychological impact causes.

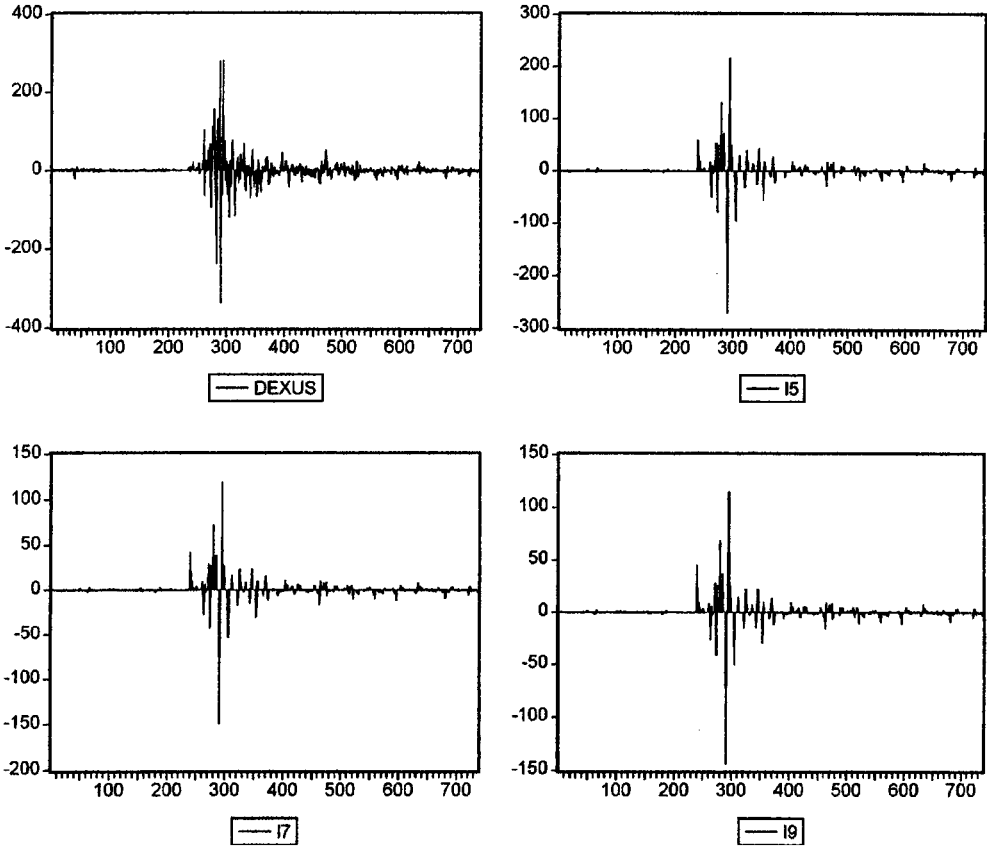
B. The Impact of Psychological Information

To figure out psychological impact, the information matrix which contains psychological factor has to be set up. The information matrix can be derived by using equation (2). Figure 3 shows the shapes of the information matrix with psychological impact. The psychological impact is abstracted from the fluctuation of $\Delta EXUS_t$.

Following Miller(1956), $\Delta EXUS_t$ and the three cases of psychological information matrix are analyzed. For the specific cases, a high level of psychological impact is chosen. They are based on $\left(\frac{PSY}{\Delta EXUS_t}\right)_t > 2$, and 17 cases were selected. In these cases, the psychological impact is two times stronger compared with the changing of $\Delta EXUS_t$ in an absolute value. It implies that the psychological impact was too strong in these cases. The direction of the $\Delta EXUS_t$ change and the psychological information matrix is randomly alternated. There does not exist a unique solution, and the direction is not matched. It looks like the supply and demand sides are affected in different ways. It can be assumed that the positive psychological impact brings an increase in $(\frac{₩}{\$})$ and means it is depreciated. If the foreign exchange market faces a positive psychological impact, the demand for the U.S. Dollar will increase and it changes to a strong money. Whereas, the Korean Won changes to a weak money, or the Korean Won is depreciated. As far as the supply side is concerned, if a positive psychological impact induces a change in the exchange market, holding the U.S. Dollar brings a benefit. It accordingly leads to a decreasing in the supply of the U.S. Dollar. Altogether, demand and supply sides may have the same direction. Definitely a

[1]The results obtained by residual based method of cointegration technique (ADF and PP tests) support it. The U.S. Dollar and short-run, mid-run, and long-run interest rates are represented as I(1) series. The cointegration technique by Johansen-Juselius methodology reveals that there exists cointegrating vector in each case, as well.

Figure 3. Psychological Information.



negative psychological impact will work the other way around. In Table 2, 11 out of 17 cases follow this manner. It is tentatively concluded that the impact of psychological factors is not easily characterized.

During the entire period of the analysis, the highest deviations between $\Delta EXUS_t$ and the psychological information matrix, where both $\Delta EXUS_t$ and the psychological matrix drastically fluctuated were on December 27, 1997(–) and on January 3, 1998(+). These cases are in Figure 4. Figure 4 depicts from November 1, 1997 to April 30, 1998 which is a high fluctuation period. The psychological impacts are highly fluctuated in this period. PSY_t and $\Delta EXUS_t$ both fluctuated, but the deviation between them is not that serious.

Most of psychological impact was reflected in the changing of $\Delta EXUS_t$, and it is in Figure 5. It was recorded on August 22, 1997. On that day, the news about economic fundamentals called “foreign credit status is in a severe condition”. The date was the beginning of the economic crisis, and therefore it seems to have

Table 2. Some Special Cases of Psychological Information

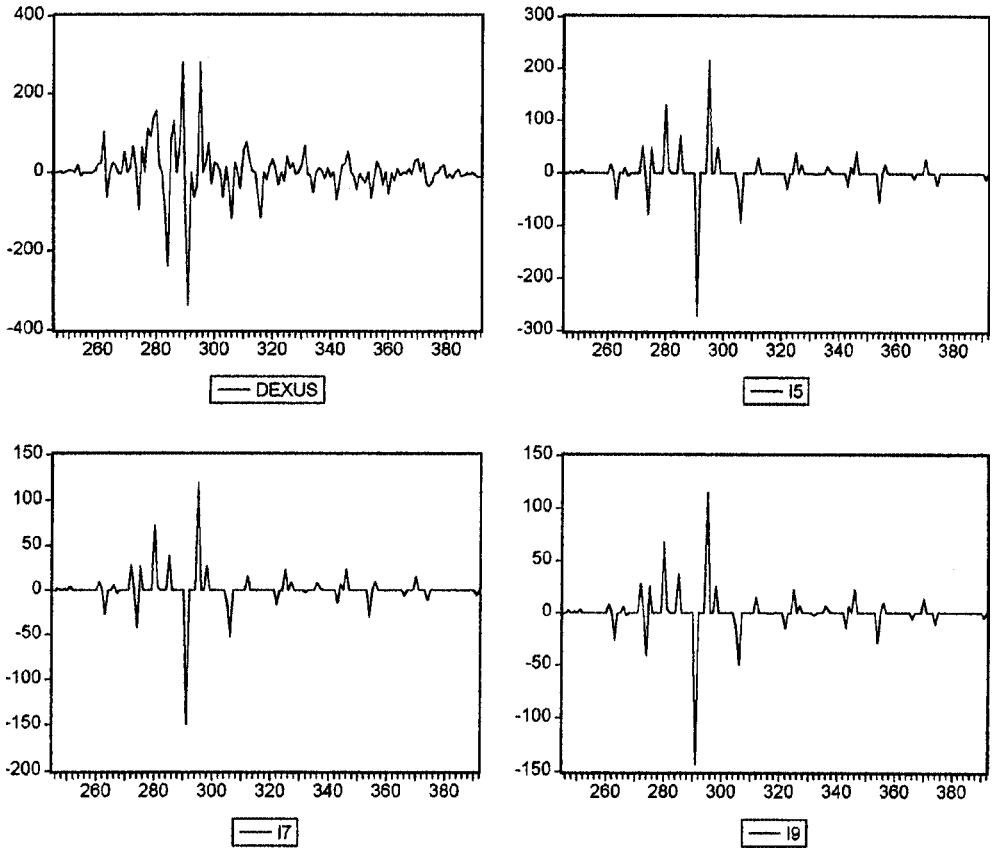
Days	Events	Psychological Impact	$\Delta EXUS_t$
97. 1. 8	· Committee for Monetary Reformation is established	+	–
97. 3. 21	· Sammi Co. is bankrupted	–	–
97. 7. 4	· Interest rate control / restrictions eliminated on short-run savings deposit set to free · Price for gold in the world market is drastically corrupted	+	–
97. 7. 11	· Baht crisis in Thailand is widespread	+	+
97. 7. 16	· Bankruptcy of Kia Group is pending · Domestic fund market is tightened	–	–
97. 8. 12	· Fund for merchant banks is heavily depleted	–	–
97. 8. 22	· Foreign credit status is in a severe condition	+	–
97. 9. 12	· Daenong Co. requests to be under juridical management	+	–
98. 3. 31	· Foreign currency trading restrictions are completely eliminated, and it will take effect by July	–	–
98. 5. 7	· Korean government and IMF agree to cut interest rates	–	+
98. 9. 2	· Dow Jones Index collapsed and world financial market has severe fluctuation	+	+
98. 11. 6	· Fund support for mid-sized firms is tightened · Agreement for free trade between Korea and Chile is established	+	+
98. 11.28	· Intern for major companies is initiated again	–	–
99. 4. 7	· Public enterprises record an 11 trillion Won deficit	+	+
99. 5. 20	· Price for gold lowest in the previous two decades · Dollar is hiked and Yen per Dollar records 124	–	-
99. 6. 22	· KOSPI records 860 points, and it is the highest in the previous three decades	–	+
99. 6. 29	· Debate on the revaluation of the Won is undertaken · KOSPI records more than 900 points	–	–

brought a relatively strong impact to the foreign exchange markets. It recorded –25.1870, –19.0392, and –15.1430, respectively. It hits its upper limit and it was sufficient to judge as a psychological crisis.

C. Preliminary Statistic of the Variables

The preliminary statistics are evaluated and the results are summarized in Table

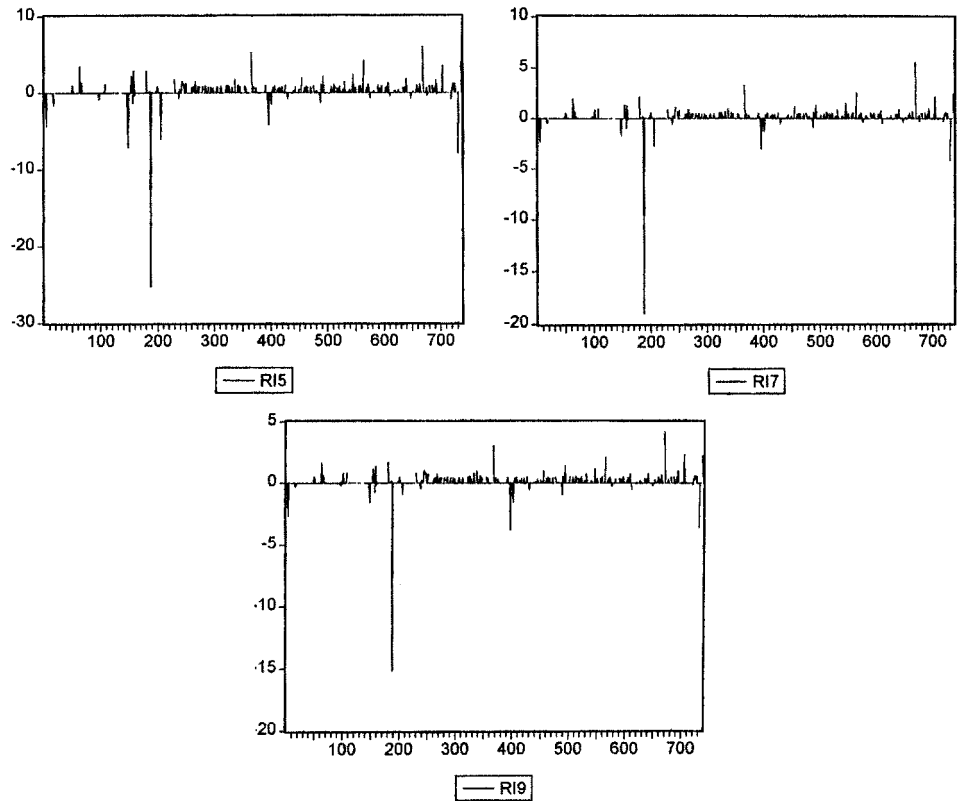
Figure 4. Highest Psychological Volatility.



3 to identify statistical characteristics of the variables. And whether the normal distribution is achieved or not for the variables is illustrated in Figure 6.

As these have shown, non-conditional distribution of all the variables is far from normal. The negative skewness shows a left-skewed, fat-tailed distribution. The Kurtosis is more than 3 in all the cases. It is a leptokurtic. The higher Jarque-Bera statistic also proves non-normality. It is an easily found volatility clustering phenomenon. To identify any existing serial correlation in the standardized residuals and squares of the standardized residuals, the Ljung-Box Q test for the serial correlation in the standardized residuals and the Ljung-Box Q^2 test for the squares of the standardized residuals are checked. It is approximately distributed as χ^2 under the null hypothesis, and lower lags are mixed. However, $Q(10)$ and $Q^2(10)$ are rejected null hypotheses. It implies that the serial correlations exist in both cases. Therefore, the traditional econometric methodology easily misleads the result. It shows that the

Figure 5. Psychological Crisis.



model which captures changing variance and covariance has to be selected. For this purpose, any econometric model which is applicable for conditional heteroscedasticity has to be taken care of. Also, for additional identification, the degree of differences and the stationarity is checked, and concluded that $\Delta EXUS_t$ and $\Delta EXUS_t^{psy}$ are I(0). It implies that the level of both variables is I(1). Therefore, the GARCH(1,1)-M model can be applied with a normal assumption.

D. Estimation of Market Clearance by Psychological Variable

According to Rhee (1997) neither the Keynesian nor the Monetarist approach explain the determination of the exchange rate in Korean foreign exchange markets. It means that any other factor besides the fundamental factor can provide a solution. Once the psychological information matrix is generated, the expected U.S. Dollar with psychological impact can be determined by executing the conditional probability of the first-differenced U.S. Dollar based on lagged information matrix. It is shown in equation (12). Based on the psychological informa-

Table 3. Preliminary Statistic of the Variables

Variables	$\Delta EXUS_t$	$PI5_t$	$PI7_t$	$PI9_t$
Mean	0.422	0.424	0.424	0.424
Std. Dev.	28.864	0.995	0.979	0.960
MAX	280.60	13.85	13.54	13.28
MIN	−337.20	−16.40	−16.06	−15.69
Skewness	−0.105	−2.695	−2.627	−2.527
Kurtosis	60.852	166.198	163.308	161.542
Jarque-Bera	102916.3	819872.6	791086.9	773705.0
$Q(1)$	17.884* [0.00]	0.004 [0.95]	0.001 [0.98]	0.001 [0.98]
$Q(2)$	32.910* [0.00]	0.564 [0.75]	0.516 [0.77]	0.528 [0.77]
$Q(3)$	38.141* [0.00]	3.777 [0.29]	3.556 [0.31]	3.536 [0.32]
$Q(10)$	301.210* [0.00]	107.050* [0.00]	103.510* [0.00]	101.560* [0.00]
$Q^2(1)$	15.392* [0.00]	0.007 [0.93]	0.009 [0.92]	0.009 [0.92]
$Q^2(2)$	110.800* [0.00]	0.017 [0.99]	0.020 [0.99]	0.020 [0.99]
$Q^2(3)$	117.960* [0.00]	0.185 [0.98]	0.180 [0.98]	0.176 [0.98]
$Q^2(10)$	445.450* [0.00]	146.820* [0.00]	144.800* [0.00]	145.120* [0.00]

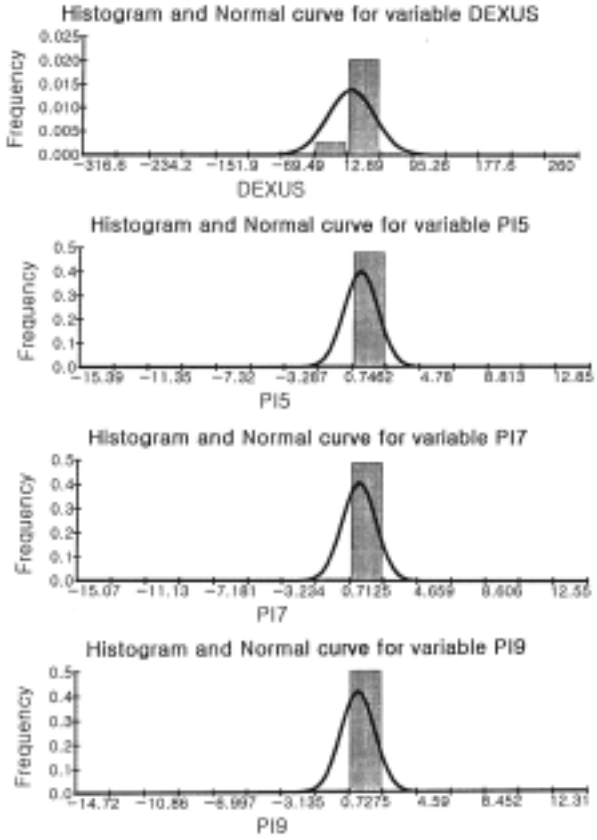
Notes: 1) The figures inside parentheses are the number of lags, and inside brackets are the *p*-values.
2) Q and Q^2 are Ljung-Box's test statistics for the serial correlation in the standardized residuals, and squares of the standardized residuals, respectively.
3) The critical values at 5% level for $\chi^2(1)$, $\chi^2(2)$, $\chi^2(3)$, and $\chi^2(10)$ are 3.84, 5.99, 7.81, and 18.31, respectively.

tion matrix, the conditional probability for $\Delta EXUS_t$ can be calculated as shown in equation (12). $\Delta EXUS_t^{psy}$ is a projection of $\Delta EXUS_t$ with psychological impact.

$$\Delta EXUS_t^{psy} = E[\Delta EXUS_t \,|\, PSY_{t-1}] \tag{12}$$

Once $\Delta EXUS_t^{psy}$ is obtained, the rational expectation can be applied to see if there exists market clearance by adapting the GARCH-M model. It is shown in

Figure 6. Statistical Distribution of the Variable.



equations (13) and (14).

$$\Delta EXUS_t = \theta + \phi \Delta EXUS_t^{psy} \Big| + \varepsilon_t \tag{13}$$

$$h_t^2 = \omega + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1}^2 \tag{14}$$

Here, the estimated coefficient of ϕ, $\hat{\phi}$ is expected to be 1 as long as the exchange market is cleared. α and $\hat{\beta}$ represent the ARCH and GARCH factors, respectively. In general, $\hat{\omega}$, $\hat{\alpha}$, and $\hat{\beta}$ are expected to be positive. To be a strong stationarity, $\hat{\alpha} + \hat{\beta} < 1$ has to be satisfied. To calculate maximum log likelihood function, BHHH (Berndt, Hall, Hall, and Hausman (1974)) algorithm is applied.

According to the results in Table 4, it is confirmed that $\hat{\phi}$ equals 1. However, it calculated 0.7824, 0.7584, and 0.7293, respectively for the entire period. It implies that the U.S. Dollar in the foreign exchange market is not cleared by the psychological impact. The period is subdivided every three months, and it cumulated until the

exchange market is cleared. The 9 cases satisfied the market clearance condition. It also has to be mentioned that the adjustment of conditional heteroscedasticity is done using the GARCH channel rather than the ARCH. The ARCH component ranges from 0.0350 to 0.4371, while the GARCH component distributes from 0.5848 to 0.8981. The summary of empirical results by the GARCH(1,1)-M model is shown in Table 4. As expected, $\hat{\omega}+\hat{\alpha}$, and $\hat{\beta}$ are positive. However, $\hat{\alpha}+\hat{\beta}<1$, is not satisfied

Table 4. Summary of Empirical Results

Periods	No. of Group *i*	Estimated Coefficients					
		θ	ϕ	ω	α	β	LR
97.1-99.6	5	–0.1060 (–2.18)**	0.7824 (2.55)**	0.2315 (11.22)**	0.3418 (16.90)**	0.7668 (73.57)**	–2458.48
	7	–0.1041 (–2.21)**	0.7584 (2.61)**	0.2300 (11.42)**	0.3425 (16.90)**	0.7667 (73.64)**	–2458.54
	9	–0.1012 (–2.18)**	0.7273 (2.56)**	0.2305 (11.52)**	0.3430 (16.92)**	0.7666 (73.74)**	–2458.72
97.7-98.3	5	–0.0551 (–0.59)	1.0137 (2.16)**	0.2638 (5.39)**	0.3527 (10.85)**	0.7828 (44.34)**	–841.98
	7	–0.0545 (–0.59)	1.0115 (2.31)**	0.2670 (5.55)**	0.3550 (10.84)**	0.7824 (44.12)**	–842.02
	9	–0.0518 (–0.56)	0.9656 (2.25)**	0.2679 (5.78)**	0.3554 (10.89)**	0.7825 (44.07)**	–842.18
97.7-98.6	5	–0.0527 (–0.80)	0.9665 (2.17)**	0.2725 (6.27)**	0.3411 (12.07)**	0.7804 (48.37)**	–1148.96
	7	–0.0510 (–0.78)	0.9452 (2.32)**	0.2716 (6.64)**	0.3404 (12.08)**	0.7809 (48.46)**	–1149.04
	9	–0.049 (–0.75)	0.8828 (2.22)**	0.2833 (7.04)**	0.3523 (11.95)**	0.7757 (47.22)**	–1149.26
97.7-98.9	5	–0.0562 (–0.92)	0.9879 (2.35)**	0.2552 (6.50)**	0.3042 (13.02)**	0.7945 (55.46)**	–1452.98
	7	–0.0537 (–0.90)	0.9503 (2.48)**	0.2564 (6.95)**	0.3051 (12.99)**	0.7942 (55.31)**	–1453.07
	9	–0.0494 (–0.82)	0.9028 (2.43)**	0.2556 (7.22)**	0.3036 (13.03)**	0.7951 (55.49)**	–1453.30
97.7-98.12	5	–0.1022 (–1.78)*	1.0739 (2.56)**	0.2868 (7.32)**	0.3180 (14.38)**	0.7794 (63.57)**	–1707.61
	7	–0.1001 (–1.77)*	1.0365 (2.69)**	0.2832 (7.78)**	0.3183 (14.47)**	0.7796 (63.83)**	–1707.72
	9	–0.0968 (–1.85)*	0.9951 (2.60)**	0.2877 (8.05)**	0.3193 (14.57)**	0.7792 (63.77)**	–1707.95

Notes : 1) The figure inside parentheses is a critical value for t-statistics.
2) * is for 10%, and ** is for 5% significant levels.
3) The median lags, –log(2/β) which capture the persistence of the psychological shocks ranges from 0.8006 to 1.2296.

Table 4. Continued

Periods	No. of Group i	Estimated Coefficients					
		θ	ϕ	ω	α	β	LR
97.7-99.3	5	–0.093 (–1.73)*	1.0577 (2.49)**	0.3166 (7.41)**	0.3337 (15.18)**	0.7707 (65.24)**	–1939.33
	7	–0.089 (–1.68)*	1.0111 (2.60)**	0.3108 (7.88)**	0.3313 (15.22)**	0.7721 (65.71)**	–1939.42
	9	–0.0871 (–1.65)*	0.9747 (2.56)**	0.3209 (8.11)**	0.3351 (15.24)**	0.7703 (65.31)**	–1939.68
97.7-99.6	5	–0.1058 (–2.09)**	0.9941 (2.33)**	0.3795 (7.79)**	0.3299 (16.04)**	0.7715 (67.77)**	–2161.03
	7	–0.1028 (–2.07)**	0.9489 (2.48)**	0.3738 (8.13)**	0.3284 (16.13)**	0.7725 (68.50)**	–2161.15
	9	–0.1006 (–2.04)**	0.9124 (2.45)**	0.3818 (8.29)**	0.3309 (16.14)**	0.7711 (68.15)**	–2161.37
98.1-98.6	5	–0.0215 (–0.18)	–0.3551 (–0.11)	12.9635 (3.37)**	0.0353 (1.81)*	0.8974 (54.41)**	–668.30
	7	–0.0130 (–0.10)	–0.7549 (–0.17)	12.7991 (3.49)**	0.035 (1.86)*	0.8979 (62.84)**	–668.28
	9	–0.0068 (–0.06)	–1.0304 (–0.24)	12.6929 (3.47)**	0.0352 (1.86)*	0.8981 (63.25)**	–668.25
98.4-98.12	5	–0.1708 (–1.77)*	0.9133 (1.30)	10.6516 (2.20)**	0.4250 (4.16)**	0.5879 (6.39)**	–858.48
	7	–0.1590 (–1.68)*	0.6450 (0.87)	10.5648 (2.16)**	0.4323 (4.22)**	0.5848 (6.37)**	–858.50
	9	–0.1421 (–1.69)*	0.2219 (1.23)	10.10 (1.99)**	0.4371 (4.31)**	0.5873 (6.45)**	–858.52
98.7-99.6	5	–0.1980 (–1.79)*	1.3551 (1.41)	4.4258 (4.93)**	0.4108 (5.71)**	0.5985 (11.64)**	–996.73
	7	–0.1888 (–1.72)*	1.1959 (1.22)	4.3791 (4.83)**	0.4106 (5.68)**	0.5997 (11.66)**	–996.81
	9	–0.1858 (–1.63)	1.1680 (1.00)	4.4115 (4.80)**	0.4152 (5.62)**	0.5969 (11.64)**	–996.83

Notes : 1) The figure inside parentheses is a critical value for t-statistics.
2) * is for 10%, and ** is for 5% significant levels.
3) The median lags, –log(2/β) which capture the persistence of the psychological shocks ranges from 0.8006 to 1.2296.

in all cases. It implies that the model does not hold a strong stationarity. The results weakly support the psychological hypothesis in the determination of the U.S. Dollar in Korean foreign exchange markets. Also, the number of major group i does not really matter. It shows that Miller's theorem does not work in this analysis.

E. Forecastbility

Forecasting with the rational expectation framework based on psychological impact was done by Anderson and Goldsmith (1994) to evaluate the decision making process. Rationality and psychology were understood as a source for an unbiased forecast in the framework, and the forecasting error is defined by the difference between evaluation at time t and prediction at time t–2. Anderson and Goldsmith (1994) also constructed an error-learning model and applied it to their empirical studies. The analysis revealed systematically biased decision making by decision makers. In general, their decision is overly optimistic. Past learning is of little consequence to the accuracy of forecasts. Such a methodology does not allow us to apply it directly to this research. However, the basic idea deserves to be reviewed. The forecasting of $\Delta EXUS_t$ is performed by ex-post simulation, and the RMSE and RMSPE are reported in Table 5. In addition to this the results are depicted in Figure 7. The periods are basically divided by a quarter and make an incremental period gradually. The last three cases are intensified for the periods which are psychological impact is mostly prevailed through the whole period. The result indicates that the model is comparatively unstable, since in most cases, the RMSE and RMSPE recorded more than 5%. It implies that the psychological impact is an unstable influence in nature.

V. Conclusion and Its Policy Implication

The role of psychological information in determining the exchange rate was examined by investigating the Korean economic crisis which occurred between January 1997 to June 1999. In generating psychological information, news about economic fundamentals was the major source. The basic theory was that psychological information participates in forming the rational expectation, and accordingly it clears foreign exchange markets. That is, psychological information plays a key factor in exchange market clearing. It was found that the U.S. Dollar can be cleared by psychological impact. However, the outcomes weakly support the psychological hypothesis in exchange rate determination. The reason is that the GARCH-M model does not have strong stability, and this is also proven by historical simulation processes. Moreover, the result was obtained by evaluating the period of the Korean economic crisis and it would be an exaggerated psychological impact on economic analysis. However, at least, the result shows that the psychological factor is partly affected in exchange rate determination. In

Table 5. Estimation of Simulation Errors

Periods	No. of Group *i*	MSPE	RMSPE	Periods	No. of Group *i*	MSPE	RMSPE
97.7-98.3	5	0.7754	0.8424	97.7-99.6	5	0.8222	0.6065
	7	0.7729	0.8265		7	0.8220	0.5819
	9	0.7770	0.7880		9	0.8232	0.5658
97.7-98.6	5	0.7947	0.7098	98.1-98.6	5	0.8282	0.4156
	7	0.7936	0.6870		7	0.8281	0.4207
	9	0.7971	0.6485		9	0.8277	0.4252
97.7-98.9	5	0.7974	0.6543	98.4-98.12	5	0.8168	0.4198
	7	0.7974	0.6277		7	0.8246	0.4143
	9	0.8001	0.6075		9	0.8364	0.4198
97.7-98.12	5	0.7932	0.6103	98.7-99.6	5	0.8461	0.6355
	7	0.7935	0.5864		7	0.8444	0.5728
	9	0.7966	0.5699		9	0.8444	0.5606
97.7-99.3	5	0.8217	0.6566				
	7	0.8211	0.6283				
	9	0.8225	0.6100				

Figure 7. Simulated Trends by Period.

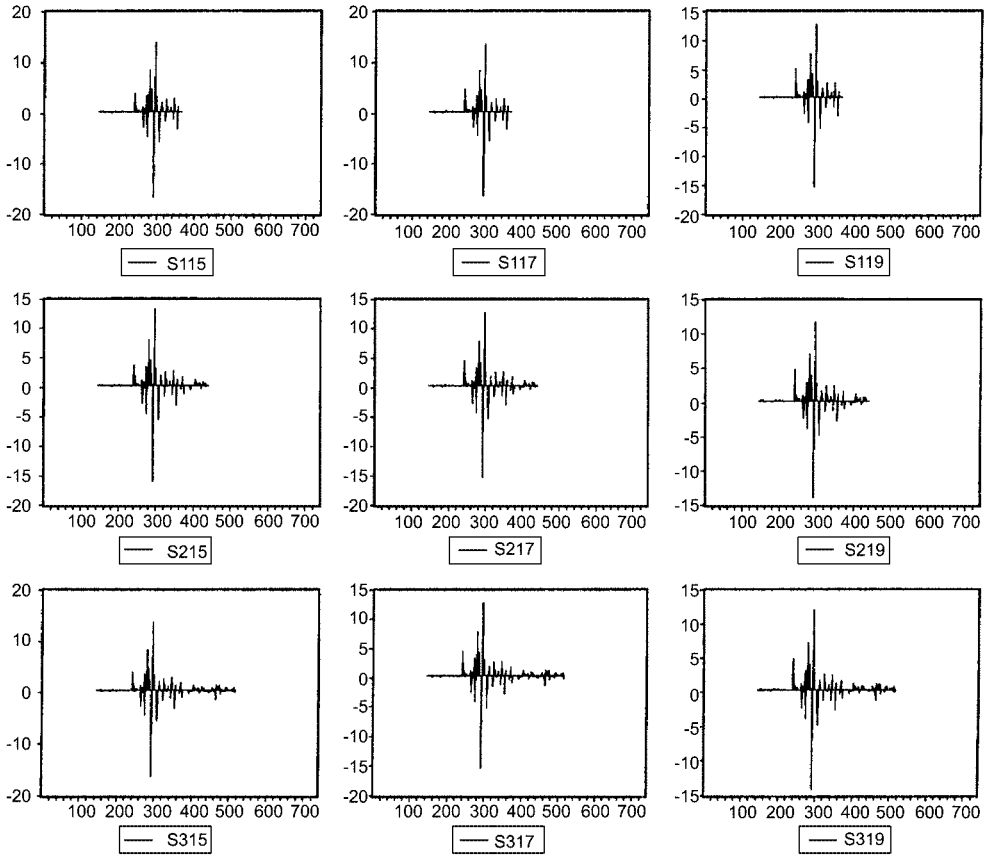
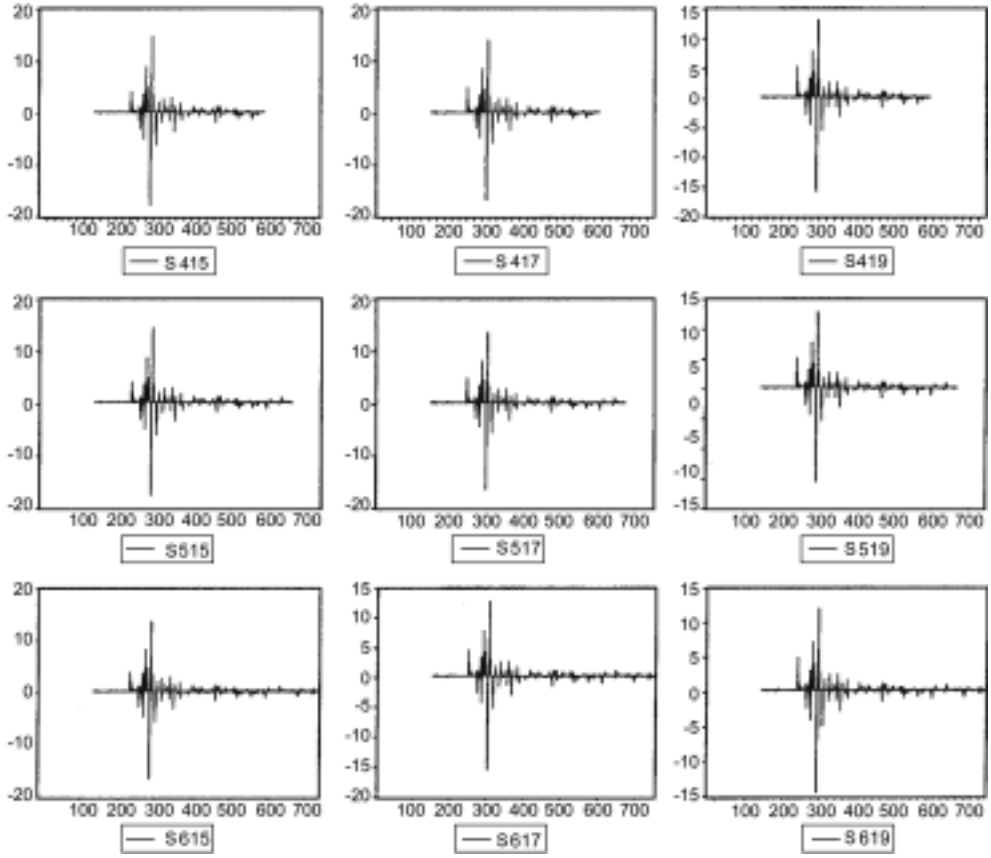


Figure 7. Continued



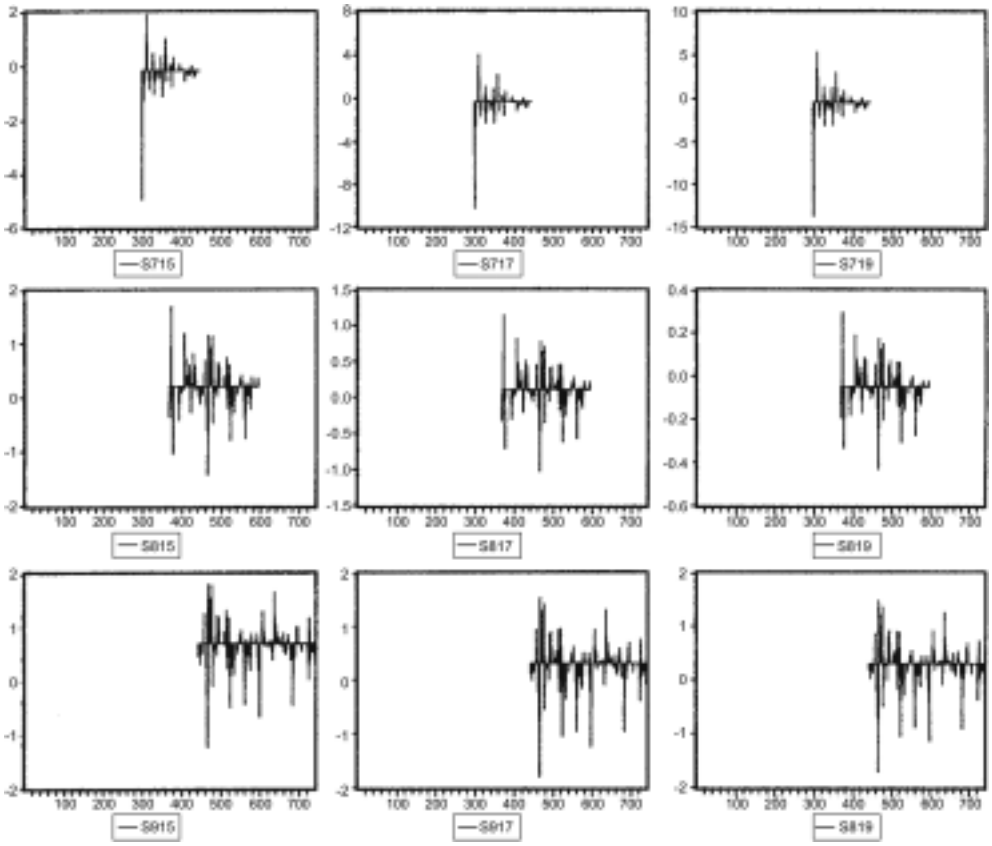
the very short run, it affects more than economic fundamentals.

Another implication is that the changing of the U.S. Dollar is an isolated factor in forming the psychological information in the foreign exchange markets. However, it may have the causation with psychological information. Also, it is ambiguous how the psychological impact affects demand or supply side. At least, the research shows that the understanding of psychological impact is necessarily for the implementation of economic policies, especially foreign exchange policies. A well designed model for analyzing psychological impact is to completely endogenized human behavior into the model. Further research in this field has to be ensue, and the research carefully analyze the psychological factor.

Acknowledgement

The research was performed while I was a Visiting Research Fellow at the Bank

Figure 7. Continued



of Korea during the summer of 1999, and presented at the seminar which was held in the Bank of Korea on October, 1999. I would like to thank to the seminar participants for their helpful comments. And, the same goes to Seongtae Lee, Soon Sang Oh, and Young Seok Oh in the Bank of Korea for their research assistances. I am indebted to In-Yong Hong for compiling a part of data. However, all remaining errors are mine.

Date accepted: May 2000

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