KIEP Working Paper 00-08

Appropriate Exchange Rate Regime in Developing Countries: The Case of Korea

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October 2000

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KIEP Working Paper 00-08
Published October 15, 2000 in Korea by KIEP

Executive Summary

The choice of exchange rate regime in developing countries carries critical importance to their self-protection from speculative attacks and currency crises, as well as achievement of long-term economic growth. Deep integration of developing countries to the global economy makes it difficult to keep the intermediate regime between the two polar solutions. Shifting to more extreme choices between free floating and credible institutional arrangement (monetary union, currency board, or even dollarization) is recommended for many developing countries.

This paper examines the viability or appropriateness of two polar solutions, especially free-floating regime for developing countries. To do so, we investigate the Korean financial markets, which provide interesting case, utilizing multivariate GARCH and various VAR (Vector Auto-Regression) tools. We find that the slightest sign of either weakness of domestic economy or fragility of international financial markets might cause foreign investors to flock out of Korean financial markets and result in inviting another turmoil in Korea. In a limited sense, it is fair to say that the current transitory period from managed to flexible exchange rate regime is a very vulnerable period for Korean economy, and we need to be well equipped to another near international financial turmoil.

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I. Introduction

The choice of exchange rate regime in developing countries carries critical importance to their self-protection from speculative attacks and currency crises, as well as achievement of long-term economic growth. Deep integration of developing countries to the global economy makes it difficult to keep the intermediate regime between the two polar solutions. Shifting to more extreme choices between free floating and credible institutional arrangement (monetary union, currency board, or even dollarization) is recommended for many developing countries.

The question for developing countries still remains whether more shifting toward to two polar extremes is viable or appropriate. There are some countries better suited for a fixed regime with monetary union or currency board, while others are better off adopting a flexible regime. A series of currency crises in the 1990s provide strong support to the view toward a flexible exchange rate regime, especially for Asian countries. The remaining question is whether it is viable or appropriate for developing countries.

To investigate this issue, this paper examines recent developments of foreign exchange market as well as financial market in Korea. Korea has provided an interesting case on the choice of exchange rate regime

for emerging market economies, since it has recently experienced both managed floating and flexible exchange rate regime. Since the crisis in 1997, Korea has adopted flexible exchange rate regime instead of previous market average rate (MAR) system which is classified as a kind of managed floating regime, and pursued more capital account liberalization. This implies that Korea has moved away from the intermediate regime. However, some questions are still remaining. First, there is a question on whether the exchange rate adjustments of flexible exchange rate regime could enough to mitigate the global shocks, and help to stabilize the domestic financial markets. Second, the adopting of flexible exchange rate arrangement will enhance the foreign exchange risk management in private sector, and increase the efficiency of the foreign exchange market.

For the first question, we explore the behavior of domestic financial variables, such as interest rates, foreign exchange rates, and shock prices, responding from the external shocks, before and after the crisis. More narrative questions are how much foreign financial variables affect levels of three domestic financial variables, and how much foreign variables stay tightly tied or become a major driving force in terms of time varying conditional correlation of the domestic financial variables. To find clues regarding these questions, we resort to a multivariate GARCH model and various VAR (Vector Auto Regression) tools for level as empirical tools. Our findings indicate that the Korean financial markets have achieved greater integration with US financial markets after the crisis. These empirical results are natural consequences of the Korean government's open measures such as liberalization of capital markets and adoption of more flexible exchange rate regime. The Korean financial markets' integration to international financial markets seems to enhance market efficiency. However, the

slightest sign of either weakness of domestic economy or fragility of international financial markets might cause foreign investors to flock out of Korean financial markets and result in inviting another turmoil in Korea.

To answer the second question, we survey the foreign exchange market behavior after the adoption of flexible exchange regime. According to our survey, whereas the environment of Korea's financial markets is globalizing, companies continue to act as they have done in the past managed exchange regime. Noticeably, factors of instability in international financial markets may well immediately give birth to volatility of domestic financial markets. Such volatility of domestic financial markets will ultimately bring about losses from foreign exchange for companies and deteriorate their global competitiveness, as well as giving rise to foreign currency liquidity crunch.

Choosing capital account liberalization and free-floating exchange regime could cause domestic financial markets to further develop. However, if external financial factors dominate financial markets of the emerging markets, then negative impact, be it local shocks or global shocks, will be exerted on the real economy, with implications of a potential foreign exchange crisis. It is therefore concluded that it is not appropriate for Korea to adopt a full free-floating exchange regime, which can increase volatility of exchange rates. Cooperative efforts of advanced countries to sustain stability in international financial markets are necessary.

This paper is organized as follows. In Section II, we review issues on the choice of exchange rate regime in developing countries. We describe the brief history of international exchange rate system, and recent issues on the exchange rate regime. Section III covers empirical analyses, followed by Conclusion in Section VI.

II. Choice of Exchange Rate Regime in Developing Countries

1. Brief History of International Exchange Rate System

(1) Bretton Woods System

Just before the end of World War II in July 1944, 44 national leaders of allied countries met at Bretton Woods, New Hampshire, to reconstruct post war monetary and financial order. The new international monetary system was launched with the declaration of fixed exchange rate parity against the US dollar, together with the creation of the IMF and IBRD. The agreement stipulated that the central bank of each IMF member country was obliged to keep its currency within a limited range against the US dollar. Each country was to keep its exchange rate within 1 percent of its par value for its currency in terms of the US dollar, which was fixed at US$35 per ounce of gold. The IMF was supposed to assist member countries by issuing foreign exchange loans to carry out their obligation. For most countries, the Bretton Woods era was characterized by more rapid growth and less inflation than the period of floating exchange rates, and faster and less variable growth than the gold standard era (Isard, 1995).

With the passage of time, the inadequate supply of gold produced a lack of liquidity in international reserve asset. To solve this, the IMF created a new reserve asset, the special drawing right (SDR) in 1968. On the other hand, significant differences in economic performance among developed countries emerged in the late 1960s. Due to the involvement in Vietnam, the US ran a large current account deficit, and later fiscal and monetary policies were tightened to correct the

deficit. As the US economy slowed down and other regions experienced economic surge, the pressure for depreciation of the US dollar increased. This resulted in the dollar crisis of 1971, which was the most serious challenge to the prevailing system. Speculation against the US dollar grew more intense, and the US authorities suspended the convertibility of US dollars to gold. In 1971, a modification to the Bretton Woods system was declared; the so-called Smithsonian Agreement was to devaluate the US dollar and increase the fluctuation around the dollar for other currencies. Despite the effort to keep the Bretton Woods system, most countries found it necessary to float their currencies. The cost of keeping a fixed rate became too expensive. In 1973, the old international exchange rate system had all but broken down and a floating exchange rate system emerged.[1)]

(2) Floating Exchange Rate System

The floating system was welcomed in the early period of post-Bretton Woods system. Many had argued that greater flexibility brought relief after the introduction of new international exchange rate system. Under the floating exchange regime, the relative price of a country's currency accurately reflects that of underlying economic performance. Also, currency values adjust quickly to reflect changes in international trade flows and in the relative prices of traded goods, which are caused by changes in mutual economic circumstances. The theories of open economy contend that, unlike the fixed rate system, the floating rate regime should prevent sustained severe imbalances between current accounts of different countries. In a true floating rate regime, there is no need for central bank intervention of the market.

1) On detailed description of the Bretton Woods period, see Isard (1995).

During the late 1970s and early 1980s, most government authorities believed that exchange rates should be left to market forces, and that central bank intervention was both expensive and irrelevant to change the market movements.

However, during the mid-to late 1980s, there were a few cases of interventions among major currencies. The G-7 council generally coordinated these attempts. The first attempt in 1985 was implemented by the G-5 council of economic ministers (the early G-7 council excludes Canada and France) at the Plaza Hotel in New York. They agreed upon a coordinated intervention aimed at lowering the value of the US dollar, and it was successful since the dollar was already on the movement of depreciation. The second attempt from the G-7 council, the so-called Louvre Agreement, started in February 1987. The purpose of the second attempt was to stabilize major currencies and limit the size of exchange fluctuations with the utilization of coordination. The Louvre Agreement, however, had difficulties in influencing the market. They failed to provide substantial aid to Japan that wanted to prevent the value of Japanese Yen from falling.

Just before the breakdown of the Bretton Woods system, a number of European countries, mostly members of the European Economic Community, established a fixed system of exchange rates among themselves. It was a fixed system of exchange rates among the members but floating against other countries was allowed. This was known as "the snake in the tunnel," but it failed since most members found maintaining a fixed rate even among members costly. In 1979, a revised fixed system was formed in Europe, the so-called European Monetary System (EMS). Under the EMS, all member currencies were linked to a composite currency, European Currency Unit (ECU), which was a GDP weighted average of the all the member currencies.

Unlike the previous arrangement, each of the member currencies was allowed to diverge by no more than 2.25 percent from its central parity rate against ECU. Adjustable peg system of the Exchange Rate Mechanism (ERM) worked relatively well to stabilize exchange rates among EMS member countries in the 1980s, but it experienced severe pressure in the 1990s. Due to the increasing capital mobility and the tightening of the adjustable band to give birth to the Economic Monetary Union, the vulnerability of the ERM increased. Market perception and speculative pressures led to ERM crisis of 1992–1993, and forced countries to make significant adjustments to their central parities (15 percent from the parity), or to abandon the ERM (Italy and United Kingdom). However, for the remaining members of ERM, the EMU has launched with the new euro to peg exchange rates in the ERM at the start of 1999.

(3) Exchange Rate Regime in Developing Countries

Although most currencies in developed countries have been allowed to float since the abandonment of the Bretton Woods system, regimes for developing countries have been varied. Since the mid-1970s, they have moved to either pegging to a basket of major currencies or adopting a more flexible exchange rates regime, away from a single currency peg. It has been believed that composite basket peg arrangement minimizes the adverse effects on economies of fluctuations in the exchange rate of major currencies since the advent of floating system in 1973. Medium- or long-term swings of major currencies have produced various problems for the developing countries, rising out of uncertainty of capital flows (including both portfolio and direct investments), international competitiveness of trade goods, manage-ment of external public and domestic debts, and foreign reserves.

To reduce such uncertainties, developing countries have had a tendency to adopt intermediate exchange regime rather than two extreme regimes. More developing countries have shifted toward a flexible exchange arrangement. According to the IMF classification, 86 percent of developing countries has chosen some type of pegged regime in 1976, with only 10 percent adopting the flexible exchange rate regime. About 45 percent of developing countries have pegged their currencies to major currencies or composite of major currencies in 1992 (Table 1). 52 percent of developing countries adopted more flexible exchange regime; over one half of developing countries are classified as floating independently, while rest of them have resorted to the managed floating arrangement.

〈Table 1〉 Exchange Rate Arrangement of Developing Countries

(Unit: percentage of total number of countries)

	1976	1981	1986	1991	1996
Pegged	86	75	67	57	45
U.S. Dollar	42	32	25	19	15
French Franc	13	12	11	11	11
Other	7	4	4	3	4
SDR	12	13	8	5	2
Composite	12	14	18	20	14
Limited Flexibility	3	10	5	4	3
Single	3	10	5	4	3
Cooperative	–	–	–	–	–
More Flexible	11	15	28	39	52
Set to Indicators	6	3	4	4	2
Managed Floating	4	9	13	16	21
Independently Floating	1	4	11	19	29
Number of Countries	100	113	119	123	123

Source: IMF. 1997. *World Economic Outlook.*

The adoption of fixed or flexible regime showed a regional pattern; countries in Africa and Middle East generally adopted the pegged regime and Asian countries were more prone to adopt flexible exchange rate regimes. Developing countries in Europe and in the Western Hemisphere adopted both types of arrangement, with low-inflation countries generally adopting a pegged regime and high inflation countries a flexible regime (Aghevli, Khan and Montiel 1991).

Economic performance of different exchange regimes in developing countries for last two decades has shown some interesting characteristics.[2] First, inflation in countries with pegged exchange rates has been consistently low and less volatile than that in countries with more flexible regimes. However, there is no clear relationship between exchange rate arrangement and output growth. The lower inflation associated with a pegged regime reflects that the consistent monetary policy is subordinate to maintenance of the peg. Nonetheless, due to the recent lower inflation rate in most countries the discrepancy has been reduced. Moreover, countries adopting a flexible regime are in general large and domestic-oriented economies. Since large countries have self-sufficient economy, they are less concerned about foreign fluctuations. On the other hand, the smaller and more open a country is, the stronger is the case for a fixed or pegged exchange rate.

2. Issues on Choice of Exchange Rate Arrangement

The theoretical literature has established that optimal choice of exchange rate regimes depend on various characteristics of an

2) See Mussa, Masson, Swoboda, Jadresic, Mauro, and Berg (2000) and Obstfeld (1995).

〈Table 2〉 Consideration in the Choice of Exchange Rate Regime

Characteristics of Economy	Implication for the Desired Degree of Exchange Rate Flexibility
Size of economy	– The larger the economy, the stronger is the case for a flexible rate
Openness	– The more open the economy, the less attractive is a flexible exchange rate
Diversified production Structure	– The more diversified the economy, the more feasible is a flexible exchange rate.
Geographical concentration of trade	– The larger the proportion of an economy's trade with one large country, the greater is the incentive to peg the currency of that country
Divergence of domestic Inflation from world inflation	– The more divergence a country's inflation rate from that of its main trade partner, the greater is the need for frequent exchange rate adjustment (But for a country with extremely high inflation, a fixed exchange rate may provide greater policy discipline and credibility to a stabilization program
Degree of economic/financial development Labor mobility	– The greater the degree of economic and financial development, the more feasible is a flexible regime
	– The greater the degree of labor mobility, when wages and prices are downwardly sticky, the less difficult (and costly) is adjustment to external shocks with a fixed exchange rate
Capital mobility	– The higher the degree of capital mobility, the more difficult it is to sustain a pegged–but adjustable exchange rate
Foreign nominal shocks	– The more prevalent are foreign nominal shocks, the more desirable is a flexible exchange rate
Domestic nominal shocks	– The more prevalent are domestic nominal shocks, the more attractive is a fixed exchange rate
Real shocks	– The greater an economy's susceptibility to real shocks, whether foreign or domestic, the more advantageous is a flexible exchange rate
Credibility of policy makers	– The lower the anti–inflation credibility of policy makers, the greater is the attractiveness of a fixed exchange rate as a nominal anchor.

Source: IMF. 1997. "Exchange Rate Arrangements and Economic Performance in Developing Countries." *World Economic Outlook.*

economy. There are the policy objectives (such as price stability and exchange stability), the nature of the shocks to the economy (such as nominal or real shocks and global or country-specific shocks), and the structure of the economy (such as wage-price flexibility, factor mobility, and openness of goods and financial markets). Because of the complexity of these concerns, it is hard to define an optimal exchange rate regime in a single country (Table 2).

In general, a policy maker's objectives are generally focused on increasing the country's welfare. In reality, it is too difficult to define the welfare objective. Thus, most policy criteria have focused on minimizing macroeconomic fluctuations. The choice of exchange rate regime depends on ways to minimize the variance of real economic variables when a country faces external and domestic random shocks.

The type of shock to the economy is a key consideration in determining the type of regime. Early advocates of flexible regime emphasized the insulating properties of exchange rate adjustment in the existence of foreign nominal shocks. Changes in the foreign price level would generate offsetting exchange rate changes protecting the value of the domestic currency and therefore protecting domestic output from foreign fluctuations. Friedman (1953) argued that if the foreign nominal shocks were more important, the flexible exchange rate regime would be preferred. Friedman's argument is effective in the case that a country has limited capital mobility. McKinnon (1963) showed that the insulating property of the flexible regime diminished with more capital mobility.

The optimal choice of exchange rate regime became more complicated whether the source of shocks was nominal or real. When domestic shocks are nominal and prices are sticky, a fixed regime would be more effective in stabilizing out. Under the fixed exchange

rate, fluctuations in the domestic money supply would simply affect only the changes in international reserves without changing the domestic output level. On the other hand, when disturbances, whether domestic or foreign, are real, a flexible exchange regime would achieve more output stability. Theoretical literature concluded that neither of the extremes of completely fixed or flexible exchange rate arrangement is optimal in seeking macro-economy stability (Aghevli, Khan and Montiel 1991).

It has been argued that more open the economy, the stronger the case is for fixing the exchange rate, since the potential costs to an economy increase when frequent exchange rate adjustments are required. Furthermore, the domestic nominal shocks are easy to transfer abroad when the exchange rates are fixed, and the economy is open. A very open country would be better off with a fixed exchange regime in this sense. However, a country would be vulnerable to external shocks if with greater economic openness. In this case, frequent adjustments in exchange rates are necessary to mitigating foreign shocks. Thus, the degree of openness does not provide adequate answers for the choice of exchange rate regime.

3. Lessons and Issues from Recent Currency Crises

The deep integration of developing countries to the global economy has many advantages and positive effects. This has promoted trade in goods and services between developed and developing countries. Capital flows to developing countries have provided great benefits clearly to foreign direct investment, which are not only more stable but which also bring technological advances and access to markets.

On the other hand, large inflows of short-term capital and abrupt

reversible capital flows to developing countries produce negative effects. This is a major different characteristic between trade capital and trade goods and services. Traditionally, trade goods and services have promoted base on the belief that it would enhance welfare between trading partners. However, a sharp reversal of capital flows possibly leads to currency and financial crises, and results in serious losses of output, investment and employment. For the sake of developing countries, more access to the global capital market poses a policy dilemma for the choice of exchange rate regime. There has been no period of time in which the choice of exchange rate regime in developing countries is more important to the prevention and resolution of currency crises and the sustenance of long-term economic growth than today.

It has been believed for a long time that exchange rate adjustments play an important role in restoring and preserving external and domestic stability in developing countries. On the contrary, many developing countries have recently been recommended to shift to more extreme choices such as flexible or fixed with monetary union (or currency board). Generally, a current consensus is that intermediate regimes between two extreme choices are no longer tenable. The rationale for the suggestion comes from the so-called principle of the impossible trinity. It holds that there is a trilemma pursuing exchange rate stability, capital mobility, and independent monetary policy. It cannot obtain all three objectives simultaneously. It is possible, at most, to achieve any two of these objectives, making it necessary to sacrifice at least one.[3] As many developing countries try to have more access

3) After the Asian Crisis, it has been observed that the less-affected countries come out with some form of hard fixed rates (Hong Kong and Argentina), heavily managed rates with capital controls (China and India) or flexible

to global financial markets, the choice is narrowed down to the degree of exchange rate flexibility, whether a perfect free floating or hard fixed rates such as monetary union, currency board, or even dollarization.

A series of currency crises from Mexico to Asia in the 1990s provided strong support of the view toward a flexible exchange rate regime. First, it has been argued that the fixed or de facto fixed exchange rates in those crisis countries produced a moral hazard in exchange rates, and induced excessive capital inflows to those countries. The fixed exchange rate regime, if it is credible or sustainable, could generate a form of implicit guarantee by increasing unhedged currency borrowing and promote more short-term capital flows (Eichengreen and Hausmann 1999).

Second, a flexible exchange rate regime allowed large adverse shocks to be more easily absorbed than a pegged exchange rate regime, and thus less likely to provoke currency crises. Furthermore, it has been argued that, with high capital mobility between developed and developing countries, a pegged-but-adjustable exchange rate regime is not viable, and even prone to crisis. The fixed exchange rate policies followed by some of the East Asian countries were held partly responsible for the crisis and this makes it relevant to ask whether some exchange rate regimes are more likely to avoid crises than others. Eichengreen (1999) concluded that pegged exchange rate regimes are inherently crisis-prone for the emerging market economies and that these countries should be encouraged to adopt a floating exchange rate regime. This is closely related the speculative attacks in a highly integrated global capital market. The first generation models of

rates (Australia).

speculative attack (Krugman 1979, and Flood and Garber 1984) showed how a fixed exchange rate policy combined with excessive pre-crisis monetary expansion can push the economy into crisis, with the private sector trying to profit from dismantling inconsistent policies. The first generation models are design to explain the 1970s and early 1980s currency crises in developing countries such as Mexico (1973–1982) and Argentina (1978–1981). The second generation models (Flood and Garber 1984 and Obstfeld 1986) explained how a currency crisis would be developed in a self-fulfilling manner and multiple equilibria be generated without inconsistent policies in the event of a speculative attack.[4)]

Third, a flexible exchange rate regime allows exchange rates to move in response to market forces, and provides a better economic environment for economic agents to recognize foreign exchange exposure risks and develop prudential management of financial institutions in a county closely integrated to global financial markets. In addition, hedging markets for foreign exchange rate would develop more efficiently in a country with a flexible exchange rate arrangement.

On the other hand, there are some worries about adoption of a flexible exchange rate in developing countries. When a country experiences massive capital flows due to higher economic growth and potential profit from investment, an irrational swing in the foreign investors' perception may exacerbate misalignment of exchange rates from economic fundamentals. If foreign investors observe appreciation in a developing country, they may invest more in expectations of further profits. Due to increasing capital inflows, a further appreciation

4) See Eichengreen, Rose, and Wyplosz (1994), Flood and Marion (1996, 1998) for details.

deteriorates the export competitiveness, current account balance and ultimately reverses capital flows, leading to a currency crash. In this sense, a flexible exchange rate regime is not immune from currency crises. In line with this, short-term volatility and mid- or long-term misalignment in the exchange rates hamper the viability of flexible exchange rate regime in developing countries.

Second, even though the adoption of a flexible exchange rate regime reduces exchange rate moral hazard by removing implicit guarantees, floating may reduce unhedged borrowing by simply reducing foreign capital inflows, leading to less investment and growth (Fernandez-Arias and Hausmann 1999).[5] This is so because unless the foreign financial institutions have willingness to buy domestic currency, it would never enough to hedge the foreign borrowing. Furthermore, with this constraint in hedging market, the cost of hedging increases as the volatility of exchange rates go up by adopting a flexible exchange rate regime, and this may also lead to less investment and growth in developing countries.

Third, while accepting a floating, in transition, many countries may suffer from nominal anchor fragility, and may reinforce their exchange rate stability by avoiding benign neglect. If the country chooses a flexible exchange rate regime, an appropriate nominal anchor for the economy is to be chosen except for exchange rate. But without long history of consistent macroeconomic policies but for fixing exchange rates, the credibility of macroeconomic policies still remains question-

5) It is argued that the double mismatches (currency and maturity) in developing countries root from original sin. Original sin says that emerging market economies cannot borrow abroad in terms of domestic currency and domestic currencies cannot be used even for long-term borrowing.

able in the market. If there is no credible policy objective, market dynamics exacerbate the misalignments and/or short-term volatility of exchange rates.

For the broad range of developing countries, exchange rate regime becomes one of the most important policy objective, and increasingly so because of the increasing access to the global capital market. The choice of exchange rate regime in developing countries means which regime would be most appropriate not only for preventing massive capital inflows and currency crises but also for better facilitating trade, direct investment and economic growth. However, it seems that there is no clear-cut determinant for a developing country to choose an appropriate exchange rate regime. Frenkel (1999) contended that an appropriate exchange rate regime varies depending on the specific circumstances of the country in question and depending on the circumstances of the time period in question. Flood and Marion (1991) argued the choice of exchange rate regime is a second-best policy choice, which can be directed toward mitigating the distorting effects of price or information rigidities.

As much as are soundness and appropriateness of individual country's exchange management so important, it seems that global or at least regional cooperation in stabilizing most currencies is desired in a highly integrated global economy. Some argued that G3 countries should limit their currency volatility (Clarida, 1999, Williamson 1994). Others preferred regional pegged system, such as Asian flexible peg system (McKinnon 1999). This reflects a reminiscence of the early Bretton Wood system.

III. Recent Financial Market Developments in Korea

Korea has adopted a more flexible exchange rate regime since the currency crisis in 1997. It was an inevitable outcome of the crisis. However, there are some concerns for current Korean Won/Dollar exchange rate movements, such as short-term volatility and mid- or long-term misalignment.

The purpose of empirical analysis in this section is to find out whether there are significant changes in interrelations among six financial variables before and after the Korean financial crisis. Six financial variables are two exchange rates (KRW/USD, JPY/USD), two short-term interest rates for Korea and US, and each country's stock index. As described below, three periods (pre-crisis, crisis, and post-crisis) have different economic environments such as regime changes in exchange rates and different degrees of capital account liberalization. Thus, our interest is to find out if six financial variables in foreign exchange, stock and bond markets for the two countries are likely to have different empirical relations in terms of level and volatility.

Since the outbreak of the Korean financial crisis, the Korean government took various measures to calm the turmoil in financial markets by adopting a free floating exchange rate regime and by more actively pursuing capital account liberalization. As a natural consequence, we may expect that Korean financial markets are more likely to be linked to one another, as well as to external factors. Many previous literatures show that the US financial variables—US interest rates, in particular—are by far the most important external factors in determining financial variables' movements in developing countries.[6]

Therefore, it is quite interesting to investigate how US financial variables affect levels of the three Korean financial variables.

There are also a number of reasons for studying second-moment links between Korea and US financial markets. Asset volatility of US financial variables and cross-country correlations are important because they affect international capital flows and volatility of the emerging economies' financial variables, partly due to international investors' diversification. In particular, each of the three US asset markets we have chosen is quite large, greatly affecting international financial markets. Importantly, a study of links between US asset markets and those of emerging economies has implications for monetary (exchange rate) and regulatory policy.

For empirical analysis, we divide the overall period into pre-crisis, crisis, and post-crisis periods. The pre-crisis period covers from Jan 4, 1995 to September 30, 1997 and the post-crisis period from October 1, 1998 to June 6, 2000. Even though all data are available from March 1, 1990, when Korea began to adopt the market average exchange rate system, empirical analyses are restricted to cover years from 1995 due to possibility of structural break or regime change in KRW/USD (hereafter KRW) exchange rates. Joo and Kim (1999), for example, argued that movements of the exchange rates were explained very well with macroeconomic fundamentals after 1995, which is not the case from 1990 to 1995, and that the exchange rates looked like exhibiting structural breaks statistically since 1995.

The time coincides with some noticeable efforts of the Korean government for capital account liberalization, such as increasing limits on stock investment for non-state owned companies by foreigners from

6) See Calvo et al. (1993) and Fernandez-Arias (1996).

10% to 12% and opening non-guaranteed convertible bonds issued by small and mid-size companies.[7] Furthermore, S&P had upgraded Korea's sovereign credit rating from A2 to A1 in May 1995, resulting in net capital inflows, expansionary monetary policy and depreciation of the Korean won.

We presume that the post-crisis period started from October 1998 because the first round of financial restructuring was completed at that time and the domestic spot rates and the offshore NDF three-month forward rates have moved tightly since then.[8] The last date of the post-crisis is dictated by the availability of the data. Since financial markets in Korea were extremely volatile during the crisis period, we do not make a separate analysis of the crisis period.

1. Methodology

There are many ways to analyze relationships among the three financial variables. One simple but useful empirical methodology to uncover and compare interrelationships among variables is variance decomposition and impulse response function within the framework of Vector Auto Regression (VAR) estimation. Variance decomposition provides information regarding the proportion of the movements in a sequence due to its own shocks versus shocks to the other variables and, therefore, a sequence is exogenous or endogenous. Impulse response function is also a practical way to visually represent the

7) Foreign investors can buy non-guaranteed convertible bonds issued by large companies and non-guaranteed bonds issued by small and mid-size companies since June 1997.

8) See Park, Chung, and Wang (1999).

behavior of a series in response to various shocks. Since it does not make sense for the levels of three Korean financial variables to affect US related financial variables, both methodologies therefore would tell us the causes of domestic financial variable movements or the consequence of movements of US related financial variables.

To investigate volatility relations among the six variables, we resort to the multivariate GARCH (Generalized Auto Regressive Conditionally Heteroskedastic) model to see if there are significant changes in time varying conditional correlations among the six variables. It is, of course, possible to estimate univariate conditional volatility by way of incorporating volatility of one market into another GARCH specification as an exogenous variable. However, this approach is not efficient. Moreover, when testing for volatility spillovers in one direction, the univariate GARCH approach assumes that there is no reverse spillover. If there is indeed a bi-directional spillover, the test statistics may be misleading. The constant correlation GARCH model,[9] which specifies multivariate GARCH process with a parametric form for the conditional correlation instead of the conditional covariance, parameterizes the conditional correlation as a constant. The obvious drawback of this model is that it allows no dynamics in the conditional correlation function. However, there is overwhelming evidence of the time variation in conditional volatility of asset returns[10] and growing evidence of the time variation in the conditional correlation between assets.[11] If the conditional correlation is time varying, then the constant correlation GARCH model is mis-specified and so are, in particular,

9) See Bollerslev (1990).

10) See Bollerslev, Chou and Kroner (1992) for an extensive survey.

11) See Longin and Solnik (1995).

any economic inference based on that specification. Full parameterization multivariate GARCH model by Baba, Engle, Kraft, and Kroner (1989) allows sufficient generality, conditional variances and covariances, and guarantees that the covariance matrices in the system are positive definite by construction. However, in our six-variate system, one would have to estimate nearly one hundred parameters.

Among numerous multivariate GARCH models, we choose a recently developed one that is more suitable for a detailed correlation analysis than existing models by Klaassen (1999). The basic motivation of the model comes from the notion that it is the correlations between variables which make multivariate GARCH modeling more than univariate GARCH modeling. Estimation procedure in Klaassen consists of two simple steps. In the first step, principal components of all unconditional correlations of the six variables are calculated by way of removing all unconditional correlations. The conditional means and variance of each component are specified by a univariate GARCH model. In the second step, the estimated first and second moments are transformed into corresponding moments of the six variables themselves.

To describe[12] Klaassen's model using a mathematical notation, we define y_t as the vector of six financial variables at time t. In the first step, we calculate six-vectors of principal components defined by:

$$f_t = W' y_t \tag{1}$$

12) We followed closely with Klaassen (1999). See Klaassen (1999) for more description and for comparison with factor GARCH models.

Here, the weighting matrix W is the unique orthogonal 6×6 eigenvector matrix of the unconditional variance $Var(y_t)$. Since the transformation is same as project y_t onto orthogonal vector space, f_t is not correlated with its components. Followed by the transformation, conditional means and variances of f_t are estimated using any univariate GARCH models. That is to say, we specify the conditional moments of f_t by:

$$E_{t-1}(f_{tj}) = \alpha_{0j} + \alpha_{1j} f_{t-1j}$$
$$V_{t-1}(f_{tj}) = \omega_{tj} + \alpha_{tj}\varepsilon^{2}_{t-1} + \beta f_{t-1j}$$
$$Cov(f_{tj}, f_{tk}) = 0$$

for principal components i, j=1,.,6.

After GARCH estimation, we transform the conditional moments of the principal components into original financial variables that we are mainly interested in. The transformation is just simply to reverse the equation (1):

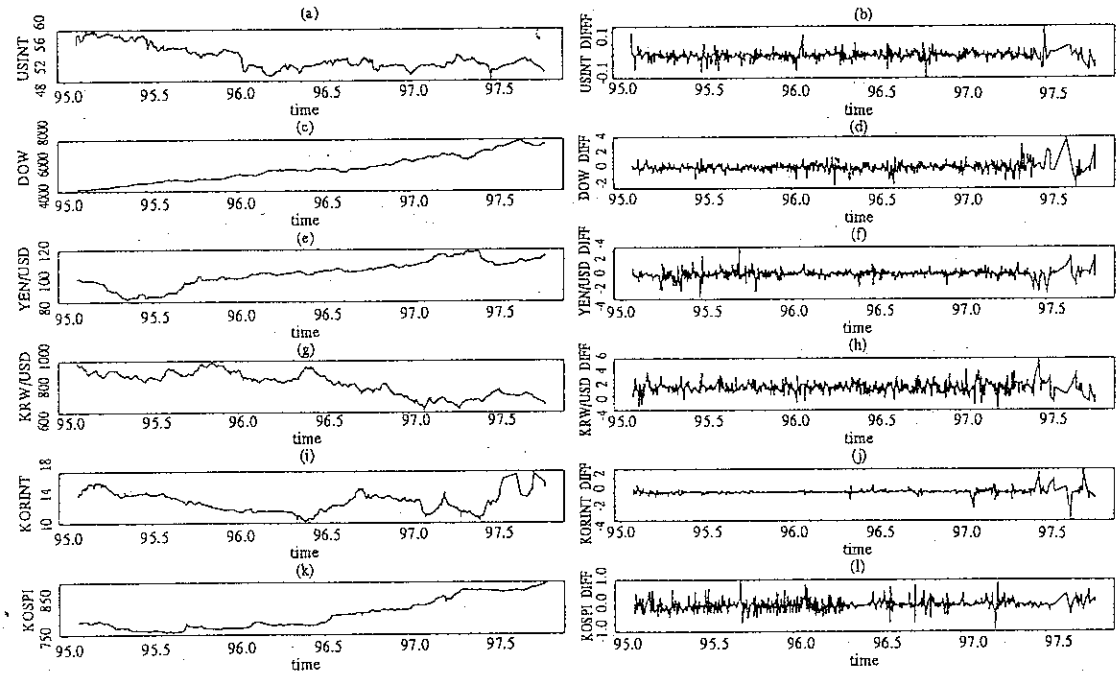
$$E_{t-1}(y_t) = WE_{t-1}(f_t)$$
$$Var_{t-1}(y_t) = WV_{t-1}(f_t)\ W'$$

2. Data Description

The data consist of daily prices of six financial variables—Korea 3 month CD rates, US 3 month T-Bill, KRW exchange rates, JPY/USD (hereafter JPY) exchange rates, Korea stock index (KOSPI), and Dow Index—from January 3, 1995 to June 20, 2000, totaling 1,176 observations. Both exchange rates and other data are obtained from Bloomberg. Exchange rates and stock indexes S_t, are transformed to

percentage changes in compounded rates: $100 \times \ln[S_t / S_{t-1}]$. The levels and differences of the six variables are depicted in Figure 1.

〈Figure 1〉 Movements of Financial Variables



Notes: (a) US interest rates (level), (b) US interest rates (difference), (c) Dow index (level), (d) Dow index (difference), (e) JPY exchange rates (level), (f) JPY exchange rates (difference), (g) KRW exchange rates (level), (h) KRW exchange rates (difference), (i) Korea interest rates (level), (j) Korea interest rates (difference), (k) KOSPI (level), (l) KOSPI (difference).

The pre-crisis period, crisis-period, and post-crisis periods have 580, 240 and 388 observations, respectively. Basic statistics of six variables are reported in Table 3. The three Korean financial variables exhibit very similar statistics in mean and standard deviations during pre-crisis and post-crisis periods. The volatility of KOSPI after crisis increases by having a twice-higher value of standard deviation than in the pre-crisis period. Similarly, KRW exchange rates show a degree of high volatility during the crisis by becoming roughly seven and

twelve times higher than that of pre-crisis and post-crisis periods, respectively. The standard deviation of KRW exchange rates during the post-crisis period shows a higher number than that of the pre-crisis period. However, volatility of KRW exchange rates during pre-

〈Table 3〉 Basic Statistics of Exchange Rates, Stock Prices and Interest Rates

	Mean	Max	Min	Standard Deviation	Skewness	Kurtosis
〈KRW/USD〉						
Whole Period	0.0297	19.0099	-20.3458	1.5447	2.0339	82.0505
Pre-crisis	0.0255	1.2458	-1.2494	0.2989	0.4907	5.1294
Crisis	-0.2055	19.0099	-20.3458	3.6023	0.7821	15.8834
Post-crisis	-0.0565	2.1006	-2.0788	0.5006	-0.1412	6.1970
〈3-Year Corporate Bond Yields〉						
Whole Period	-0.0076	3.0000	-3.7500	0.4420	0.0280	16.2292
Pre-crisis	0.0022	3.0000	-3.7500	0.3685	-0.2411	38.0289
Crisis	-0.0270	3.0000	-2.2500	0.7505	0.1150	4.3780
Post-crisis	-0.0123	1.7500	-1.5000	0.3032	0.4422	11.9956
〈KOSPI〉						
Whole Period	-0.0034	10.0238	-14.2108	2.4640	-0.0884	6.0218
Pre-crisis	-0.0754	6.6017	-4.9790	1.3573	0.1705	4.6208
Crisis	-0.3312	10.0238	-14.2108	3.7781	-0.2066	4.1004
Post-crisis	0.2772	8.9202	-7.6248	2.8263	0.1086	3.0250
〈Dow Index〉						
Whole Period	0.0922	5.5165	-6.5782	1.1010	-0.0106	6.4101
Pre-crisis	0.1260	5.5165	-3.3504	0.8570	0.6061	8.6940
Crisis	-0.0125	4.8605	-6.5782	1.4444	-0.2853	5.8138
Post-crisis	0.0968	4.0896	-4.2613	1.2115	0.0282	3.6819
〈US Interest Rate〉						
Whole Period	0.0001	0.2320	-0.3160	0.0483	-0.1701	7.4332
Pre-crisis	-0.0012	0.2320	-0.1720	0.0401	0.2344	7.2486
Crisis	-0.0037	0.1700	-0.1310	0.0505	0.2834	3.8288
Post-crisis	0.0040	0.1890	-0.3160	0.0573	-0.6073	7.7151

Notes: Period 1 is from March 1, 1995 to September 30, 1997; Period 2 is from October 1, 1997 to September 30, 1998; and Period 3 is from October 1, 1998 to May 30, 2000.

crisis and post-crisis periods are less than that of JYP exchange rates but much more volatile during the crisis period. KOSPI and CD rates during pre-crisis and post-crisis periods move more frequently than the US counterparts. All variables do show large deviation from a normal distribution in terms of Jarque-Bera test except KOSPI for the post-crisis period.

3. Empirical Results

(1) Level Interrelations

Before exercising variance decomposition and impulse response function, it is common to determine lag length of the six-variate system. For the selection of lag length, we resort to the multivariate generalizations of the AIC and BIC and choose one as a lag length as seen in Table 4. The choice is very reasonable since we are dealing with daily frequency financial variables.

〈Table 4〉 Lag Selection

Lags	Before Crisis		After Crisis	
	AIC	SIC	AIC	SIC
1	5.827037	6.143401	9.734313	10.16558
2	5.870586	6.458902	9.494178	10.29822
3	5.852551	6.713546	9.501255	10.68099
4	5.884094	7.018497	9.579634	11.13803
8	6.009125	8.244521	9.847066	12.95047
12	6.107288	9.455614	10.15796	14.85699
16	6.308211	10.78162	10.29738	16.64547
20	6.393771	12.00463	10.33173	18.38536
24	6.564706	13.32562	10.32929	20.14823

〈Table 5〉 Decomposition of the Forecast Error Variance for KOSPI (pre-crisis)

Lags	DOW	JPY	CD 90 Days (Korea)	KOSPI	KRW	US 3-Month Gov.
1	0.014738	0.096839	0.090056	97.72823	1.070134	0.000000
2	0.334865	0.688917	0.738692	96.69980	1.079914	0.457816
3	0.342470	0.690456	0.738411	96.68700	1.083691	0.457941
4	0.342694	0.690987	0.738540	96.68607	1.083718	0.457991
8	0.342694	0.690989	0.738541	96.68606	1.083723	0.457991
12	0.342694	0.690989	0.738541	96.68606	1.083723	0.457991
16	0.342694	0.690989	0.738541	96.68606	1.083723	0.457991
20	0.342694	0.690989	0.738541	96.68606	1.083723	0.457991
24	0.342694	0.690989	0.738541	96.68606	1.083723	0.457991
28	0.342694	0.690989	0.738541	96.68606	1.083723	0.457991
32	0.342694	0.690989	0.738541	96.68606	1.083723	0.457991
36	0.342694	0.690989	0.738541	96.68606	1.083723	0.457991
40	0.342694	0.690989	0.738541	96.68606	1.083723	0.457991
44	0.342694	0.690989	0.738541	96.68606	1.083723	0.457991
48	0.342694	0.690989	0.738541	96.68606	1.083723	0.457991
52	0.342694	0.690989	0.738541	96.68606	1.083723	0.457991

〈Table 6〉 Decomposition of the Forecast Error Variance for KRW/USD (pre-crisis)

Lags	DOW	JPY	CD 90 Days (Korea)	KOSPI	KRW	US 3-Month Gov.
1	0.081595	0.000000	0.000000	0.000000	99.91840	0.000000
2	0.105550	3.086827	0.196760	0.138616	96.46458	0.007668
3	0.125296	3.143716	0.196892	0.139816	96.38566	0.008624
4	0.125913	3.145429	0.196962	0.140053	96.38298	0.008668
8	0.125931	3.145515	0.196971	0.140056	96.38286	0.008672
12	0.125931	3.145515	0.196971	0.140056	96.38286	0.008672
16	0.125931	3.145515	0.196971	0.140056	96.38286	0.008672
20	0.125931	3.145515	0.196971	0.140056	96.38286	0.008672
24	0.125931	3.145515	0.196971	0.140056	96.38286	0.008672
28	0.125931	3.145515	0.196971	0.140056	96.38286	0.008672
32	0.125931	3.145515	0.196971	0.140056	96.38286	0.008672
36	0.125931	3.145515	0.196971	0.140056	96.38286	0.008672
40	0.125931	3.145515	0.196971	0.140056	96.38286	0.008672
44	0.125931	3.145515	0.196971	0.140056	96.38286	0.008672
48	0.125931	3.145515	0.196971	0.140056	96.38286	0.008672
2	0.125931	3.145515	0.196971	0.140056	96.38286	0.008672

〈Table 7〉 Decomposition of the Forecast Error Variance for CD (pre-crisis)

Lags	DOW	KRW	CD 90 Days (Korea)	JPY	KOSPI	US 3-Month Gov.
1	0.078636	0.011643	99.90972	0.000000	0.000000	0.000000
2	2.078690	0.044626	97.19031	0.229530	0.113062	0.343779
3	2.079515	0.049506	97.17983	0.229525	0.113049	0.348571
4	2.079510	0.049577	97.17947	0.229793	0.113072	0.348576
8	2.079510	0.049580	97.17946	0.229800	0.113072	0.348576
12	2.079510	0.049580	97.17946	0.229800	0.113072	0.348576
16	2.079510	0.049580	97.17946	0.229800	0.113072	0.348576
20	2.079510	0.049580	97.17946	0.229800	0.113072	0.348576
24	2.079510	0.049580	97.17946	0.229800	0.113072	0.348576
28	2.079510	0.049580	97.17946	0.229800	0.113072	0.348576
32	2.079510	0.049580	97.17946	0.229800	0.113072	0.348576
36	2.079510	0.049580	97.17946	0.229800	0.113072	0.348576
40	2.079510	0.049580	97.17946	0.229800	0.113072	0.348576
44	2.079510	0.049580	97.17946	0.229800	0.113072	0.348576
48	2.079510	0.049580	97.17946	0.229800	0.113072	0.348576
52	2.079510	0.049580	97.17946	0.229800	0.113072	0.348576

〈Table 8〉 Decomposition of the Forecast Error Variance for KOSPI (post-crisis)

Lags	DOW	JPY	CD 90 Days (Korea)	KOSPI	KRW	US 3-Month Gov.
1	0.422395	0.061097	0.091093	99.42541	0.000000	0.000000
2	8.475624	0.246836	0.246605	90.55336	0.427499	0.050076
3	8.582075	0.266716	0.316923	90.23297	0.499616	0.101700
4	8.582054	0.272519	0.316883	90.22008	0.504109	0.103902
8	8.582514	0.272870	0.316882	90.21954	0.504175	0.104019
12	8.582514	0.272870	0.316882	90.21954	0.504175	0.104019
16	8.582514	0.272870	0.316882	90.21954	0.504175	0.104019
20	8.582514	0.272870	0.316882	90.21954	0.504175	0.104019
24	8.582514	0.272870	0.316882	90.21954	0.504175	0.104019
28	8.582514	0.272870	0.316882	90.21954	0.504175	0.104019
32	8.582514	0.272870	0.316882	90.21954	0.504175	0.104019
36	8.582514	0.272870	0.316882	90.21954	0.504175	0.104019
40	8.582514	0.272870	0.316882	90.21954	0.504175	0.104019
44	8.582514	0.272870	0.316882	90.21954	0.504175	0.104019
48	8.582514	0.272870	0.316882	90.21954	0.504175	0.104019
52	8.582514	0.272870	0.316882	90.21954	0.504175	0.104019

〈Table 9〉 Decomposition of the Forecast Error Variance for KRW/USD (post-crisis)

Lags	DOW	JPY	CD 90 Days (Korea)	KOSPI	KRW	US 3-Month Gov.
1	0.005949	6.855585	1.061029	5.990686	86.08675	0.000000
2	1.399597	9.227582	1.478094	5.833010	81.69091	0.370804
3	1.499581	9.290309	1.510528	5.839812	81.45678	0.412995
4	1.507382	9.292758	1.510431	5.828822	81.44634	0.414271
8	1.507546	9.292968	1.510464	5.828876	81.44582	0.414418
12	1.507546	9.292968	1.510464	5.828876	81.44582	0.414423
16	1.507546	9.292968	1.510464	5.828876	81.44582	0.414423
20	1.507546	9.292968	1.510464	5.828876	81.44582	0.414423
24	1.507546	9.292968	1.510464	5.828876	81.44582	0.414423
28	1.507546	9.292968	1.510464	5.828876	81.44582	0.414423
32	1.507546	9.292968	1.510464	5.828876	81.44582	0.414423
36	1.507546	9.292968	1.510464	5.828876	81.44582	0.414423
40	1.507546	9.292968	1.510464	5.828876	81.44582	0.414423
44	1.507546	9.292968	1.510464	5.828876	81.44582	0.414423
48	1.507546	9.292968	1.510464	5.828876	81.44582	0.414423
52	1.507546	9.292968	1.510464	5.828876	81.44582	0.414423

〈Table 10〉 Decomposition of the Forecast Error Variance for CD (post-crisis)

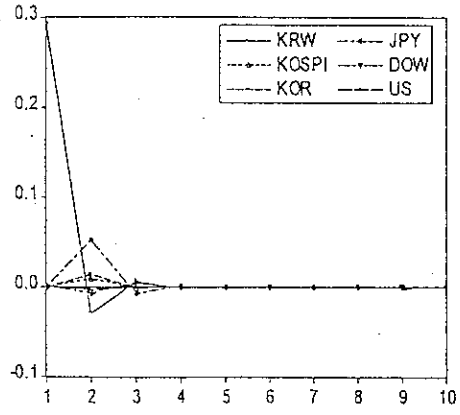
Lags	DOW	KRW	CD 90 Days (Korea)	JPY	KOSPI	US 3-Month Gov.
1	0.119402	0.000000	98.59103	1.289566	0.000000	0.000000
2	0.128654	0.923121	97.07123	1.289633	0.585597	0.001768
3	0.168902	0.940039	96.98469	1.296349	0.595130	0.014892
4	0.169871	0.940073	96.98321	1.296312	0.595138	0.015398
8	0.169871	0.940079	96.98319	1.296313	0.595138	0.015408
12	0.169871	0.940079	96.98319	1.296313	0.595138	0.015408
16	0.169871	0.940079	96.98319	1.296313	0.595138	0.015408
20	0.169871	0.940079	96.98319	1.296313	0.595138	0.015408
24	0.169871	0.940079	96.98319	1.296313	0.595138	0.015408
28	0.169871	0.940079	96.98319	1.296313	0.595138	0.015408
32	0.169871	0.940079	96.98319	1.296313	0.595138	0.015408
36	0.169871	0.940079	96.98319	1.296313	0.595138	0.015408
40	0.169871	0.940079	96.98319	1.296313	0.595138	0.015408
44	0.169871	0.940079	96.98319	1.296313	0.595138	0.015408
48	0.169871	0.940079	96.98319	1.296313	0.595138	0.015408
52	0.169871	0.940079	96.98319	1.296313	0.595138	0.015408

Tables 5–10 provide a look at the variance decomposition for the three Korean financial variables. The impact of the foreign factors on the domestic variables is not large during the pre–crisis period. We can see that innovations to the foreign financial variables account for less than 2% of the variance in KOSPI in two days or 12 months. This phenomenon is almost the same as KRW exchange rates, although the accountability of foreign variables increases by more than 3%. Among foreign variables, JPY has stronger influence on the three Korean financial variables than others. The fact that JPY shock had stronger influence reflects the competitiveness of Korean industries against that of Japanese industries. Also, Korea adopted a market average system during the pre–crisis period, which is a conjecture that the Korean government has been watching JPY in order to manage KRW.

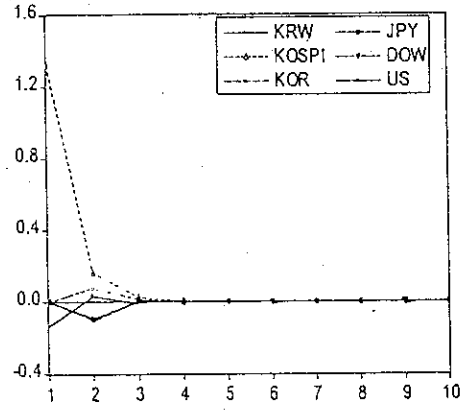
After the crisis, the influence of foreign variables and other domestic financial variables increase by more than two times compared to the pre–crisis period. We can see that innovations of the Dow Index account for about 8.5% of the variance in KOSPI on a 12–month horizon. Alternatively, domestic variables are less important. The accountability of Dow Index is less important to KRW exchange rates than KOSPI, but the number increases up to five times compared to the pre–crisis period. The shocks to JPY exchange rates provide more information than other domestic variables over all– time horizons. For the Korean short–term interest rate, its own shocks account for most of variance in both periods.

The impulse response functions are illustrated in Figures 2–7. These figures are sharing a similar economic spirit with the results of variance error decomposition. During the pre–crisis period, other shocks to domestic variables do not affect each financial variable. Shocks to JPY cause a relatively large spike and influence KRW out 3–4 days. For

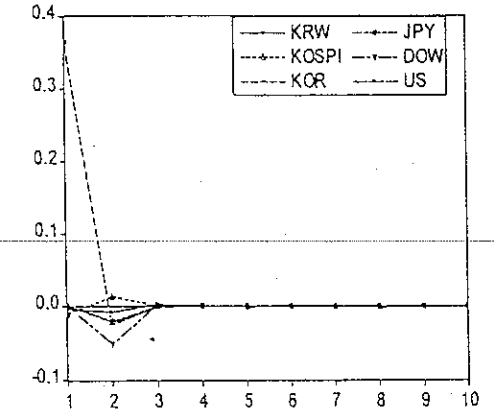
〈Figure 2〉 Impulse Response Function of KRW (pre-crisis)



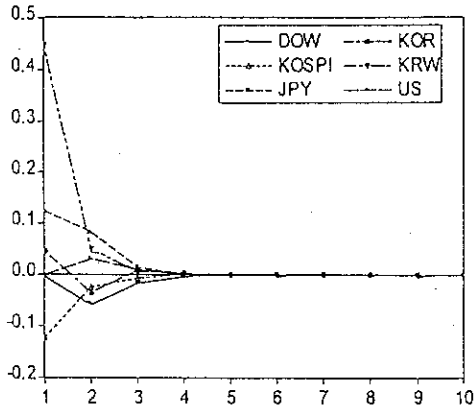
〈Figure 3〉 Impulse Response Function of KOSPI (pre-crisis)



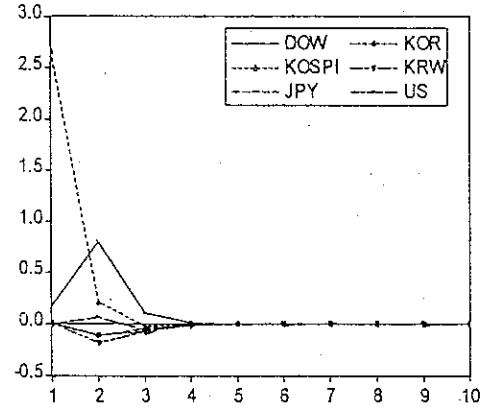
〈Figure 4〉 Impulse Response Function of Korea interest rate (pre-crisis)



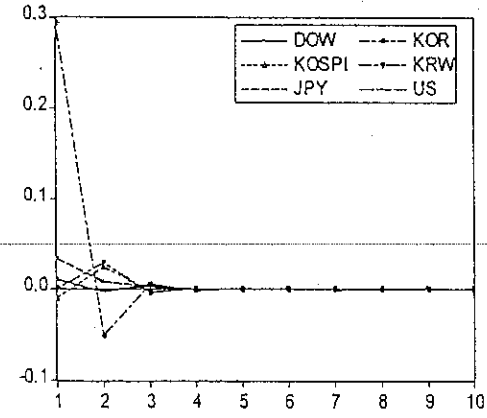
〈Figure 5〉 Impulse Response Function of KRW (post-crisis)



〈Figure 6〉 Impulse Response Function of KOSPI (post-crisis)



〈Figure 7〉 Impulse Response Function of Korea interest rate (post-crisis)



KOSPI, all variables other than itself do not cause any large spike. For KRW after the crisis, shocks to JPY and KOSPI cause a bigger hump than other variables. After the crisis, shocks to Dow Index, however, bring out a large spike in KOSPI and continued increase in KOSPI returns out 4 days. Shocks to other variables except Dow Index affect KOSPI out 2–3 days and levels off toward the pre–shock level.

For the Korean interest rates, US interest rates create a relatively larger hump shape than domestic variables for the pre–crisis period; KOSPI, on the other hand, brings out the biggest hump shape after the crisis. As we saw in variance decomposition for the short–term interest rate, we cannot take the results as foreign factors being less important after the crisis since its own shocks are the dominating ones compared to other two domestic variables.

In sum, active liberalization of capital markets and adoption of a flexible exchange rate regime after the crisis has exposed the economy to foreign shocks.

(2) Volatility Interrelations

As we have mentioned in previous sections, the first step for Klaassen's GARCH model is to find weighting matrix composed of eigenvectors of the sample covariance of six variables during pre–crisis and post–crisis periods. Table 11 presents the results with naming dominating factor in column head. For example, the second column is called "US_INT" since US interest rates have the highest weighting number, 0.99. The third column is called "–KOSPI," as KOSPI is negatively dominating variables in the column. We can easily notice that each column title is either domestic factor (or combined ones) or foreign factors. However, the column head in Table 12 (post–crisis period) is not as much obvious as in Table 11. Three out of six

〈Table 11〉 Principal Component Weights (pre-crisis)

	US_INT	-KOSPI	-KOR_INT	YEN-DOW	-DOW-YEN	WON
US_INT	0.999951	0.007468	0.005956	0.000529	0.002309	0.001379
DOW	0.002532	0.010084	-0.013789	-0.252591	-0.967404	-0.005327
YEN	0.000936	0.066717	-0.071373	0.962517	-0.249820	0.040061
WON	0.001228	-0.024537	-0.007164	0.041328	0.005442	0.998803
KOR_INT	0.005928	0.004283	-0.997270	-0.066237	0.031546	0.004142
KOSPI	-0.007404	-0.997382	-0.009065	0.060526	0.026240	0.027206
Variance	0.001595	0.085800	0.133270	0.570782	0.745690	1.845689
Exp. Var.	0.04718	2.536430	3.939744	16.87353	22.04418	54.55894

〈Table 12〉 Principal Component Weights (post-crisis)

	US_INT	-KOR_INT+KOSPI	KOSPI+YEN	YEN-DOW+KOSPI	DOW+YEN	-WON
US_INT	0.999864	-0.013856	0.003320	0.008250	0.000451	-0.000750
DOW	0.002843	0.014267	0.002574	-0.275830	0.958393	-0.071993
YEN	-0.008034	0.011990	0.144460	0.950882	0.273378	0.003360
WON	-0.000797	0.004740	0.048515	0.029850	0.066178	-0.996169
KOR_INT	-0.013490	-0.990522	-0.132269	0.025945	0.022683	0.001010
KOSPI	0.004073	0.135292	0.979421	0.134571	0.043054	0.049512
Variance	0.003167	0.088169	0.210823	1.228122	1.515546	8.775888
Exp. Var.	0.026790	0.745822	1.783354	10.38870	12.82002	74.23532

weighting vectors are mixed even if either domestic or foreign weight is a single dominating one. The last two rows in Tables 11 and 12 are variance of each component and explained variance. The

terminology of explained variance denotes that each component sample variance is divided by the sum of the sample variances of the individual six financial variables. Therefore, explained variance can be used as a measure of importance of principal components. During the pre-crisis period, the components dominated by the domestic variables explain approximately 61% of the total variance. However, the "WON" component is a single dominant one after the crisis (over 74%).

The next step is to estimate each component using a GARCH model. We have tried to use the GARCH model with standard normal distribution but goodness-of-fit test indicated that the standardized residuals are non-normal in all six variables. We, therefore, explored other error density to improve the fit of the model. Since it has known that financial variables have higher peaks and fatter tails than the standard normal, we use Student-t distribution. In the mean equation, f_t is an autoregressive of order 1(AR1), and error term is normally distributed with zero mean and variance h_t conditional on past information:

$$f_{it} = \alpha_0 + \alpha_1 f_{it-1} + \varepsilon_{it}$$
$$\varepsilon_{it} \sim T(0, h_{it})$$
$$h_{it} = \omega + \alpha \varepsilon_{it}^2 + \beta h_{it-1}$$

Here, T stands for Student-t distribution.

Tables 13 and 14 report the results of fitting the mean and univariate GARCH models to the six principal components. In each case, we report the coefficient estimates with standard errors, likelihood function values, and various residual diagnostics.[13] As usual in financial

13) We do not report the coefficient estimates and residual diagnostics for GARCH with standard normal to conserve space, though they are

variables, all but principal component $f6$ after the crisis shows persistence in variance, that is to say, the value $(\alpha + \beta)$ is more than 0.9. Therefore, principal components share a very important characteristic in original six variables in the sense that the magnitude of residuals

〈Table 13〉 GARCH Estimation Results for Principal Components (pre-crisis)

	f1	f2	F3	f4	f5	f6
a_0	-9.70×10^{-4} (3.96×10^{-2})	8.90×10^{-3} (8.68×10^{-3})	2.02×10^{-4} (4.64×10^{-3})	4.93×10^{-3} (2.33×10^{-2})	-0.175 (2.91×10^{-2})	7.26×10^{-2} (4.94×10^{-2})
a_1	-2.08×10^{-2} (0.717)	-0.132 (4.68×10^{-2})	0.354 (4.56×10^{-2})	-7.33×10^{-2} (5.05×10^{-2})	6.23×10^{-2} (5.37×10^{-2})	0.142 (4.83×10^{-2})
ω	1.83×10^{-4} (2.22×10^{-3})	9.97×10^{-3} (1.38×10^{-2})	6.07×10^{-4} (7.43×10^{-5})	1.33×10^{-2} (1.09×10^{-2})	3.11×10^{-2} (3.36×10^{-3})	0.146 (8.57×10^{-2})
α	0.151 (3.80×10^{-2})	0.404 (0.172)	0.122 (2.34×10^{-3})	4.50×10^{-2} (2.87×10^{-2})	0.173 (6.08×10^{-3})	0.107 (6.31×10^{-2})
β	0.715 (3.66×10^{-2})	0.588 (0.261)	8.76 (2.97×10^{-3})	0.942 (3.53×10^{-2})	0.799 (6.03×10^{-3})	0.815 (9.3×10^{-2})
D	5.970 (870)	3.965 (0.702)	11.09 (14.23)	3.269 (0.620)	6.901 (1.891)	7.752 (2.274)
Ln L	1107.46	−35.00	49.46	−568.16	−664.53	−957.802
ARCH(4)	0.300 (0.877)	1.121 (0.345)	0.0663 (0.991)	1.903 (0.108)	1.805 (0.127)	0.187 (0.944)
$Q_x(24)$	20.163 (0.632)	26.42 (0.119)	27.99 (0.216)	36.36 (9.53×10^{-3})	25.20 (0.339)	16.70 (0.820)
$Q_{xx}(36)$	32.70 (0.085)	40.562 (0.003)	0.097 (1.00)	23.66 (0.209)	29.31 (0.170)	12.586 (0.960)

Notes: (1) Values in parenthesis for mean and volatility parameters denote standard errors and those for residual tests denote p-value. (2) $Q_x(n)$ and $Q_{xx}(n)$ stand for Ljung-Box statistics corresponding to nth serial correlation.

available on request.

〈Table 14〉 GARCH estimation results for principal components (post-crisis)

	F1	f2	f3	f4	F5	f6
a_0	3.74×10^{-3} (2.57×10^{-3})	1.39×10^{-3} (1.19×10^{-2})	2.57×10^{-2} (1.56×10^{-2})	-5.68×10^{-2} (4.61×10^{-2})	5.52×10^{-2} (6.37×10^{-2})	−0.197 (0.156)
a_1	-2.23×10^{-2} (5.45×10^{-2})	−0.145 (6.84×10^{-2})	-1.56×10^{-2} (5.04×10^{-2})	-8.16×10^{-2} (4.84×10^{-2})	1.35×10^{-2} (5.42×10^{-2})	0.103 (5.25×10^{-2})
ω	1.829×10^{-4} (8.99×10^{-5})	2.43×10^{-3} (2.32×10^{-4})	3.23×10^{-2} (2.58×10^{-2})	4.36×10^{-2} (3.59×10^{-2})	3.16×10^{-2} (3.38×10^{-2})	5.239 (0.365)
α	0.110 (4.51×10^{-2})	0.174 (1.08×10^{-2})	0.266 (0.129)	6.39×10^{-2} (4.33×10^{-2})	2.89×10^{-2} (1.85×10^{-2})	3.52×10^{-2} (3.36×10^{-2})
β	0.827 (5.32×10^{-2})	0.788 (6.31×10^{-3})	0.626 (0.195)	0.883 (7.27×10^{-2})	0.951 (3.31×10^{-2})	0.326 (4.50×10^{-2})
D	6.74 (2.25)	16.56 (10.70)	3.717 (0.706)	7.759 (3.104)	16.37 (12.13)	31.507 (39.07)
Ln L	596.72	47.58	−186.20	−499.10	−615.59	−947.140
ARCH(4)	0.644 (0.631)	0.553 (0.697)	0.433 (0.784)	2.00 (0.093)	0.024 (0.999)	0.105 (0.980)
$Q_x(24)$	28.99 (0.145)	26.10 (0.295)	21.64) (0.541)	9.077 (0.996)	4.301 (0.230)	21.73 (0.536)
$Q_{xx}(36)$	11.80 (0.961)	16.87 (0.815)	11.93 (0.971)	20.78 (0.594)	12.57 (0.960)	11.70 (0.974)

Notes: (1) Values in parenthesis for mean and volatility parameters denote standard errors and those for residual tests denote p-value.
(2) $Q_x(n)$ and $Q_{xx}(n)$ stand for Ljung-Box statistics corresponding to nth serial correlation.

appears to be related to the magnitude of recent residuals. In terms of diagnostics, both tables show that GARCH with Student-t distribution fits very well. Null hypothesis that there is no ARCH up to order four in the residuals is fairly well accepted in both periods. Most of the Ljung-Box Q-statistics in normalized residuals and their square, $Q_x(36)$ and $Q_{xx}(36)$, do not detect any significant dependence

except a principal component $f2$ before the crisis.

Since we have made multivariate GARCH estimations, we can now answer the main questions: Have domestic financial variables become more closely tied among themselves and foreign ones, and how do they evolve over two periods? In Figure 8, we plot the estimated conditional correlations during pre-crisis and post-crisis periods. For the sake of exposition, we have smoothed the actual estimates using the Hodrick-Prescott filtering method.

We can easily see that correlations are time varying and two periods are distinguished from each other. The post-crisis period is characterized by an increase in correlation with absolute value. The conditional correlation between US interest rates and KRW (panel (a)) increases in absolute value, as well as turning into positive ones as implied by uncovered interest parity. Also, the shape of the correlation between US interest rates and Korea interest rates (panel (b)) shares similar characteristics with panel (a). These results economically make sense. After the East Asian crisis, the U.S. was lowering interest rates to stimulate world economy up until mid-1999 and then making the opposite move for fear of inflation in US economy. On the other hand, KRW continuously depreciates due to favorable world economic conditions and Korea's own restructuring efforts. After KRW maintains around 1,150~1,200 KRW against the US dollar, foreign portfolio investment flows mainly determined by US interest rates are most important factor that determines the movement of KRW, resulting in a high positive correlation between KRW and US interest rates.

US interest rates and KOSPI have become either negatively or loosely tied after the crisis relative to pre-crisis period (panel (c)). The negative correlation in late 1998 or early 1999 might be due to the fact that KOSPI steeply recovered its level and US interest rates

decreased. Two asset markets would cause the positive correlation after mid-1999—US bond market and Korea stock market—sharing on-average upward trends.

The correlation shape between Dow Index and the three domestic financial variables (panel (d), (e), (f)) are very similar to that of the relations between US interest rates and domestic variables. The loosely tied relation between Dow Index and Korean interest rates become tight after the crisis. We expect that Dow Index would be the most influential factor of KOSPI, with the relation, however, loosely tied after the crisis.

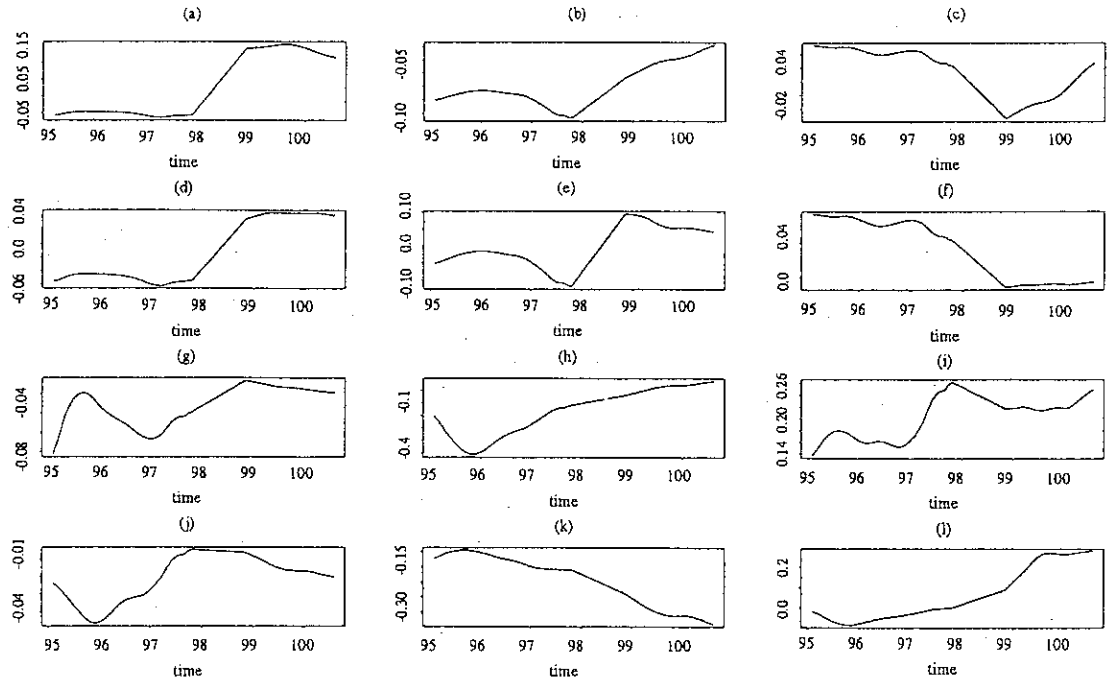
The correlation between JPY and domestic variables decreases after the crisis except for KOSPI. Even if JPY does not move closely with KRW, contrary to our expectation, stock investors take JPY as most important foreign variables affecting KOSPI index.

Among domestic variables, KRW and short-term domestic interest rates become loosely tied. Possible interpretations are that short-term interest rates do not reflect either the money market's liquidity situation or the Korean government intervenes in the foreign exchange market either directly or indirectly. The Korean government was trying to keep interest rates low to speed up the financial sector restructuring. That is, high interest rates would result in increasing non-performing loans in the banking sector, causing the government to allocate more resources to the sector. Therefore, the interest rates are not market price reflecting demand and supply for KRW. There are many clues for other interpretation. The Korean government is trying to take various measures to keep KRW from rising (in value), such as encouraging local banks to purchase dollars in order to provide for their foreign currency-denominated non-performing loans. However, the pairs of (KRW, KOSPI) and (interest rates, KOSPI) become tight

after the crisis.

In sum, we found that the correlation between the three Korean financial variables and foreign ones become higher after the crisis. That is to say, foreign environment is a major driving force for Korean domestic financial markets. KRW moves closely with US interest rates and KOSPI. This implies that the foreign exchange market is influenced by capital inflows. The fluctuation in YEN is a major foreign driving force for KOSPI. The short-term interest rates in Korea are closely

〈Figure 8〉 Conditional Correlations between US and Korean Financial Variables



Notes: (a) (US Interest Rates, KRW)
(b) (US Interest Rates, Korean Interest Rates),
(c) (US Interest Rates, KOSPI), (d) (DOW, KRW),
(e) (DOW, Korean Interest Rates), (f) (DOW, KOSPI), (g) (YEN, KRW),
(h) (YEN, Korean Interest Rates), (i) (YEN, KOSPI),
(j) (KRW, Korean Interest Rates), (k) (WON, KOSPI),
(l) (Korean Interest Rates, KOSPI)

tied with US interest rates and Dow Index with correlation magnitude amounting to roughly 0.1 and loosely tied, on the other hand, with KRW.

4. Findings from Survey Data on Foreign Exchange Risk Management

From the above empirical results, Korean financial markets are found to be closely tied to international financial markets. Also, volatility of international financial markets can turn Korean financial markets volatile. Such volatility of financial market can dampen the real economy and hinder economic growth; the probability is clearly shown in the result of a recent survey on Korean companies' exchange rate risk management by the Korea Institute for International Economic Policy.

According to the survey result, losses from exchange rate continue to increase for Korean firms since the introduction of free floating exchange rate regime in 1997. With the exception of 1995, losses from foreign exchange in general outnumber profits. In particular, net profits

〈Table 15〉 Comparison of Foreign Exchange Profits and Losses of Korean Companies

(Unit: billion, Korean won)

	1981	1985	1990	1995	1996	1997	1998
Profits from Exchange	21.33	42.49	99.31	263.15	213.33	1,115.56	1,984.14
Losses from Exchange	61.84	120.19	113.75	151.02	404.95	1,384.76	2,062.53
Profits &Losses	-40.51	-77.70	-14.44	112.13	-191.63	-269.20	-78.39

Source: Bank of Korea. *Annual Company Performance Analyses.*

from foreign exchange (profits minus losses) reached –269.2 billion Korean won in 1997, the biggest difference ever recorded. The reason for the enormous loss was an unexpected steep rise in exchange rate, i.e. devaluation of the Korean won, rising out of the foreign reserves crisis of 1997.

From a survey on foreign exchange risk management of large companies in Korea, over 30% of Korean large firms were found not to be managing exchange risks. Reasons for not managing exchange risks include lack of adequate means of exchange management (24%) and absence of risk awareness on the part of the management (15%). When asked what urgent tasks lay ahead for systematic exchange risk management, companies gave the following answers: keen awareness of the top management (32%); training and reasonable compensation system of professionals (34%); systematic internal reporting mechanism (17%); and diversification of financial products (17%).

Approximately 75% of Korea's small– and mid–size export–import companies are not managing exchange risks, signaling a red alert. Some small– and mid–size companies appear to be managing exchange risks, but they are blue–chip companies with large transactions of export and import, and also just a fraction of the entire number of small– and mid–size companies. In the case of risk–managing small– and mid–size companies, almost none of them are managing risks by means of forward exchange rates, futures and options. The majority of companies are using matching or netting techniques. Since the foreign currency crisis, awareness of exchange risks has become higher among small– and mid–size companies and necessity of exchange risk management is felt stronger.

In conclusion, whereas the environment of Korea's financial markets is globalizing, companies continue to act as they have done in the

past fixed exchange regime. As previously mentioned, factors of instability in international financial markets may well immediately give birth to volatility of domestic financial markets. Such volatility of domestic financial markets will ultimately bring about losses from foreign exchange for companies and deteriorate their global competitiveness, as well as giving rise to foreign currency liquidity crunch.

Choosing capital account liberalization and free-floating exchange regime could cause domestic financial markets to further develop. However, if external financial factors dominate financial markets of the emerging markets, then negative impact, be it local shocks or global shocks, will be exerted on the real economy, with implications of a potential foreign exchange crisis. It is therefore concluded that it is not appropriate for Korea to adopt a full free-floating exchange regime, which can increase volatility of exchange rates. Cooperative efforts of advanced countries to sustain stability in international financial markets are necessary.

IV. Conclusion

Since the currency crisis, most crisis-hit countries have shifted toward two polar solutions. Countries, which choose more flexible exchange regime, concern the choice lies on volatility of the short-term exchange rates, and misalignment in mid- or long-term exchange rates. For developing countries with shallow financial markets, volatility of exchange rates make the country more vulnerable. Furthermore, it is a general consensus that the exchange rate volatility does not always derive from economic fundamentals. This exaggerates the situation in the emerging markets. If it were true even in mid- or long term period, a free floating exchange rate regime would remain to prone to crisis, as the intermediate regime would. Even in When G-3 currencies deviate from their par values, it is quite possible to bring significant foreign shocks for developing countries such as Korea, not to manage by themselves. It is a main point that we addressed in this paper. The impact of foreign shocks on domestic financial variable after the structural changes (both opening of capital markets and adoption of flexible exchange rate regime) has been increased by more than two times, compared to previous period. On the other hands, foreign shocks are becoming the major forces for Korean financial markets' fluctuations. The Korean exchange rates are moving closely with the U.S. interest rates and Japanese Yen. This implies that, without exchange rate correction, the exchange rate in Korea will deviate from domestic equilibrium more open. However, the dilemma for Korean authority is that frequent interventions will produce unwanted market perception such that the Won exchange rates are managed.

It has been suggested that a flexible exchange rate regime provides a way of giving domestic financial institutions and firms stronger incentives to hedge their foreign exchange exposure and hence the hedging market will develop. However, our survey data showed that it is not the case for Korea. Financial institutions and firms have still not adjusted themselves to the flexible exchange rate system. Thus, there is a significant risk not to be hedged in the market. Furthermore, the hedging instrument has not been developed yet to cover most foreign transactions.

To conclude, a free-floating regime is not viable and appropriate for Korean economy, totally mitigating the negative effect of a flexible exchange rate regime. Of course, the period of empirical studies is not long enough to verify the appropriateness of the flexible exchange rate regime. However, it is fair to say that the current transitory period from managed to flexible exchange rate regime is a very vulnerable period for Korean economy, and we need to be well equipped to another near international financial turmoil.

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國文要約

아시아 외환위기 이후 신흥시장(emerging markets) 국가들의 적정환율제도에 관한 논의가 활발히 진행되고 있다. 아시아 외환위기 발발 직후 자유변동환율제도의 우월성을 설명하는 연구가 同 논의의 主流를 차지하였다. 그러나 최근 자유변동환율제도가 개도국에 적정하지 않다는 논의가 대두되고 있어 아직까지 미해결 과제로 남아 있다. 선진국과 달리 신흥시장국가들의 환율제도는 급속한 자본유출입의 직접적인 원인을 제공할 수 있어 통화정책에 직접적인 영향을 미칠 수 있다. 즉, 통화정책과 외환정책을 분리할 수 없는 상황이라 할 수 있어 환율제도의 선택은 거시경제정책에 직접적인 영향을 미칠 수 있다고 할 수 있다.

본 연구에서는 한국이 현재 채택 운영하고 있는 자유변동환율제도가 적정한가를 연구의 출발점으로 하여 기존의 환율제도 논의를 살펴보고 경험적 분석을 통하여 적정성 여부를 살펴본다. 우리나라 금융시장이 외환위기를 전후하여 어떠한 특징을 갖고 있는가를 실증분석한 결과 우리나라 금융시장은 국내금융변수보다는 국제금융변수에 의해 영향을 받는 것으로 나타나고 있다. 즉, 원/달러 외환시장은 일일 자본유출입, KOSPI지수는 엔/달러 환율에 의해 지대한 영향을 받는 것으로 분석되었다.

이러한 결과는 우리나라 금융시장이 국제금융시장에 통합되는 과정에서 나타날 수 있는 자연스러운 결과로서 시장 효율성 측면에서 긍정적 측면이 있는 것도 사실이다. 그러나 국제금융시장이 불안한 경우 국내금융시장이 불안한 양상을 보일 수 있으며 또한 급속한 자본유출로 원/달러 환율이 급격히 절하될 수 있다. 결국 정책당국은 급속한 자본유출입에 대비하여 외환보유고를 일정규모 이상 유지할 수밖에 없으며 외생적 충격에 독립적인 통화정책을 수행하기 어렵다고 할 수 있다. 이러한 점을 고려할 때 한국이 자유변동환율제도를 채택하는 것은 바람직하지 않다고 판단된다. 한국을 포함한 신흥시장국가들은 자국의 통화를 안정적으로 또한 장기적으로 차입하기 위한 제도적 여건 즉, 장기국채시장을 육성할 필요가 있으며 선진국 역시 국제통화체제의 안정을 위하여 선진국간 환율의 안정을 위해 노력할 필요가 있다.

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Appropriate Exchange Rate Regime in Developing Countries: The Case of Korea

2000년 10월 10일 인쇄
2000년 10월 15일 발행

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인 쇄 오롬시스템(주) 전화 : 2273-7011 대표 이호열

등 록 1990년 11월 7일 제16-375호

ISBN 89-322-4085-X
89-322-4026-4(세트)

값 5,000원

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