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UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

COLLAPSING EXCHANGE RATE REGIME: A THEORETICAL AND EMPIRICAL INVESTIGATION WITH SPECIAL REFERENCE TO KOREA

A Dissertation

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

Doctor of Philosophy

By

SUNG-HOON SIM

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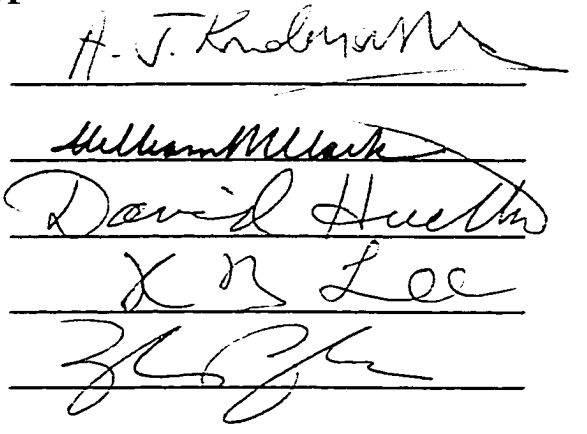
1999

COLLAPSING EXCHANGE RATE REGIME: A THEORETICAL AND EMPIRICAL INVESTIGATION WITH SPECIAL REFERENCE TO KOREA

A Dissertation APPROVED FOR THE DEPARTMENT OF ECONOMICS

BY



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ABSTRACT

The wave of turmoil in Asian currencies in 1997 has put, again, the economic research of currency crisis or speculative attack on the forefront of old debates in finding the main causes of the crises. Two generations of currency crisis models coexist since the crises that occurred in some member countries of European Monetary System (EMS), and Mexico during the 1970s-1990s.

The first group of models regard inconsistency between macroeconomic fundamentals and the existing fixed exchange rate regime as the root of the crisis. More recent theoretical researches, which are so-called second generation models of speculative attacks, put more weight on the speculation itself, than on the bad economic fundamentals, in examining the driving force of collapse of a fixed exchange rate regime. However, the Korean currency crisis during 1997 could not be understood on the basis of only an one-sided view. The Korean crisis seems to have both characteristics of first and second generation models; a mixture of weak fundamentals (stressed in the first view), and factors leading to a self-fulfilling attack such as financial panic and contagion effects (emphasized in the second view).

In this regard, this paper attempts to examine the main causes of the Korean currency crisis by introducing the features stressed in both generation models. For this purpose, this paper develops a theoretical framework, which is based on the modified monetary model of exchange rate determination (or modified first generation models). The model includes the following assumptions: (1) a relaxation of the purchasing power parity condition; (2) an inclusion of income in the money demand equation; (3) a

sterilization of the reserve losses; (4) inclusions of external credit shocks as well as domestic credit shocks; (5) inclusions of currency substitution motive and non-performing loans in the money demand function; and (6) an introduction of a time-varying risk premium to the interest parity condition. Based on this extended theoretical model, one-period-ahead probabilities of fixed exchange rate regime are derived using the estimated reserve floor and shadow exchange rates.

The empirical model performs relatively well since it predicts high ex ante collapse probabilities during the crisis and lower bounds for the new post-collapse market clearing exchange rates. The principal research findings show that the collapse probability of the Korean exchange rate regime might have been lowered by decreasing the external credit shocks, the magnitude of sterilization, and the variability of relative price shocks. The impact of the uncertainty surrounding domestic credit growth on the probabilities of regime collapse varies during the sample period.

In addition to these results, this paper provides some policy implications for avoiding a future currency crisis. The implications are taken from both generation models: (1) the need of maintaining stable economic fundamentals (especially, current account balance and enough accumulation of usable foreign reserves) along with a more flexible exchange rate system; (2) the need of a stable financial system by controlling capital flows and thus by avoiding a moral hazard problem.

CHAPTER 1

Introduction

In the aftermath of the 1992 Exchange Rate Mechanism (ERM) crisis in the European Monetary System (EMS) and the 1994 Mexican peso crisis, old debates have been revived concerning the roles of economic fundamentals and speculation in tracing out the determinants of the currency crises.

Before the ERM crisis of 1992-93 took place, there was consensus in explaining the main driving force of speculative attacks on the currency: inconsistency between government's long-term macroeconomic policies and government's willingness to maintain the fixed exchange rate regime. However, the advents of ERM and Mexican crises in the early 1990s forced some economists not to regard the above inconsistency as a main cause of the speculative attacks. They believe that the EMS countries and Mexico who experienced crises were performing sound macroeconomic polices along with their exchange rate systems when investors attacked their currencies. Some economists emphasize the importance of speculation itself as a main force of regime collapse.

The first view that was developed in response to the currency crises in developing countries such as Mexico (1973-82) and Argentina (1978-81), called first generation models of speculative attack, was initiated by Krugman (1979) and simplified by Flood and Garber (1984b) and others.[1] As a main source of the crisis, the first generation models stress the relation between investors' speculative behavior and deteriorating macroeconomic fundamentals that are related to the determinants of exchange rate and

[1] A useful survey of the first generation models of speculative attacks is found in Agénor, *et al.* (1992).

the government budget deficit. That is, these models show how the co-movement of a fixed exchange rate policy and overly expansive fundamentals ends with a transition of the peg into a floating regime, faced with investors' efforts to make profit by attacking the currency.

According to this view, collapse of the peg is inevitable when the central bank international reserves fall to a critical threshold level below which the reserves are abruptly exhausted by private speculation and thus the central bank abandons the currency peg. Thus, in this context, the collapse of the fixed regime is predictable and takes on the destiny of demise under a certain condition of the fundamentals. In short, any attempt to sustain a fixed exchange rate regime while simultaneously attempting to expand money supply for the purpose of financing fiscal deficit induces a fundamental inconsistency with the regime and then pushes the economy into crisis.

The second view attributes the cause of currency crises, especially those of ERM in 1992-93 and the Mexican peso collapse in December 1994, to the market's abrupt speculative activity, rather than to a preceding period of unsustainable government policies. The supporters of this view argue that pre-crisis macroeconomic fundamentals were not obviously inconsistent with existing fixed regimes in ERM and Mexico in the early 1990s. Therefore, they maintain that a period of nonsustainable government policy accompanied by gradual depletion of international reserves may be a necessary condition, but not a sufficient condition, for the collapse of a fixed exchange rate regime. In this respect, they suggest a self-fulfilling crisis as an alternative interpretation on the recent currency crises, but with the following mechanism.

Assuming the existing government policies are consistent with macroeconomic fundamentals, the market is not expected to anticipate the gradual exhaustion of central bank foreign reserves. But, if the investors recognize the government's intention to use more expansionary policies to cope with internal imbalance (e.g., growing unemployment) which may be induced by external shock such as the loss of competitiveness (and thus output decline), they may attack the currency by expecting more aggravating internal imbalance (e.g., the higher rate of unemployment). This worsening imbalance comes from the combination of an expansionary policy (in order to sweep internal imbalance) and a policy of increasing interest rates (in order to defend the currency peg). That is, this increase in the interest rates depresses the domestic economy and so leads it to worse unemployment. Thus, the loss of confidence in government commitment to defend the fixed regime by the above mechanism can generate an attack equilibrium and then lead to a currency collapse.

Put differently, in the presence of a central bank and government attempting to maximize internal objectives (such as output and employment) and external objectives (such as maintenance of the peg), a shift in the market's expectation on the government policy can make a speculative attack self-fulfilling. Thus, the attack takes on the nature of multiple equilibria because arbitrary change in the private expectation yields the collapse of an otherwise viable exchange rate regime.[2]

On the other hand, the wave of meltdown of some Asian currencies in 1997 has pushed, again, the economic field of currency crisis to the forefront of economic studies. The negative impacts of these crises on their domestic economies and on the economy of

[2] Flood and Garber (1984b) and Obstfeld (1986b) first proposed the models which analyzed a speculative attack based on the framework of multiple equilibria.

the rest world are tremendous and may be unprecedented. Therefore, the two different views stated above are expected to compete in attempting to examine the 1997 Asian currency crises.

In fact, the Korean currency crisis seems to have characteristics of the above two different views on the basis of the following grounds.

First, the factors that might support the view of first generation models of a speculative attack (i.e., deteriorating macroeconomic fundamentals and poor economic policies) are as follows.

Although the Korean currency, the won, had been depreciated against the U.S. dollar in the nominal term during the 1990s, its depreciation could not be regarded as large enough to compete in the world goods market because the yen/dollar rate had been increasing faster than the won/dollar rate since 1995.[3] This gives an important implication about the loss of price competitiveness since a number of Korean export products compete with Japanese exports in the world market. Therefore, the won might have been under pressure of the potential realignment (i.e., further depreciation).

The current account deficit marked a record high of 4.8 percent of the GDP in 1996.[4] The large current account deficit itself can be problematic. However, a more important implication is how it is financed. That is, if the deficit is financed in a way that can yield a potential reversal problem, this imbalance would raise a question of its sustainability. Moreover, when the way of financing the current account imbalance

[3] The Japanese yen was depreciated over 50 percent until the summer of 1997 compared to the spring of 1995. Between 1991 and 1995, the yen was very strong;80 yen per U.S. dollar.

[4] Even though this large current account deficit was mainly caused by the sharply increasing trade deficit that stemmed from the slowdown of export growth due to external shocks such as adverse terms of trade (e.g., fall in the world price of semiconductors) and a long-period recession of Japanese economy, a question on the sustainability of the large current account deficit can be raised because the deficit was aggravating since 1994.

provides a secondary problem for the banking system, the large current account deficit can be an important source of triggering a currency crisis. In fact, the way of financing the current account deficit in Korea seems to fit the above case on the following ground.

The financing was mainly channeled by the banking system in the form of short-term foreign-currency denominated liabilities (i.e., unhedged borrowing) under the lack of prudential supervision and regulation of the financial system. When a number of questionable investments by Korean firms who borrowed largely from domestic banking system became unprofitable due to shock such as slowdown of domestic and/or world economy, many of the firms went bankrupt. The banking system that borrowed from abroad in the above way was more fragile with non-performing loans and was also vulnerable to speculative attacks in the event of a sudden loss of confidence by foreign investors (who had suspected the sustainability of Korean economy due to a large current account deficit and a misalignment of the peg since their observing of the southeast Asian currencies' crashes). Thus, the large current account deficit in Korea can be regarded as a key force of the 1997 currency crisis.

Other indicators that could be used as . measures of the condition in the macroeconomic fundamentals are the size and structure of foreign debt. The accumulation of the foreign debt in Korea was increasing during the 1990s, reaching to more than $120 billion in the end of 1997. Also, the ratio of external debt to GDP (which is frequently used as a measure of the external debt sustainability of a country) shows an upward trend through the 1990s. Especially, the ratio of short term external liabilities to total foreign debt and to foreign reserves remained at very high levels compared to other

developing countries.[5] This ratio is a crucial indicator of financial fragility. This aggravating debt structure played a key role in the 1997 Korean currency crisis. Since this bad debt structure gave rise to a situation where foreign investors were unwilling to roll over the existing short-term credit, Korea was exposed to the speculative attacks and suffered from a serious liquidity problem. The amount of foreign reserves itself (about U.S.$29 billion in the first quarter of 1997) held by bank of Korea, which was increasing until the middle of 1996 and then gradually decreasing, was inadequate to withstand speculative attacks, compared to those of foreign reserves held by Singapore ($80 billion) and Taiwan (over $100 billion).[6]

On the other hand, there also seems to exist some evidences that the basis of the Korean crisis can be attributed to the features of second generation models of speculative attacks; self-fulfilling and multiple equilibria natures of currency crises.

In the presence of unfavorable developments in some macroeconomic fundamentals such as growing current account deficit, increasing pressure on the exchange rates, and worsening debt structure, the collapse of Thai baht in early 1997 combined with the bankruptcies of several Korean big business groups (*chabol*)[7] pushed the Korean economy to a crisis when the domestic and foreign investors panicked and attacked the

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[5] In Korea, the ratio of short term foreign debt to total foreign debt was about 70% in the middle of 1997. This ratio was very high compared to the countries such as Indonesia (25%), Thailand (45%), Malaysia (40%), Mexico (15%), and Brazil (25%). The ratio of short term foreign debt to the foreign reserves also shows a much larger level (300%) in Korea than in the above countries; Indonesia (160%), Thailand (110%), Malaysia (55%), Mexico (125%), and Brazil (70%).

[6] The currencies of these countries are not regarded as experiencing a regime collapse, though the currencies were depreciated about 18% (in Taiwan) and 2% (in Singapore), respectively. These depreciation rates were far below those of the crisis-experienced Asian countries. The main reason of the Taiwan devaluation mainly stemmed from the appraisal of Taiwan's competition problem rather than the shortage of the foreign reserves. Also, these countries are still accumulating foreign assets by running current account surpluses.

[7] These *chabols*' bankruptcies first occurred in a decade and originated from the long-term problems of economic and political structures in Korea.

won. In other words, although the story that deteriorating fundamentals along with a worsening banking system would be vulnerable to the internal and/or external shocks has been well-known to the investors for years, after the collapse of Thai baht, the market changed their relatively optimistic expectation about the above previously neglected economic problems which they regarded as minor. That is, when the foreign investors recognized the pressure on the Korean exchange rate due to the combination of the concern of contagion from southeast Asian crashes and the worsening economic conditions (e.g., the increasing burden of maintaining the exchange rate regime under a large current account deficit and decreasing foreign reserves; and vulnerable financial market), they hedged their investments by gradually attacking the won.

Especially, the pressure on the won became more severe when a competition problem surfaced after the 15 percent depreciation of the Taiwanese new dollar in October 1997, because Taiwan is a direct competitor in Korea's major exports like semiconductors. Thus, the shift in the market's expectation might have generated an attack equilibrium and then the attack became a self-fulfilling currency crisis of an otherwise viable exchange rate regime even under the same macroeconomic imbalances.

A political instability could be considered as an additional source of financial panic since the turmoil of the presidential election (which was set in December 18, 1997) gave the market an impression of a lack of leadership to cope with the currency crisis.

Even if the pre-existing economic weaknesses themselves in Korea were not critical (or might not have seemed to be vulnerable) to the external/internal shocks under normal times, these weaknesses may surface and so could be vulnerable to the shocks when there is a speculative attack under the deteriorating economic situation. Thus, if this attack is

successful, it becomes a self-fulfilling speculative attack and generates multiple equilibria. However, since this self-fulfilling crisis requires any motive of changing the market's expectation, it is not a sufficient condition but a necessary condition for the currency crisis.

In short, the Korean currency crisis seems to have both natures of first and second generation models of speculative attacks, which are the mixture of weak economic fundamentals and the factors leading to a self-fulfilling attack such as financial panic and contagion.

In this respect, the purpose of this study is to examine the main causes of the Korean currency crisis on the basis of the estimated probability of regime collapse. First, the theoretical model is developed so as to capture the features that are stressed in the two generation models. In addition, the model is based on the monetary model of exchange rate determination that is a modified version of standard speculative models (i.e., a modified first generation model) such as Krugman (1979) and Flood and Garber (1984b).

This modification allows for the previously neglected factors in those models: (1) a relaxation of purchasing power parity (PPP)-- this reflects the presence of overvaluation, in part, due to a higher rate of Korean inflation as compared to the world level (the deviation from PPP is divided into two factors, systematic and random deviations); (2) an inclusion of income in the money demand equation-- this affects the probability and the timing of regime transition by allowing the real side of economy (i.e., output) to influence the real money balance; (3) a sterilization of the reserve losses during the attack period-- this reflects the real economic policy adopted by the Korean monetary authorities at the time of attack; and (4) inclusions of external credit shocks as well as

domestic credit shocks-- these shocks examine how the attack was triggered (that is, whether the shocks were externally or/and internally induced).

The theoretical model is further extended in order to describe the characteristics of second generation models as follows: (1) inclusions of the currency substitution motive and the ratio of non-performing loans into the money demand function -- this allows the model to capture the speculative behavior by changing speculator's portfolio motives; and (2) an introduction of speculative shock to the model by permitting the risk premium (which is embedded in the interest parity condition) to vary period by period-- the time-varying risk premia along with the external and internal shocks lead to a more realistic nature of the recent crisis event in Korea (i.e., uncertainty surrounding actual speculative attack).

This paper also provides the probability of regime collapse and shadow exchange rates using the solution of the econometric model which is developed on the basis of the above theoretical framework. For the explicit computation of the probability, the method of one-step-ahead forecast will be applied to the experience of Korea between 1995 and 1998, using monthly data.

The remainder of this paper is organized as follows. Chapter two briefly presents the previous studies on the currency crises which are concerned with the 1992-93 ERM, the 1994 Mexican, and the 1997 Asian crises (from the view points of both generation models). Chapter three provides a theoretical framework by modifying the standard speculative models and derives the probability of regime collapse and shadow exchange rate. This chapter also discusses the comparative statics to analyze how the collapse probability is sensitive to the changes in the variables and shocks in the model. Chapter

four estimates the critical reserve floor that will be used for the computation of collapse probability in chapter five. This chapter also presents a brief review of the exchange rate system in Korea and gives an explanation of the trend of international reserves along with the flows of current and capital accounts in the pre-crisis period. In chapter five, the patterns of pre-crisis macroeconomic variables will be briefly discussed, and this chapter also introduces the data analysis and estimation procedure. Then, the modified crisis model will be applied to the Korean experience. And the one-period-ahead probability and shadow exchange rate series are estimated using the empirical model. Based on the estimation results, this chapter analyzes the forces contributing to the Korean currency crisis and then examines the results of counterfactual experiments by changing the magnitude of variables and shocks in the model. This work provides some policy implications surrounding the Korean currency crisis. Chapter six draws conclusions and policy lessons.

CHAPTER 2

Survey of the Literature

2.1 Introduction

Two generations of currency crisis models examining the reasons why a fixed exchange rate regime may be subject to speculative pressure coexist in the literature.

The first models, called first generation models of speculative attack, have been widely attended by economists and extended to various directions after the theoretical work was initiated by Krugman (1979). This group of models were proposed to analyze the causes of the currency crises that occurred in Latin America in late 1970s and early 1980s. These models regard, as a root of the crisis, inconsistency between macroeconomic fundamentals and the existing fixed exchange rate system, rather than considering that pure speculation is enough to trigger a crisis.

More recent theoretical researches, so-called second generation models of speculative attack, put more weight on the speculation itself than on the bad economic fundamentals in explaining the driving force of fixed regime collapse. The second generation models were originated in the work of Flood and Garber (1984a) and Obstfeld (1986b) and were used to examine the 1992-93 ERM and the 1994 Mexican currency crises. These models generate self-fulfilling attacks and multiple equilibria in that the change in speculators' belief on the government's policy is assumed to influence the government's willingness whether or not to defend the currency peg.

The next two sections describe these two generation models of currency crisis in more detail and also present some models that illustrate the characteristics of two respective generation theories.

2.2 First Generation Models

The first generation models of currency crises rely on the conflict between macroeconomic policies and long-term maintenance of the fixed exchange rate. The speculative attacks stemming from the conflict lead to a natural and an anticipated collapse of existing fixed regime. This trend of explaining balance of payment crises, initiated by Krugman (1979) and extended by Flood and Garber (1984b) and by others, emerged to understand the currency crises of Latin American countries such as Mexico (1973-1982) and Argentina (1978-1981).

The first generation models have generally the following several features. First, the theory is based on the macroeconomic models of exchange rate determination and monetary approach to the balance of payments in which the behavior of fundamentals is mainly determined by a continuously expanded monetary stance to finance government budget deficit.

Second, the timing of the regime collapse depends on the amount and the depletion rate of central bank reserves. When the reserves hit critical threshold level by speculative attacks, the fixed regime is abandoned by monetary authorities. While this critical reserve floor may be known to monetary authorities, the speculators have no exact information on the floor level until the collapse of the fixed regime is actually materialized. Even under this uncertainty of attack timing, which is related to the

market's imperfect information on the reserve floor, the fact that collapse is predictable (i.e., its nature of demise) is still effective and is an essence of the first generation models, given government policy of expansionary domestic credit creation.

Third, the time of regime transition is determined at a certain time point where the shadow floating exchange rate is equal to or greater than the existing fixed exchange rate. The shadow exchange rate reflects market fundamentals after the crisis period, and so it would clear the foreign exchange market when foreign reserves reach the critical floor level. Speculators will make profits from buying a central bank's foreign reserves when the shadow rates exceed the fixed rates. Thus, an attack equilibrium arises from the speculators' competition for such opportunities of benefits from the attacks.

Fourth, the first generation models produce a crisis as soon as there is a successful speculative attack. This rules out multiple equilibria through the process of backward induction coming from the speculators' competition for the profits.

The earlier works of first generation models focused on the money market under simplified assumptions, such as full employment and purchasing power parity (PPP). These models have been extended to several directions in order to illustrate better real economic phenomena like deviation from PPP, uncertainty about domestic policies, and investors' portfolio behavior, and so on.[8] In the next section, several models are presented to show the characteristics of the first generation models.

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[8] Goldberg (1988,1991,1994), including myself, studied this relaxation of the PPP assumption that allows pre-attack fiscal expansions to be accompanied by increasingly overvalued real currency and current account deficits. The assumption of the deviation from PPP also better reflects the real side of economy, for example, by probable formation expected future exchange rate development by distinguishing between actual and equilibrium prices or exchange rates. Flood and Garber (1984b) and Claessens (1991) show how the balance of payments crisis models are incorporated under the assumption of the market's uncertainty about monetary and fiscal policies. Under this uncertainty, the rate of reserve depletion increases due to faster growing shadow exchange rates. Penati and Pennacchi (1989) extend earlier speculative attack models by deriving agents' optimal consumption and portfolio decisions from a

Salant and Henderson (1978)

The basic idea in the study of collapse models is originated by Salant and Henderson's (1978) application of the Hotelling (1931) model. Salant and Henderson show that the government's attempt to fix the price of gold leads to speculative attacks on the stock of the gold and results in the depletion of all of the government reserves. Furthermore, Salant (1983) considers government price stabilization schemes with a fixed commodity price by using a buffer stock of that commodity. He also shows that speculative attack would occur as soon as government reserves fall below the smallest government stock below which level government can not support the fixed price. In other words, whenever the official price of the commodity is exceeded by the present discounted market value, the attack must take place, reflecting the expected profits by the commodity holders. The model illustrates that the government realizes the exhaustion of its stock with continuous attempts to stabilize the official price.

Krugman (1979)

The basic framework of Salant and Henderson (1978) was extended to the literature on the collapse of a fixed exchange rate regime (or balance of payments crisis) by Krugman (1979) in which he considers the assumptions such as one product, two assets, perfect foresight, law of one price, and fully flexible wages and prices.

Krugman (1979) views that the leading force of speculative attack is originated from the fundamental inconsistency between the government fiscal policy and the

---

monetary intertemporal capital asset pricing model, in which agents are allowed to rebalance their portfolio before attack, resulting in accelerated losses of central bank reserves by investors' hedge against a currency crisis.

government attempt at sustaining a fixed exchange rate system. That is, any attempt to maintain the fixed exchange rate regime, faced with increasing domestic credit due to financing government budget, results in gradual reduction in the central bank's international reserves. Under this circumstance, investors expect a future depreciation of a domestic currency and thus government reserves would be exhausted by the consequent speculative attack, ending with a floating exchange rate. Thus, this view stresses that if a country abandons a currency peg when central bank foreign reserves reach a threshold level, that country is confronted with the inevitable balance-of-payments crisis due to continuous speculative attacks. The importance of Krugman's (1979) study is to show the systematic mechanism of a currency crisis occurring when a central bank tries to defend a currency peg with finite reserves. However, there also exist some limitations in the model such as the assumption of perfect foresight on the part of speculators, the lack of restrictive equilibrium[9], and the ignorance of the policy options available to authorities.

Connolly and Taylor (1984)

Connolly and Taylor (1984) modified Krugman's (1979) model of balance-of-payments crisis in order to find the exact time of a regime collapse by using a simple calculation. They consider the effect of collapse on the relative price of traded goods and the effect of one time shock to expenditures on the fixed exchange rate regime. They show that the collapse time is positively correlated with the growth rate of domestic credit and negatively correlated with the level of reserves.

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[9] These properties lead to an immediate collapse of a fixed exchange rate regime.

Flood and Garber (1884b)

Two extensions of Krugman (1979) model by Flood and Garber (1984b) allow for a solution for the exact collapse timing using a linear model with or without the market's speculative behavior. The first model, the continuous time model with perfect foresight, illustrates the inverse time paths between reserves and domestic credit with a constant money supply, prior to collapse. When monetary base equals domestic credit (i.e., total exhaustion of reserves), the fixed exchange rate shifts to a floating rate. Since a speculative attack is not involved in this transition (i.e., the collapse of fixed regime is purely based on the market fundamentals not on the abrupt attacks), the model does not produce discrete jump in the exchange rate.

The second model, set in a discrete time with uncertainty (or stochastic version), allows for the exact calculation of collapse probability under the presence of the larger values of shadow exchange rates[10] than the values of the fixed rates. The model includes stochastic terms in the domestic credit creation, which provides uncertainty about the collapse time for the speculators. The importance of their model is to show how to derive a collapse probability using observable variables. One of the weaknesses of the model is, however, no possibility of devaluation. That is, government has no flexibility in its policy, except for being faced with regime collapse (i.e., there is no optimizing specification of a government policy), before depletion of international reserves with or without speculative attacks.

[10] Shadow exchange rate is defined as a floating rate that would prevail at time $t+1$ if a collapse is materialized at period $t+1$.

Obstfeld (1984)

Obstfeld (1984) extends the first model (i.e., non-stochastic version) developed by Flood and Garber (1984b) by showing the possibility of devaluation rather than a fixed regime collapse. To show this possibility, he considers the central bank's withdrawal from the intervention in the foreign exchange market when the international reserves reach a critical level. In addition, he considers the assumptions of speculators' certainty about the time interval of the transitional period during which a peg is allowed to float, about a new fixed rate after that transition, and about the threshold level of reserves.

He also shows that, under these assumptions, the timing of the speculative attack would be affected by the anticipated post attack policies by the speculators. And he illustrates that during the transitional period (i.e., after devaluation) the time path of capital flows is related to the monetary authority's success in choosing a realistic exchange rate and in adopting appropriately restrictive macroeconomic policies.

Obstfeld (1986a)

Obstfeld (1986a) analyzes inevitable transition between a fixed and a floating rate regime in a balance of payments model with explicit specification of individual intertemporal preference in which an individual receives transfers from a government and chooses between domestic money, domestic bonds, and foreign bonds.

In the model, he shows that central bank reserves can become inevitably negative with no violation of the government intertemporal constant. That is, a government can avoid a collapse when the reserves are supplemented through borrowing indefinitely from abroad, and as long as it raises taxes to service its debt. Since there needs no lower

bound on a central bank's foreign reserves, the linkage between threshold level in reserves (and so time of regime switch) and the size of currency devaluation weakens.

Thus, his study implies that the analogy between reserve path and the path of an exhaustible resource (e.g., gold in the study of Salant and Henderson (1978)) becomes vague, under the conditions in which the private sector can have access to the world capital market or the government can borrow through the official route. However, there exists a possibility of a collapse when the country's access to the world capital market is rationed.

Following Flood and Garber's (1984b) discrete time model with uncertainty, several studies have shown the predicted probability of collapse of a fixed exchange rate system by performing empirical tests.

van Wijnbergen (1988)

van Wijnbergen (1988) considers the sustainability of the transition from a flexible to a fixed exchange rate as part of the effort to control high inflation in Brazil, Argentina and Israel. Using Flood and Garber's speculative model, van Wijnbergen illustrates the linkage between inconsistent policy measures and their post-collapse inflationary consequences.

Blanco and Garber (1986)

Blanco and Garber (1986) attempt to model the devaluation of the Mexican peso from 1973 to 1982, estimating the logarithmic version of Flood and Garber's (1984b) model. They estimate a time series of one-step ahead probability that the shadow

exchange rate would exceed the fixed rate in the next period. The results show that devaluation did occur when the shadow floating rate exceeds the fixed rate, and the devaluation probabilities peak prior to real major devaluation. Even though their empirical results are encouraging, they tested for only one country, and the method they used needs a certain condition such as the presence of a future currency market which is, in fact, rarely developed in many countries with fixed exchange rate systems.

In addition, as shown in Goldberg (1991), if some variables which could have affected the collapse probability had been omitted, their results would have been under-or-overestimated as follows: underestimated to the extent that prices and external credit supplies exhibit short-term randomness; overestimated to the extent that there are non-traded goods in the domestic consumption, positive and significant risk premium, systematic deviation from purchasing power parity and currency substitution motives influencing the demand for real balances. More importantly, as studied in Flood, Garber and Kramer (1996), the usual monetary model of speculative attack is inappropriate to demonstrate even a temporarily viable fixed exchange rate regime.[11]

Goldberg (1994)

Goldberg extended the Flood and Garber (1984b) model to overcome Blanco and Garber's (1986) incorrect estimations of the empirical works by adding some variables into the money demand equation. The real income, the expected rate of devaluation (considered as currency substitution) , and three random disturbances were added into the money demand function. Three random components are divided into the short-term price

[11] This is the case without modeling sterilization. This will be explained in detail in the next chapter.

shock and two disturbances to the domestic credit expansion. The first component from the last two disturbances is the uncertain government revenue or unexpected government expenditure which affects the monetization to finance fiscal deficits. The second shock is the random and uncertain availability of external credit inflows, which makes uncertain the share of government deficits to be financed by external borrowing instead of inflationary finance. The empirical tests produce relatively successful results of forecasting the probabilities of the peso crisis between 1980 and 1986. According to those results, the currency speculation would have been sharply reduced by increasing the uncertainty surrounding domestic credit creation and the frequency of currency realignments, and by decreasing domestic credit growth and the size of currency realignments. In Goldberg (1994), monetary and fiscal polices are more important factors in triggering speculative attacks on the Mexican peso, than anticipated external credit shocks.

Melick (1996)

Melick (1996) applies a speculative attack model of exchange rate crisis to the Mexican peso including the most recent events in 1994. Although his empirical findings are not quite satisfactory due to some reasons, the major contribution is a derivation of maximum likelihood estimators for the model.[12] According to Melick (1996), the disappointing empirical results may stem from the highly stylized model and the nature of the Mexican experience such as political instability around 1994. Furthermore, Melick

[12] The first reason is that reduced form estimates are inconsistent with the theoretical assumption. And the second reason is that the forecasted probabilities of collapse are not consistent with the actual major devaluation.

(1996) argues that a question might be raised whether the standard speculative attack model could be applicable to the recent Mexican crisis. This was due to the following several weaknesses of standard models[13] such as the common assumptions of government fiscal deficits, no sterilization, the reserve losses at the time of collapse, inappropriate measure of domestic credit resulting from the standard log-linear speculative attack model, and the omission of some elements like a weakened banking sector and the political instability. Melick (1996), therefore, concludes that more applicability of standard speculative models is guaranteed in the economy which is experiencing the unsustainable fiscal position, like Mexico in the 1980s.[14]

Ötker and Pazarbaşioğlu (1997)

Based on the monetary model of speculative attacks, Ötker and Pazarbaşioğlu (1997) attempt to estimate the contribution of economic fundamentals to the exchange market pressures of EMS members in 1992-93. Using a probit model, they estimate one-step-ahead probability of regime changes in the six sample countries, Belgium, Denmark, France, Ireland, Italy, and Spain. Their empirical results show that in the cases of Belgium, Ireland, Italy, and Spain, the speculative pressure and observed exchange rate regime changes stemmed from the inconsistency between the aggravating economic fundamentals such as domestic credit expansions and increasing government deficits and the existing exchange rate systems. For Denmark and France, the episodes of speculative attack pressure seem not to be originated by the deteriorating economic fundamentals,

[13] That is, the simple monetary models of exchange rate determination.
[14] Previous studies, including Conolly and Taylor (1984), Blanco and Garber (1986), Goldberg (1988, 1994), van Wijnbergen (1988), and Cumby and van Wijnbergen (1989), focused on the period of 1980s.

rather by other factors which are not captured by their monetary model. Their results imply that the ERM crises were involved in both fundamental and speculation (i.e., self-fulfilling) factors, though they give more weight on the fundamental view.

2.3 Second Generation Models

Although first generation models provide appropriate solutions for understanding the currency crises that took place in Mexico and Argentina between the late 1970s and early 1980s, the emergence of the ERM and Mexican crises in early 1990s has shifted researcher' attention in a different direction in order to capture the characteristics of those crises. This was so because some EMS countries and Mexico were considered to experience the currency crises under conditions such as no constraint of borrowing international reserves, no monetary excesses, low inflation, and without increasing current account deficits. The contrary of the above features was found in the earlier Mexico and Argentina crises in the 1980s. Thus, the development of a subsequent generation of theoretical models (so-called second generation models of speculative attacks) has been proposed with the different assumptions and predictions from those of first generation models.

Second generation models attempt to examine the regime collapse caused by speculative attacks in terms of the macroeconomic fundamentals as in first generation models, but the models further consider that the fundamentals are susceptible to changes in private expectations about the government policies. That is, if market participants have some information on the government policies that attempt to stabilize output, employment, and banking system, etc. at the expense of the currency peg, faced with

worsening domestic conditions, they anticipate the inevitable regime transition. And then, they attack the currency without evidence of deteriorating fundamentals such as high inflation, growing current account deficits, monetary excesses, continuously increasing overvaluation.

Therefore, according to the proponents of this view, a currency crisis (in which the driving force is arbitrary shifts in the private sector's expectation) can occur even when macroeconomic policies are consistent with the long-term fixed exchange rate policy. In other words, when the private sector anticipates the government policy change owing to their successful attacks, the possibility of multiple equilibria arises. Therefore, the exchange rate regime is not related to the current fundamentals and future fundamentals with no attacks, but to the anticipated future fundamentals accompanied by attacks. Thus, these models generate multiple equilibria in the following manner: one equilibrium with no attack and no changes in fundamentals (i.e., permanent fixed exchange rate regime); the other equilibrium with attacks and changes in fundamentals (i.e., regime switch) which attacks thus, become self-fulfilling by causing the regime collapse.

One contribution of second generation models for capturing recent currency crises is that the models are well designed to consider the previously neglected features. These features include social-political issues (which may lead to a change in the market's expectation) as well as macroeconomic fundamentals (which are focused on the first generation models).

More recent studies that still possess the nature of self-fulfilling and multiple equilibria have been extended to several directions in order to consider currency crises in the context of fixed exchange rate regimes with contagious effects, an escape clause, and

herding behavior, and so forth.[15] The following section also describes the features of these extended models.

Obstfeld (1986b)

Obstfeld (1986b) modified the second model of Flood and Garber (1984b) with an assumption of relaxation of constant domestic credit growth which gives a possibility of self-fulfilling crisis. He shows that a collapse can arise from the changes in the agent expectation on the government policy. That is, a collapse could be self-fulfilling because the driving force of the collapse is not the government domestic credit policy in a fixed rate regime but it is the agents' knowledge that the domestic credit policy adopted by the government would be changed in the event of a collapse.

Obstfeld (1994)

Questions about the underlying causes of currency crises were raised from the turmoil of some EMS members in 1992-93.

Obstfeld (1994) gives a doubt whether the ERM currency experience could be properly understood in terms of classical theory of currency crises, *a la* Krugman (1979), because some European countries under the speculative pressures on their currency pegs had enough foreign reserves. Furthermore, their macroeconomic policies were not obviously inconsistent with the stability of their currencies against the Deutsche mark.

He considers that many other factors such as the effects of high interest rates and growing unemployment could be main sources in determining how different governments

[15] These include Obstfeld (1996), Flood and Marion (1997), Goldfajn and Valdes (1997a,b), Jeanne (1997), Sachs, *et al.* (1996),etc.

responded to the 1992-93 ERM currency turbulence. Obstfeld (1994) provides two models which show that the crisis stems from the reciprocal behavior between rational private economic actors (or rational market participants) and a government running well-defined policy goals. The first model that is based on the effects of high interest rates on the government fiscal position provides a possibility of multiple equilibria. This is so because a different set of private expectations (rather than the interaction of high nominal interest rates and market's devaluation expectation) would have prevented the government from abandoning the fixed exchange regime.

The second model, based on the close economy models by Barro and Gorden (1983) and Kydland and Prescott (1977), also presents multiple equilibria caused by the shift in the market's expectation on the government policy. Although the government's attempt to alleviate the negative output shocks to competitiveness and employment is the original source of a devaluation, a sudden change in the private expectation on the government policy, such as its desire to permit a high rate of unemployment, also can trigger a devaluation that would not take place under another set of market expectations.

Cole and Kehoe (1996)

Cole and Kehoe (1996) attempt to show that a debt crisis can arise from a self-fulfilling feature under a certain condition of the government debt, called a crisis zone. A self-fulfilling debt crisis is dependent on the realization of a sunspot variable which is a random variable of the model not related to the fundamentals. For some initial values of government debt, a crisis takes place when the debt laid inside of a crucial interval (called

a crisis zone) is combined with an unfavorable realization of the sunspot variable. On the contrary, a crisis does not occur when the realization of the sunspot variable is favorable.

When their model is applied to the Mexican debt crisis in 1994, they find that the size of the crisis zone relies on the average length of maturity of the government debt. Their result shows that the crisis zone in which a crisis can occur is above 10 percent in the ratio of debt to GDP. They attribute this low ratio to the very short average maturity of the Mexican government's debt, which was most 200 days in December 1994.

They further show that when a crisis is taking place, the government's effort to change the maturity of debt is invalid because it is too late, and thus resulting in the inevitable crisis. Another source that can render multiple equilibria can stem from the different result under the equal economic fundamentals; for example, reputation.

Eichengreen, Rose, and Wyplosz (1996)

Another issue which is related to the self-fulfilling speculative attacks has been proposed as a subject of discussion in the literature of currency crisis in the wave of recent Mexican turmoil. Eichengreen, Rose, and Wyplosz (1996) stress that self-fulfilling speculative attacks may have contagious effects on other currencies. They set up an index of exchange market pressure and estimate a binary probit model using the index in order to test the existence of contagious currency crises which are not believed to stem from the domestic fundamentals such as money and output, but from the existence of speculative attacks in the rest of the world. Using quarterly macroeconomic and political data of 20 industrial countries from 1959 to 1993, they find that a speculative attack elsewhere in the world increases the probability of a domestic currency

crisis by about 8 percent, even after controlling for domestic economic and political factors.

Even though their work can be regarded as a first step showing the contagious effects on the currency crisis, it rules out the importance of a country's macroeconomic and/or trade policies because those policies would have changed the degree of contagious effect (which can be another source of triggering speculative attack in the neighboring country) by affecting the economic fundamentals of the neighboring country.

Gerlach and Smets (1995)

One of first systematic theoretical treatments analyzing contagious speculative attacks is the study by Gerlach and Smets (1995). They extend a two-country version of the model developed by Flood and Garber (1984b) and show how the collapse of the Finnish markka in 1992 made an impact on the subsequent attack on the Swedish krona.

The contagious transmission stems from two channels in their model. First, the contagion comes from the real economy side, like trade of merchandise under the condition of sticky money wages. A devaluation of country A's currency caused by a speculative attack improves the competitiveness of country A's goods exports. This leads to a trade deficit as well as a gradual depletion of foreign reserves in country B, and thus finally resulting in a speculative attack on country B's currency.

The second channel of contagious effect stems from the lowered consumer price in country B. That is, with an appreciation of country B's currency led by the weak currency value in country A, country B is faced with lower import prices and thus with further deflated money stock due to a lower overall price level. This decrease in the

demand for domestic money leads to a fall in the international reserves because of the predetermined domestic credit. Thus, the above mechanism of declining reserves may shift country *B*'s economy to an attack equilibrium from a no-attack equilibrium, and otherwise the currency peg of country *B* could have survived.

The importance of this paper is to show how a country's devaluation caused by a successful speculative attack can give rise to another speculative attack in the neighboring country by deteriorating its economic fundamentals. However, as pointed out by Buiter *et al.* (1998), the Gerlach and Smets's (1995) study seems to be confined in an analytical framework for the country case in which the countries have balanced (or similar) economic environments.

Buiter, Corsetti and Pesenti (1998)

To understand the root of ERM currency crises in 1992-93, Buiter, Corsetti and Pesenti (1998) use an escape clause model of exchange rate policy which, unlike previous studies based on the unilateral peg, emphasizes the structural policy spillovers among EMS countries and stresses the effects of coordination of monetary and exchange rate policies within the system. In a framework of $N+1$ countries, N countries called "the periphery" of the system peg their currencies to the last one (defined as "the center"). In model, the center is unwilling to coordinate its monetary policy with the periphery, while the periphery countries are allowed to cooperate among themselves.

Faced with a shock to the center country's fundamentals (i.e., higher interest rates than the periphery, which is caused by the inflationary consequence of the internal boom), the periphery countries are under certain circumstances (i.e., whether they

cooperate to remain in the system or to leave the system) since their pegs are required to be adjusted by the shock.[16] A contagion may arise from all the periphery members' decisions to leave the system.[17] However, a smaller scale contagion occurs when not all the members of the periphery opt out of the system. In this case, the currency pegs of the remaining members in the system can be stabilized by changing the center's policy toward the loose monetary stance because the center now recognizes that its currency is overvalued. Thus, this change in the monetary stance of the center can alleviate the pressure on the currencies of the remaining periphery countries.

The center-periphery model shows that the adverse macroeconomic shock to the center can break the exchange rate regimes of the periphery, and also shows that the results of different reactions to the center's macroeconomic shock may give rise to the selective contagion in the periphery.

Calvo and Mendoza (1997)

The idea of herding behavior may in part explain the recent Korean financial crisis. Calvo and Mendoza (1997) consider global investors who react more to market rumors than to economic fundamentals. Under the conditions of a growing global financial market and incomplete information on it, portfolio diversification made by investors requires more fixed cost to collect information on a specific market. Therefore, they rely more on the market rumors and thus, they move in herds. That is, fund managers'

[16] A higher interest rate in the center country leads to capital flows from the periphery to the center. This leads to depreciation of the periphery currencies against the center if the periphery members do not take steps about the drop in the demand for their domestic currencies.

[17] This result is equal to the case of unilateral peg in that the periphery members behave symmetrically as if they were a single currency area vis-à-vis the center.

attitudes toward the assessment on their performances make them invest in the same portfolio without discrediting the rumors, even though the market's fundamentals do not warrant further profit from those investments. Thus, this line of herding behavior can produce multiple equilibria such that the economy move from no-attack to the attack equilibrium.

As mentioned in Corsetti, Pesenti and Roubini (1998), the herding may in part give some idea as to why an asset bubble exists for a long period in emerging markets that face with weak economic fundamentals. In addition it may also explain why the magnitude of the bubble burst is larger (than it would have been) in the face of a reversal of market estimation on the bad economic fundamentals.

2.4 The Models on the Asian Currency Crisis

Corsetti, Pesenti and Roubini (1998)

Using a similar concept to the center-periphery model as in Buiter, Corsetti and Pesenti (1998) (which is used to explain the 1992-93 ERM crises), Corsetti, Pesenti and Roubini (1998) analyze the meltdown of some Asian currencies in 1997.

They show how the economies of the periphery countries are influenced by an economic shock to one periphery (e.g., a devaluation by this periphery country against the center country).[18] This devaluation ultimately leads to an increase in this periphery's output and so causes consequent devaluations in the rest of periphery countries since

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[18] The authors assume no intra-trade among the periphery countries. The periphery is allowed to trade with the center. In their model, one periphery country hit by first shock is assumed to be Thailand because the Asian crisis was originated in Thailand. Indonesia, Malaysia, and Korea are assumed to be the other periphery countries.

they attempt to avoid any gap in cost-competitiveness and to maintain their existing shares in the center country. In other words, when one periphery gets a blow from a shock leading a devaluation in its currency, the other periphery countries ultimately follow the way as the one periphery did, and thus end with a competitive devaluation that stems from the structural links (in trade) across countries.

Corsetti, Pesenti and Roubini (1998) stress that the resulting Nash equilibrium of such a non-cooperative game among the peripheries requires much more cost than in a case of a cooperative equilibrium. That is, a coordinated realignment against the center would have produced much smaller cumulative devaluation in the periphery countries.

Krugman (1998)

Another view concerned with the origin of the Asian crises is suggested by Krugman (1998). His view does not rely on the first generation models which focus on bad economic fundamentals nor on the second generation models where crises are brought on by self-fulfilling prophecy. Instead, the view relies on the financial excess by the moral hazard problem (which leads to an asset bubble) and on the financial collapse (which is caused by the burst of the bubble).

Krugman (1998) argues that domestic financial conditions of the troubled Asian countries were distorted by financial intermediaries that excessively borrowed from abroad[19] under the implicit government guarantee of bail-out and lent excessively to uncertain (or risky) investment projects. This excess domestic investment, which stems

[19] In the 1990s, the bank lending in many Asian countries substantially increased. The ratio of bank lending to GDP expanded up to 50% in Thailand and Philippines, by 27% in Malaysia, about 15% in Korea and Indonesia. If non-banking institutions were contained to the financial intermediaries, the ratio would have had a further increase.

from the moral hazard problem both in the financial intermediaries and the government, leads to inflation in the asset prices. That is, the overestimated value of the risky assets was gradually increasing due to the continuous guaranteed foreign borrowing, resulting in market's continuous misinterpretation of the financial condition of those intermediaries (i.e., overestimation of the assets). Under this circumstance, when the asset bubble bursts, the asset prices begin to fall and the falling rate speeds up as the intermediaries have no further access to the foreign credit markets due to the previous blast of the asset bubble.

Krugman (1998) further points out that this circular mechanism of asset values may provide some implications about the features of Asian episodes such as the contagion effect[20] among Asian economies, an effect which may stem from a self-fulfilling crisis in an economy due to the above bubble-burst cycle in the asset prices.

Radelet and Sachs (1998)

Radelet and Sachs (1998) emphasize the importance of financial panic as a driving force in triggering the Asian financial crises. With such reasons as continuously increasing capital inflows prior to crisis period[21], major indicators showing sound economic fundamentals in that region through the 1990s, and sound economic conditions in the world market (unlike the time of Latin American crises in 1970s-1980s), they regard the Asian crisis as a problem of financial panic, rather than a problem of economic

[20] Many Korean financial institutions, in fact, had been involved in the turmoil of the southeast Asian crises even before the Korean currency crisis because they invested substantially in those countries.

[21] Such surge in capital inflows in to this region through the 1990s is based on the following reasons. First, capital market liberalization in developed countries allows much more investment to the emerging markets, including this region. Second, low interest rates in the U.S. and Japan made the investors' attention turn toward the Asian countries. Third, foreign creditors' optimism on the continuing high economic growth of this region. Finally, financial deregulation of Asian countries also made the capital inflows easier.

fundamentals. They also attempt to trace the origin of the crisis from the financial panic on the basis of the market's non-anticipation of the crisis (which might stem from the above economic condition of the region) and on the basis of the credit rating agencies' (e.g., Standard and Poor's and Moody's) ongoing assessment of credit risk in the emerging markets.

According to Radelet and Sachs (1998), due to the above interpretation of economic circumstance prior to the crisis, the early warning signals did not operate, although some macroeconomic fundamentals became unfavorable to the region. However, once a crisis took place in Thailand, the contagious effect was quickly transmitted to the countries in that region under the existing potential weaknesses in the fundamentals and in the financial markets. This contagion, then, rapidly spread out, gearing with the withdrawal of foreign investments.

Radelet and Sachs (1998) share with Corsetti *et al.*' (1998) view that the worst outcome of the Asian crisis could have been avoided, not by using the concept of cooperative game among the countries in that region suggested by Corsetti *et al.*(1998), but by conducting relatively moderate adjustments and appropriate policy changes in each country.[22] Their view of triggering the crisis is also different from Krugman (1998) (in which onset of the crisis is attributed to the bubble-burst cycle due to the moral hazard problem) in that they stress the importance of financial panic coming from the shift in the market's attitude toward its investment in that region.

[22] This yields multiple equilibria because allowing the policy changes and adjustments would provide better outcome compared to a crisis.

2.5 Conclusion

Previous sections briefly describe some features of two different generation models of currency crises, in which the models illustrate the main causes of a currency crisis that took place in different regions and periods. However, no model could provide an appropriate solution for understanding all the crises. A certain model is in a favorable position in analyzing a certain crisis, but that model may be inferior to another one in examining another crisis. This fact seems to be true even in the same generation models because each model has its own view point and approach to a crisis, even though the models share the same theoretical base with the other models in the same category. For example, this nature has been found in the previous section's studies suggested by Buiter *et al.* (1998), Corsetti *et al.* (1998), and Radelet and Sachs (1998). While the first two stress the importance of deteriorating economic fundamentals (e.g., the loss of competitiveness), the last model emphasizes the nature of self-fulfilling prophecies (e.g., financial panic) to explain the Asian crisis.

I will analyze the Korean currency crisis from the view point of the first generation model by using a monetary model of exchange rate determination and by presenting some reasons to support this approach (i.e., deteriorating economic fundamentals). Furthermore, the model will be modified to allow for several characteristics of second generation models, such as a self-fulfilling speculative attack and/or contagious effects which may have played, in part, an important role in the onset of the Korean currency crisis in 1997.

CHAPTER 3

Theoretical Framework

3.1 Introduction

A model of collapse of a fixed exchange rate regime adopted in this chapter extends the Goldberg (1991) and Flood, Garber and Kramer (1996) models of speculative attack, which are modified versions of the Flood and Garber (1984b) model. The basic assumptions of the Flood and Garber (1984b) model are retained in the model of this chapter: (1) a discrete-time model with uncertainty; (2) an emphasis on the money market equilibrium condition; and (3) an assumption of a small open economy. However, the model presented in this chapter departs from the standard first-generation models of exchange rate crisis, such as Krugman (1979) and Flood and Garber (1984b) in several ways.[23]

The first departure is that the model allows deviation from purchasing power parity(PPP). This deviation is separated into two factors, systematic (i.e., long-run) and random (i.e., short-run) components. The nonrandom (or systematic) deviation from purchasing power parity, considered as long-run phenomenon, had been found in Korea as well as in the troubled Asian economies long before the currency crises occurred in that region. That is, most of the troubled Asian countries experienced real depreciation in their currencies during 1991-1995 by pegging their currencies to the U.S. dollar since

[23] Even though the model developed in this chapter has several departures, it could be said that the model is still based on the idea of first generation of speculative attack models since these departures come from the need to illustrate deteriorating fundamentals and to describe more realistic economic atmosphere.

the U.S. dollar was weakened relative to Japanese yen and Deutsche mark during this period. However, after the middle of 1995, the Asian currencies experienced a large real appreciation because the U.S. dollar, with which Asian currencies were tied, began to be strong relative to the other major currencies. Thus, this departure from PPP needs to be contained in the model to reflect the real economic phenomena.

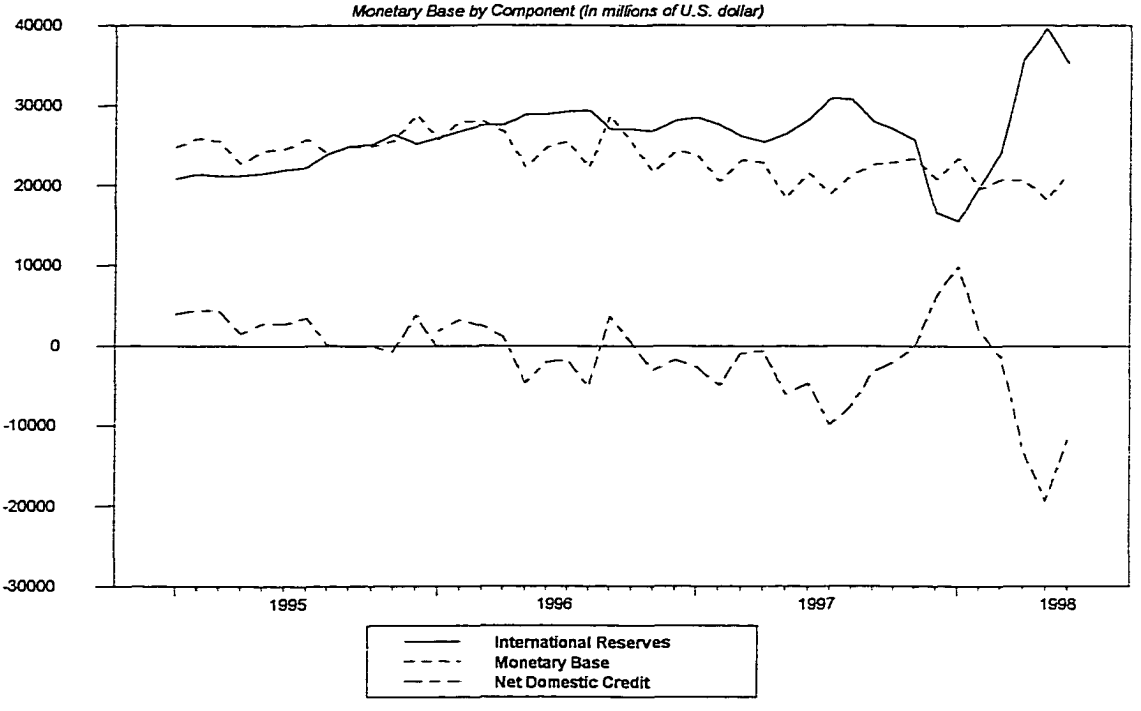
The second departure is an inclusion of the income in the money demand equation, which enables us to consider the real side of the economy to affect the probability of the collapsing exchange rate. The third departure is that the consumption bundle is decomposed into home and traded goods. This decomposition allows real exchange rates to change during a currency crisis.

The fourth departure is a separation of the random term in domestic credit creation into two components. The additional term is an uncertain access to supplies of external credit for the troubled economy. This indicates that domestic credit expansion is impacted by the external shock as well as by the internal factor (i.e., monetary financing of government deficits). Although the government budget deficit in Korea was almost balanced before the crisis period, unexpected government expenditure (i.e., internal shock) is included in the model to reflect the government current or future fiscal deficit which may come from the financing of non-performing loans in the banking system that in part resulted from the government implicit and/or explicit bailout. Furthermore, the capital inflows to Korea became significantly restrictive around the currency crisis period by the effect of southeast Asian crises. If access to external credit had not been limited (i.e., external shock < 0), the probability of the regime collapse would have sharply

decreased. In this context, the inclusion of these shocks plays an important role in formulating the model.

This chapter also introduces the role of sterilization operation by the central bank. The sterilization policy was actually adopted by the Korean monetary authorities[24] around the crisis period in 1997 as well as in Mexico in 1994-1995.[25] That is, as shown in figure 3.1, the Korean monetary authorities sterilized the fall in reserves at the time of the attack (i.e., in 4th quarter of 1997) as well as prior to attack period.

Figure 3.1: Domestic Credit and International Reserves



[24] In the presence of speculative attacks, as analyzed by Corsetti, et al. (1998), the Korean monetary authorities reacted against speculative attacks by taking steps such as a sterilization policy for the reserve losses and a stable interest rate policy. They might have adopted these policies in order to avoid a slowdown in the economic activity (which was against the highly growth-oriented policy for several decades in Korea) due to sharply increased interest rates and to avoid bankruptcies of many firms and financial intermediaries due to a monetary contraction (and so a credit squeeze).

[25] See Flood, Garber and Kramer (1996) and Griffith-Jones (1997) for the studies that explain the sterilization policy at the time of the 1994 Mexican currency crisis.

Therefore, the monetary base does not sharply drop at the time of attack, unlike the assumption made in the standard speculative attack models where the reserve losses are assumed to be sterilized only before the attack period and thus the base money sharply drops during attack time. Thus, the standard speculative attack models (i.e., first generation models of fixed regime collapse) should be modified to have the sterilization effect on the money supply.

Since the sterilization operation is accomplished by the monetary authority's open-market purchase of domestic government bonds from the private sector in the final attacks against domestic currency, it is necessary to introduce domestic government bonds held by the private sector into the currency crisis model. For the sterilization process, a monetary model of balance of payments needs to be extended to the portfolio balance model of balance of payment and exchange rate with assumption of imperfect asset substitutability. The approach used in this chapter is to follow Flood, Garber and Kramer (1996) which is a portfolio balance model of Tobin's (1971) version.

In addition to the above departures, the following three factors are introduced to the model in this chapter in order for the first generation models to be incorporated with second generation models by stressing the importance of speculative behavior.

The first factor is an addition of currency substitution motive into the money demand function. Introducing this term allows the model to capture the speculative activity of changing investors' portfolio motives. In the presence of this term, money demand is reduced, and it also prevents an overestimation of monetary expansion that can be sustained without a collapse of the exchange rate regime.

Second, the ratio of non-performing loans to total loans in the banking system is added to the money demand function. This additional factor could be considered as an indicator of government's current or future fiscal deficits. Although most Asian countries experiencing economic crises showed low fiscal deficits prior to the crises, they held a magnificent amount of non-performing loans which may stem from the implicit and/or explicit government's bail out. This fact implies a serious burden on the current and/or future fiscal balances for those governments of the troubled economies. As long as market participants recognize this logic and they anticipate the monetization of such deficits, the ratio of non-performing loans could be considered as an indicator of future devaluations. Thus, this variable is negatively related to the money demand, implying the change in the market's expectation on the domestic economic condition.

The third additional factor is a risk premium which is embedded in the interest parity condition. This time-varying stochastic risk premium may be another source of speculative attack and the attack then can be self-fulfilled. These self-fulfilling prophecies about exchange market risk can be induced in some range of fundamentals and thus provide multiple equilibria.

3.2 Description of the model

The theoretical framework is based on the following nine equations:

$$\frac{M_t^d}{Q_t} = a_0 - a_1 i_t + a_2 y_t - a_3 \frac{(E_t S_{t+1} - S_t)}{S_t} - a_4 N_t \qquad (1)$$

$$i_t = i_t^* + \frac{E_t S_{t+1} - S_t}{S_t} + \frac{\theta(B_t - S_t B_t^*)}{S_t P_t^* \varpi} \qquad (2)$$

$$Q_t = \alpha P_t + (1-\alpha) P_t^* S_t \tag{3}$$

$$\frac{P_t}{S_t} = P_t^* + \Omega_t^{'} \tag{4}$$

$$\Omega_t^{'} = \rho_t + \Omega_t \tag{5}$$

$$M_t^s = R_t + D_t \tag{6}$$

$$D_t = D_{t-1} + \mu_t + \varepsilon_t \tag{7}$$

$$\varepsilon_t = \gamma_t - \phi_t \tag{8}$$

$$M_t^s = M_t^d \tag{9}$$

Equation (1) represents the demand for real money balance, which is deflated by the domestic price level, Q_t. The money demand equation is positively related to the income, y_t, which is assumed to be an exogenous component, through transaction motives, and negatively related to the interest rate, i_t, through portfolio motives. A currency substitution motive, $(E_tS_{t+1} - S_t)/S_t$,[26] reduces the real money balance. This motive is expressed by the expected rate of domestic currency depreciation, $(E_tS_{t+1} - S_t)/S_t$, with negative sign of the coefficient a_3. The ratio of non-performing loan to total loans in the banking system, N_t, could be considered as a future fiscal burden of domestic government.[27] Thus, as this ratio increases, market participants will conceive that the domestic financial system will become more unstable, and so they will decrease their holdings of domestic currency. Therefore, the real money demand is reduced by this

[26] S_t refers to the nominal exchange rate in terms of won/U.S. dollar. E_tS_{t+1} is expected exchange rate formed at time t.

[27] This term was added into the money demand equation in the study of Gruben and Welch (1996).

component. Although this ratio of non-performing loans may be also viewed as an opportunity for the currency substitution, like the expected rate of domestic currency depreciation component $[(E_tS_{t+1} - S_t)/S_t)]$, it is essential to include this ratio in order to understand the recent Asian currency crises.

Equation (2)[28] stems from a convenient version of Tobin's (1971) portfolio balance model. When it is rearranged in terms of the domestic interest rate, we have the form of equation (2). The last term in equation (2) is introduced to explain the sterilization operation through the bond market. This term can also reflect the compensation for the market participants who want to invest in the riskier domestic assets. Thus, the last term also implies a bond-based risk premium on the domestic currency due to imperfect asset substitutability. Permitting this risk premium to vary period by period generates a nonlinearity in the market behavior, and thus this can provide multiple equilibria by changing attack time that comes from their maximization behavior which is reflected in the feedback relation among the interest rates, the money demand, and the variability in the exchange rate.

The domestic price is determined according to equation (3). The level of domestic price is a weighted sum of domestically produced goods price, P_t, and imported goods price converted to domestic currency, $S_tP_t^*$. Since the weight of non-traded goods, α, is assumed to be given, there would be no expenditure switching or expenditure reducing considerations resulting from the exchange rate change. Equation (4) assumes that the

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[28] Equation (2) is derived in terms of i_t from $B_t - S_tB_t^* = \theta_t^{-1}\{i_t - i_t^*(E_tS_{t+1} - S_t)/S_t\}S_tP_t^*\varpi$, $\theta > 0$, where θ is worldwide liquid real wealth and i_t^* is foreign interest rate, which are constants. B_t is the stock of domestic currency denominated interest-paying debt issued by the domestic government and held in the private sector at home and abroad, and B_t^* is analogous foreign magnitude.

short-run purchasing power parity does not hold. This is done by introducing the additional variable, Ω_t', into the assumption of purchasing power parity condition, $P_t / S_t = P_t^*$. Equation (5) defines the pattern of movement in the deviation of purchasing power parity, which is divided into a systematic component, ρ_t, and a random component, Ω_t. The distribution of the random variable will be discussed later in this chapter in detail. Equation (6) defines the money supply as the sum of domestic credit, D_t, and foreign reserves, R_t, held by the central bank. Equation (7) gives the specification for the process of domestic credit creation, which is divided into three components; D_{t-1}, domestic credit created in the previous period, μ_t, the trend ratio of domestic credit creation (which is manageable by domestic government (i.e., reflection of the expected trend growth rate of the credit to finance the government budget deficit)) and ε_t, the variability of the trend rate.

Equation (8) divides the variability of a trend rate in equation (7) into two random terms. The first source of variability, γ_t, reflects unexpected government expenditure to finance the budget deficit as well as random or uncertain government revenue. If there is unanticipated government expenditure or random revenue, the domestic credit will be unexpectedly created above its trend, μ_t. Therefore, this random term, γ_t, has a plus sign in equation (8). This shock is also assumed to be an independent random disturbance. The second disturbance of trend rate, ϕ_t, reflects uncertain or random access to the external credit flows from rest of the world into the domestic economy.[29] The budget deficits of the domestic government would be further financed by printing money when this access

[29] This comes from Harberger and Edwards (1982). This shock may be attributed to one of most important factors for understanding the recent Asian currency crises.

to external credits is more constrained. If $\phi_t > 0$, then government will be able to use the unexpected external credit to finance its deficits rather than using inflationary finance. $\phi_t < 0$ indicates negative shocks to the availability of the external capital market, implying domestic credit creation above its trend, μ_t. The two components, therefore, can be regarded as orthogonal factors which offset in each other an increase (or a decrease) in the domestic credit creation. These shocks are assumed to be independently distributed and will be studied in more detail later in this chapter.

Equation (9) defines the condition for money market equilibrium. This equilibrium condition determines the movement of reserves under a fixed exchange rate system and the time path of the exchange rate under a flexible rate regime. Therefore, excess domestic credit will not change the exchange rate under the fixed rate system. Instead, this leads to a decrease in foreign reserves. On the contrary, if foreign reserves are not allowed to move when there is an excess supply of domestic credit, the exchange rate needs to be adjusted under a flexible exchange rate regime. The condition for money market equilibrium is, therefore, determined by an interaction of movements in foreign reserves, domestic credit, and the exchange rate.

3.3 Solution for the Shadow Floating Exchange Rate

When the exchange rate is fixed, the condition for money market equilibrium is retained, and we can rewrite this condition as follows:

$$M_t^s = M_t^d \tag{9}$$

$$R_t + D_t = M_t^d \tag{10}$$

To explicitly solve the right hand side of equation (10), we need to combine equation (1) through equation (4). Before doing this, we have to rewrite equation (2) in order to provide an explicit form of the bond-market implications of the central bank's intervention. This intervention is to sterilize foreign reserve losses and to maintain a fixed exchange rate regime. Combining equation (3) and equation (4) gives

$$Q_t = (P_t^* + \alpha \Omega_t^{'}) S_t$$

Substituting this Q_t and equation (2) into the equation (1) yields [30]

$$\frac{M_t}{(P_t^* + \alpha \Omega_t^{'}) S_t} = a_0 - a_1 \left[i_t^* + \frac{(E_t S_{t+1} - S_t)}{S_t} + \frac{\theta (B_t - SB_t^*)}{S_t P_t^* \varpi} \right] + a_2 y_t - a_3 \left(\frac{E_t S_{t+1} - S_t}{S_t} \right) - a_4 N_t$$

Rewriting the above equation, we have

$$\begin{aligned} \mathrm{M}_t = \left(P_t^* + \alpha \Omega_t^{'}\right) S_t \Bigg[& a_0 - a_1 \left(i_t^* + \frac{(E_t S_{t+1} - S_t)}{S_t} + \frac{\theta (B_t - SB_t^*)}{S_t P_t^* \varpi} \right) + a_2 y_t \\ & - a_3 \left(\frac{E_t S_{t+1} - S_t}{S_t} \right) - a_4 N_t \Bigg] \end{aligned} \tag{11}$$

[30] As analyzed in Flood, Garber and Kramer (1996), if the monetary authority fully sterilizes the reserve losses during the speculative attacks, the discrete falls in the monetary base can be eliminated, but the reserve losses do not remove the discrete adjustment from the money demand because of the shift in the domestic interest rate. To balance these jumps, the bond-market considerations should be introduced. Otherwise, the fixed exchange rate cannot survive even temporarily. With the bond markets in the model, we can equate money supply and money demand.

To find the rate of reserve losses, the following assumptions need to be proposed. First, the rate of expected exchange rate depreciation as well as exchange rate depreciation itself, are zero. This (i.e., $(E_tS_{t+1} - S_t/S_t) = 0$) rules out the peso problem.[31] Second, the real exchange rate is fixed. Thus, $\Delta(P_t / S_t) = \Delta(P_t^* + \alpha\Omega_t^{'}) = 0$, where Δ indicates the time difference. Third, the real income (y_t) is given, and the foreign interest rate $\left(i_t^*\right)$ and the rate of non-performing loans (N_t) are also considered as exogenous factors. Thus, $\Delta\left(a_0 + a_2 y_t - a_1 i_t^* + (a_1 + a_3)(E_t S_{t+1} - S_t)/S_t\right) = 0$. Fourth, B (the stock of domestic currency denominated interest-paying debt issued by the domestic government and held in the private sector at home and abroad) is constant but B^* is not. B^* moves the following pattern in terms of the market with a constant initial level of B^*, B_0^*. That is, B^* changes as follows:

$$B_t^* = B_0^* + \frac{R_0 - R_t}{\bar{S}} \tag{12}$$

where R_0 is the initial level of reserves, and $\bar{S}$ indicates a fixed exchange rate.[32] Taking first difference of equation (11) yields the time path of money supply under the above restrictions as follows:

$$\Delta D_t + \Delta R_t = -\left(\frac{a_1\theta(P^* + \alpha\Omega')}{P^*\varpi}\right)\Delta R$$

[31] As defined in Krasker (1980), the peso problem is a statistical problem in the tests for the efficiency and rationality of markets, and of forward exchange markets in particular. This sometimes invalidates the test procedures used by the previous studies in the sense that the true Type I error probability (the probability of rejecting the efficiency and rationality of the market when it is true) is larger than one is led to believe. This is sometimes called the peso problem since it was first suspected shortly before the Mexican peso devaluation in 1976.

[32] Since R (foreign reserve) is expressed in the domestic currency, it needs to be converted to the foreign currency units by dividing the exchange rate.

Since the change in the domestic credit creation is assumed to be retained at the rate of μ_t, the above equation becomes as follows:[33]

$$\mu_t + \Delta R_t = -\left(\frac{a_1\theta(P^* + \alpha\Omega')}{p^*\varpi}\right)\Delta R \tag{13}$$

This equation shows that the rate change in the domestic credit creation is not perfectly offset by that of reserve losses, reflected in the difference between the two rates (i.e., the term , $a_1\theta(p_* + \alpha\Omega')/p^*\varpi$ is not zero) during the fixed rate regime. Although the two rates do not show perfect inverse-movement, when one component decreases the monetary base does not sharply drop (unlike the assumption of the standard generation speculative attack models) during the attack time because of the central bank's sterilization operation. Thus, this rate of foreign reserve losses can be applied during the speculative attacks.

When the exchange rate is variable, we can find the path of floating exchange rate by using equations (11) and (12), and this leads to an equilibrium condition followed by a successful attack with sterilization as follows:

$$R_c + D^+ = \left(P_t^* + \alpha\Omega_t'\right)S_t\left\{a_0 - a_1\left[i_t^* + \frac{\dot{S}_t}{S_t} + \theta\left\langle B_0 - B_t - \tilde{S}\left(B_0^* + \frac{R_0 - R_c}{\bar{S}}\right)\right\rangle\right]\right.$$

$$\left. + a_2 y_t - a_3\frac{\dot{S}_t}{S_t} - a_4 N_t\right\} \tag{14}$$

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[33] The rate in the reserve change, therefore, is $\Delta R_t = -\{1/[1-(a_1\theta(p^* + \alpha\Omega')/p^*\varpi)]\}\mu_t$. If ϖ is sufficiently large so that $\{1/[1-(a_1\theta(p^* + \alpha\Omega'/p^*\varpi)]\}$ is close to one, $\Delta R = \mu_t$ can be achieved.

where $\dot{S}_t = (E_t S_{t+1} - S_t)$ and $R_c + D^+$ is the level of monetary base after attack which is identical to the pre-attack level because it is sterilized by the exact amount of reserve losses (D^+ - D).[34] Thus, B takes the form of ΔB_t ($= B_0 - B_t$) from the above equation to reflect the amount of sterilization during attack. We can, therefore, replace $R_c + D^+ = M_t^s$ and equate $M_t^d = M_t^s$. Rearranging the above equation gives

$$\frac{M_t^s}{(P_t^* + \alpha \Omega_t')} = -\frac{a_1 \theta B_0}{P_t^* \varpi} + \frac{a_1 \theta B_t}{P_t^* \varpi} + aS_t - (a_1 + a_3)\dot{S}_t \qquad (15)$$

where $a = a_0 - a_1 i_t^* + a_2 y_t - a_4 N_t + a_1 \theta \{B_0^* + (R_0 - R_c)/\bar{S}\}/P_t^* \varpi$. Here, let $P_t^* + \alpha \Omega_t' = A$ and $-(a_1 \theta B_0 / P_t^* \varpi) + (a_1 \theta B_t / P_t^* \varpi) = C_t$.

Then equation (15) becomes

$$\frac{M_t^s}{A} = C_t + aS_t - (a_1 + a_3)\dot{S}_t \qquad (16)$$

When the availability for the source of foreign reserve is limited by some reasons such as fundamental disequilibrium (i.e., a systematic decline of reserves stemming from prolonged currency overvaluation) or limited external credit inflows, the fixed exchange rate with continuous reserve losses (due to above reasons) in equation (16) would not be

[34] Since foreign reserves is assumed to fall to a critical level (R_c) at the time of regime transition, R_c exists in the equation, unlike in Flood, Garber and Kramer (1996) where they assume zero reserves at the time of regime collapse. D^+ is the level of domestic credit during the attack, which is larger than the pre-attack D due to the sterilization of reserve losses.

maintained, at which level of reserves the exchange rate is forced to change. Thus, equation (16) becomes

$$\frac{M_t^s}{A} = C_t + a\tilde{S}_t - (a_1 + a_3)\dot{\tilde{S}}_t \qquad (17)$$

where $\tilde{S}_t$ is called the shadow exchange rate, following Flood and Garber (1984b), this rate will clear the money market in period $t+1$ when the rate is equal to or greater than the fixed rate in period t with expectation of agents' profits from speculative attacks in period t.

The method of undetermined coefficient is used to postulate the time path of the $\tilde{S}_t$, shadow floating rate. First, we need to posit the solution for $\tilde{S}_t$ in equation (17) as follows: $\tilde{S}_t = \lambda_0 + \lambda_1 M_t$.

When the reserves hit the critical level, R_c, the fixed exchange rate would float. The monetary base, however, would remain at the same level before collapse of the fixed exchange rate regime due to the sterilization operation by the central bank.

The solution for $\tilde{S}_t$ is

$$\tilde{S}_t = \left[\frac{(a_1 + a_3)\mu_t}{Aa^2} - \frac{C_t}{a}\right] + \left[\frac{1}{Aa}\right] M_t$$

Therefore, the derived coefficients are $\lambda_0 = (a_1 + a_3)\mu_t / Aa^2 - C_t / a$ and $\lambda_1 = (1/Aa)$, respectively. Rearranging the above equation gives the following shadow floating rate:

$$\widetilde{S}_t = \frac{1}{Aa}\left[\frac{(a_1 + a_3)\mu_t - AaC_t}{a} + M_t\right]$$

where, again, $A = P_t^* + \alpha\Omega_t^{'}$, $C_t = -(a_1\theta B_0)/P_t^*\varpi + (a_1\theta B_t)/P_t^*\varpi$ and $a = a_0 - a_1 i_t^* + a_2 y_t - a_4 N_t + a_1\theta\{B_0^* + (R_0 - R_c)/\overline{S}\}/P_t^*\varpi$, respectively. Replacing M_t by using equation (7) and (8) and using R_c for the shadow rate, $\widetilde{S}_t$, and finally rewriting A and C_t for the original forms, we have the time path of $\widetilde{S}_t$ as follows:

$$\widetilde{S}_t = \frac{1}{a(P_t^* + \alpha\Omega_t^{'})}\left\{\frac{(a + a_1 + a_3)\mu_t}{a} - \frac{A(a_1\theta B_0 - a_1\theta B_t)}{P_t^*\varpi} + D_{t-1} + R_c + \gamma_t - \phi_t\right\} \qquad (18)$$

Three shocks exist in equation (18), and these shocks affect the speed of $\widetilde{S}_t$. The positive relative price shock ($\Omega_t > 0$) makes the pressure on the exchange rate decrease by raising the money demand for transaction motives. The positive domestic government budget shock ($\gamma_t > 0$) caused by the unanticipated expenditures and uncertain government revenues leads to an upward devaluation pressure by increasing the domestic credit creation, D_t (also by increasing the money supply). If there are unexpected capital inflows to the crisis economy (i.e., positive external credit shocks, $\phi_t > 0$), the pressure on the exchange rate would be alleviated by decreasing the need for domestic credit creation, and thus the money supply would also decrease. Even if domestic fiscal policies are in good shape, the pressure on the exchange rate could increase due to an

abrupt restriction in the external capital inflow.[35] Furthermore, with large-prolonged systematic overvaluation, there could be an upward pressure on the shadow floating rate even with external credit inflows.[36]

3.4 Solution for the Probability of a Regime Collapse

When the shadow floating rate ($\widetilde{S}_{t+1}$) in period $t+1$ exceeds the fixed ($\overline{S}_t$) rate in period t, we can obtain a knowledge of π_t, the collapse probability of a fixed exchange rate regime, defined as follows:

$$\pi_t = \Pr\{\widetilde{S}_{t+1} > \overline{S}\} \tag{19}$$

$$= \Pr\left\{\frac{1}{a(P^*_{t+1} + \alpha\Omega^{'}_{t+1})}\left[\frac{P^*_t \varpi(a + a_1 + a_3)\mu_{t+1} - aAa_1\theta(B_0 - B_{t+1})}{P^*_t \varpi\, a} + D_t + R_c + \gamma_{t+1} - \phi_{t+1}\right] > \overline{S}\right\}$$

If speculators anticipate the regime collapse in the next period by their attacks against the foreign reserves held by a central bank (i.e., if they expect $\widetilde{S}_{t+1} > \overline{S}$), they may continue purchasing the reserves at price $\overline{S}$, reselling immediately in the beginning of period $t+1$ at price $\widetilde{S}_{t+1}$. With this sale, they would make a profit of $((\widetilde{S}_{t+1} - \overline{S}) > 0)$ per unit of

[35] In reality, troubled Asian economies were limited to the external capital access due to reluctance of roll-over by the foreign financial institutions.

[36] Asian crisis-countries have been experiencing large currency overvaluations, leading to magnificent current account imbalances. This, in fact, affects positive pressure on the devaluation in these countries.

reserves. If $\widetilde{S}_{t+1} < \overline{S}$, speculators would not buy the foreign reserves since they recognize that there will be no profits from these transactions of reserves.

3.4.1 Derivation of the Probability under Distributions of Random Disturbances

Three random components are found in equation (19), which are Ω_t, γ_t and ϕ_t.[37] First, it is crucial to set up the distributions of these disturbances in order to evaluate the π_t, probability of collapse.

Following Flood and Garber (1984b) and Goldberg (1994), the random components, Ω_t, γ_t and ϕ_t, are assumed to be exponentially and independently distributed with means adjusted to zero and variances of $(1/w)^2$, $(1/\lambda_1)^2$ and $(1/\lambda_2)^2$, respectively.[38] The random component of the deviation from purchasing power parity is

$$\Omega_t = -\frac{1}{w} + \omega_t \tag{20}$$

where ω_t is distributed with mean $1/w$ and density function is

$$f_\omega = \begin{cases} w \cdot \exp[-w \cdot \omega_t], & \text{if } \omega_t > 0 \\ 0, & \text{if } \omega_t \le 0 \end{cases}$$

The stochastic component of domestic credit creation by random revenue is

$$\gamma_t = -\frac{1}{\lambda_1} + v_{1t} \tag{21}$$

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[37] In equation (4), the only random shock is Ω_t, and the distribution mentioned here is about this component, not Ω_t' term. The term, Ω_t' will be replaced with $\rho + \Omega_t$ to explicitly derive π_t, as below.

[38] The reasons for the assumption of exponential distribution are analytically convenient and intuitively appealing, when there are large positive shocks to domestic credit creation and to the other random disturbances.

where v_{1t} is distributed with mean $1/\lambda_1$ and the density function is

$$f_{V_1} = \left\{ \begin{array}{cc} \lambda_1 \cdot \exp[\ -\lambda_1 v_{1t}], & if\ v_{1t} > 0 \\ 0, & if\ v_{2t} \le 0 \end{array} \right\}$$

The random disturbance of domestic credit creation by access to external credit is

$$\phi_t = -\frac{1}{\lambda_2} + v_{2t} \qquad (22)^{39}$$

where v_{2t} is distributed with mean $1/\lambda_2$ and the density function is

$$f_{V_2} = \left\{ \begin{array}{cc} \lambda_2 \cdot \exp[-\lambda_2 v_{2t}], & if\ v_{2t} > 0 \\ 0, & if\ v_{2t} \le 0 \end{array} \right\}$$

Plugging equations (20), (21) and (22) into equation (19), and then rearranging so as for the random components to be collected at the same side, yields

$$\begin{aligned} \pi_t = \Pr\Big\{ & (\bar{S}a\alpha + C_{t+1}\alpha)\omega_{t+1} - v_{1,t+1} + v_{2,t+1} < \frac{(a + a_1 + a_3)\mu_{t+1}}{a} + D_t + R_c \\ & - \frac{1}{\lambda_1} + \frac{1}{\lambda_2} - (\bar{S}a\alpha + C_{t+1})(P^*_{t+1} + \alpha\rho_{t+1} - \frac{\alpha}{w}) \Big\} \end{aligned} \qquad (23)$$

[39] In equation (20), (21) and (22), $1/w$, $1/\lambda_1$ and $1/\lambda_2$ are shift variables for the random disturbances to be distributed with zero means.

When the right side (i.e., nonrandom components) and the left side terms (i.e., random components) in equation (23) are replaced by K_{t+1} and Z_{t+1}, respectively, and then equation (23) is shortened as follows:

$$\begin{aligned}\pi_t &= \Pr\{(\bar{S}a\alpha + C_t\alpha)\omega_{t+1} - v_{1,t+1} + v_{2,t+1} < K_{t+1}\} \\ &= \Pr\{Z_{t+1} < K_{t+1}\}\end{aligned} \tag{24}$$

To calculate the probability of collapse, equation (23) needs to be expressed as equation (24) by using the joint probabilities of disturbances as seen below. The probability density functions (*pdf*s) of the random variables X, Y_1 and Y_2 are

$$X_{t+1} = (\bar{S}a\alpha + C_{t+1}\alpha)\omega_{t+1} \qquad \text{with } pdf \quad f_X = f_{(\bar{S}a\alpha + C_{t+1}\alpha)\omega_{t+1}}$$

$$Y_{1,t+1} = v_{1,t+1} \qquad \text{with } pdf \quad f_{Y_1,t+1} = f_{v_1,t+1}$$

$$Y_{2,t+1} = v_{2,t+1} \qquad \text{with } pdf \quad f_{Y_2,t+1} = f_{v_2,t+1}$$

and so,

$$\begin{aligned}Z_{t+1} &= (\bar{S}a\alpha + C_{t+1}\alpha)\omega_{t+1} - v_{1,t+1} + v_{2,t+1} \\ &= X_{t+1} - Y_{1,t+1} + Y_{2,t+1}\end{aligned} \tag{25}$$

To derive the probability of collapse, the *pdf* of Z must be first solved. The *pdf* of Z is

$$f_z(Z) = \iint f_X(X) \cdot f_{Y_1}(Y_1) \cdot f_{Y_2}(Z - X + Y_1)\, dY_1 dX \tag{26}$$

Once we have the *pdf* of Z, we know the probability that the shadow floating rate would exceed the fixed rate:

$$\pi_t = \int_{-\infty}^{K_t} f_Z(Z)\, dZ \tag{27}$$

First, we need to solve equation (26) to have the explicit form of f_Z, with which we can calculate π_t from equation (27).

$$f_Z(Z) = \int_0^{\infty}\int_{X-Z}^{\infty} \left[\frac{w\lambda_1\lambda_2}{\bar{S}a\alpha + C_{t+1}\alpha}\right] \cdot e^{-\lambda_2 Z} \cdot e^{-(\lambda_1+\lambda_2)Y_1} \cdot e^{\left(\lambda_2 - \frac{w}{\bar{S}a\alpha + C_{t+1}\alpha}\right)X}\, dY_1 dX$$

So that

$$f_Z(Z) = \left[\frac{w\lambda_1\lambda_2}{A_1(\lambda_1+\lambda_2)}\right]\left[\frac{1}{\lambda_1 + (w/A_1)}\right] \cdot e^{\lambda_1 Z} \tag{28}$$

where $A_1 = \bar{S}a\alpha + C_{t+1}\alpha$ and $C_{t+1} = -\frac{a_1\theta B_0}{P^*_{t+1}\varpi} + \frac{a_1\theta B_{t+1}}{P^*_{t+1}\varpi}$, respectively.

Integrating equation (28) gives the final solution for the probability of collapse

$$\begin{aligned} \pi_t &= \int_{-\infty}^{K_t} f_Z(Z) \\ &= \left\{\frac{w\lambda_2}{\left[(\bar{s}a\alpha + C_{t+1}\alpha)\lambda_1 + w\right]\left[\lambda_1+\lambda_2\right]}\right\} \cdot e^{\lambda_1 K_t} \end{aligned} \tag{29}$$

where $K_t = \left\{\frac{(a+a_1+a_3)\mu_{t+1}}{a} + D_t + R_c - \frac{1}{\lambda_1} + \frac{1}{\lambda_2} - (\bar{S}a + C_{t+1})(P^*_{t+1} + \alpha\rho_{t+1} - \frac{\alpha}{w})\right\}$

3.5 Movement of π_t along with the Change in Variables

Several variables affect the probability, π_t, in equation (29). The probability of collapse of the exchange rate system is a positive or negative function of such variables as the level of domestic income (y_t), the risk premium, the share of non-traded goods (α), the rate of domestic credit creation (μ_t), the critical floor level of reserves (R_c), the variance of relative prices ($1/w$), the variance of domestic credit creation ($1/\lambda_1$), the variability of external credit inflows ($1/\lambda_2$), systematic deviation from purchasing power parity (ρ_t), the rate of non-performing loans (N_t), and the level of sterilization.

The probability of a collapse in period $t+1$, computed in period t, rises as the domestic credit expands. This can be derived by differentiating equation (29) with respect to μ_t.

$$\frac{\partial \pi_t}{\partial \mu_t} = \left[\frac{w\lambda_2}{[(\bar{s}a\alpha + C_{t+1}\alpha)\lambda_1 + w][\lambda_1 + \lambda_2]}\right]\left[\frac{(a + a_1 + a_3)}{a}\right] \cdot \lambda_1 \cdot e^{\lambda_1 K_t} > 0$$

$$\frac{\partial^2 \pi_t}{\partial \mu_t^2} = \left[\frac{w\lambda_2}{[(\bar{s}a\alpha + C_{t+1}\alpha)\lambda_1 + w][\lambda_1 + \lambda_2]}\right]\left[\frac{(a + a_1 + a_3)}{a}\right]^2 \cdot \lambda_1^2 \cdot e^{\lambda_1 K_t} > 0$$

The sufficient conditions for the above two relations are $a > 0$ and $a_1 + a_3 > 0$, respectively.[40] These relationships can be figured in terms of π_t against the trend rate of domestic credit creation.

[40] The three shocks, λ_1, λ_2, and w, are assumed to be positive.

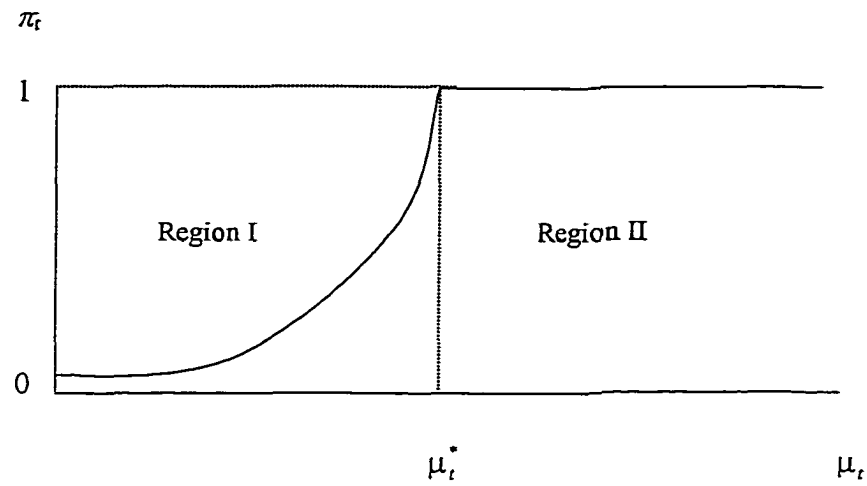

Figure 3.2: Plot of the Collapse Probability of Fixed Regime against μ_t.

From figure 1, the probability of collapse becomes one at and above the level of μ_t^*.[41] In region I, the probability of collapse increases as μ_t approaches to μ_t^*. Even when $\mu_t = 0$, π_t remains at a level greater than zero. That is, if $\mu_t = 0$, only $(\alpha + \alpha_1 + \alpha_3)\ \mu/\alpha$ term in K_t is eliminated and the non-exponential component is not removed, and thus π_t is not zero. This implies that while there is no fiscal deficit, the domestic credit could be created by random shocks such as unexpected government expenditure and unanticipated external credit shortage, and this leads to reserve losses even though the μ_t is zero.

The probability of collapse is also a function of the level of the reserve floor. Differentiating equation (28) with respect to R_c yields

[41] This fact results from the assumption of the shape of $f_z(z)$. The *pdf* of $f_z(z)$ is assumed to be exponentially distributed with $K_t < 0$ when π_t is less than zero.

$$\frac{\partial \pi_t}{\partial R_c} = \left\{ \frac{w\lambda_2}{[(\bar{s}a\alpha + C_{t+1}\alpha)\lambda_1 + w][\lambda_1 + \lambda_2]} \right\} \lambda_1 \cdot e^{\lambda_1 K_t} > 0$$

The sufficient condition is $a > 0$. Although this level of the reserve floor is set by the monetary authority, the agents would not be informed before the collapse of the exchange rate regime. This uncertainty about the reserve floor would lead to a series of mini-speculative attacks on the central bank reserve stock. To evaluate this floor level, an econometric methodology will be introduced in the next chapter.

3.5.1 Elimination of the Collapse Probability

From the previous section we know that the probability of collapse is not eliminated even when $\mu_t = 0$. Observing equation (29), the probability will become zero under several conditions.

First, if K_t goes to infinity (i.e., $K_t \rightarrow -\infty$)[42], the collapse will be removed. However, this condition is highly unlikely. In terms of domestic credit creation (μ_t), this condition does not seem to be achievable, even if reducing the rate of domestic credit creation (μ_t) lowers K_t, and so probability of collapse as seen in figure 1, because even when $\mu_t = 0$, π_t is greater than zero. Second, if λ_1 approaches to infinity (i.e., if $1/\lambda_1 \rightarrow 0$)[43], it is satisfied for π_t to be zero. This condition tells that if the public knows thoroughly the path of money growth, the threat of collapse would be removed; since $1/\lambda_1$ is the mean of the

[42] Previously, K_t is assumed to be negative when $\pi_t < 1$.

[43] Even when there is no assumption of $K_t < 0$, if $1/\lambda_1 \rightarrow 0$, then π_t approaches to zero because the non-exponential term in equation (28) goes to zero under condition of $\lambda_1 \rightarrow \infty$ ($=1/\lambda_1 \rightarrow 0$).

exponentially distributed random money growth term, $1/\lambda_1 \rightarrow 0$ implies that this random component becomes completely non-random.

Third, when $1/\lambda_2$ goes to infinity, the probability of collapse can be eliminated. This condition is, however, highly unlikely because ($1/\lambda_2 \rightarrow \infty$) means that the variability of supplies of external credit should be infinity for the prevention of a collapse.

Fourth, if $1/w \rightarrow \infty$ (i.e., if the short-run variability of deviation from the purchasing power parity goes to zero), then there will be no collapse of a fixed regime. But this condition is also highly unlikely.

3.5.2 Comparative Statics

To analyze the changes in the probability of collapse associated with the movement in some variable in term a, we first need to differentiate π_t with respect to a. Then, taking the differentiate a with respect to a certain variable contained in a yields the following results.

$$\frac{\partial \pi_t}{\partial a} < 0, \qquad if \quad \frac{(a_1 + a_3)\mu_{t+1}}{a^2} + \bar{S}\left(P^*_{t+1} + \alpha\rho_{t+1} - \frac{\alpha}{w}\right) > \frac{-\bar{S}\alpha}{(\bar{S}a\alpha + C_{t+1})\lambda_1 + w}$$

where $a = a_0 - a_1 i^*_{t+1} + a_2 y_{t+1} - a_4 N_{t+1} + a_1\theta\left\{B^*_0 + (R_0 - R_c)/\bar{S}\right\}/P^*_{t+1}\varpi$.

The sufficient conditions to satisfy $\partial\pi_t/\partial a < 0$ are that $P^*_{t+1} + \alpha\rho_{t+1} > \alpha/w$[44], $a_1 + a_3 > 0$, and $\mu_{t+1} > 0$.

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[44] $[(a_1 + a_3)\mu_{t+1}/a^2 + \bar{S}\ (P_{t+1}{}^* + \alpha\rho_{t+1} + \alpha/w)] > -\bar{S}\ \alpha / [(\bar{S}\ a\alpha + C_{t+1})\ \lambda_1 + w]$ is different from the result in Goldberg (1988).

Next, differentiating a with respect to y (real income) gives

(a) $$\frac{\partial a}{\partial y_t} > 0, \quad then, \quad \frac{\partial \pi_t}{\partial y_t} < 0$$

The probability of collapse is the inverse function of real income. So, when the government adopts policies for raising real income, the chance of a collapsing exchange rate regime would be lowered. This implies that the supply of domestic credit creation is offset by the increase in the real money demand due to raised transactional demand, so that this mechanism will alleviate the pressure on the currency depreciation of the exchange rate. However, an increased transaction caused by higher real income could aggravate the trade balance and thus current accounts (by accelerating the demand for the imported goods).[45]

(b) $$\frac{\partial \pi_t}{\partial r_t} < 0$$

In equation (2), the risk premium is added to the interest rate, expressed as $\theta (B_t - SB_t^*) / SP^* \varpi$. Therefore, to find the probability change related to the movement in risk premium, we need to analyze the influences of B and B^* on the π_t in equation (29). But, in equation (29), only B_t is a variable, and B_0 and B_0^* are assumed to be constant in the previous section. By differentiating π_t with respect to B_t, we have $\partial \pi_t / \partial B_t < 0$. This relationship implies that when the demand for the domestic bond increases, the risk

[45] In fact, economically troubled Asian countries had experienced magnificent current account and trade account deficits in the period leading to the crises (1995-1996). One of the main factors to affect these deficits could be the consumption boom partly due to the large increase in the rate of real income, caused by excessively optimistic expectations for the future economy.

premium for the domestic currency would also increase. Thus, this relationship can be translated into the effect of risk premium on the change in π_t as follow, $\partial \pi_t / \partial r_t < 0$.

As mentioned in Goldberg (1994), the negative relationship between π_t and r_t stems from the fact that the demand for real balance will be lowered with an increase in the domestic interest rate.

(c) $$\frac{\partial \pi_t}{\partial a_3} > 0$$

The sufficient conditions for this inequality are $a > 0$ and $\mu_{t+1}>0$. The probability of collapse is positively related to the source of leakage from the demand for domestic real money, as theoretically expected.[46] With devaluation expectations, the demand for domestic real balances will be lowered, thus this accelerates the foreign reserve stock out of the central bank. π_t, therefore, would rise and the collapse time will be also hastened with higher level of a_3, implying larger currency substitution.

(d) $$\frac{\partial \pi_t}{\partial N_t} > 0, \quad if \quad \frac{\partial \pi_t}{\partial a} < 0$$

The conditions for this negative relationship are that $P_{t+1}^* + \alpha\rho_{t+1} > \alpha / w$, $a_1+a_3>0$, and $\mu_{t+1}>0$.

[46] In the literature, however, there have been conflicts with this view. Roger's (1992a,b) empirical findings show that there is a negative and a statistically significant relationship between devaluation expectations and the ratio of the Mexodallar (dollar-denominated holdings in Mexican bank accounts) to peso-denominated holdings. On the contrary, as argued in Ortiz (1983) and Ramirez-Rojas (1985), the rate of the Mexodollar to total Mexican bank deposits is positively correlated with devaluation expectations. Gruben and Welch (1996) maintain the negative sign on devaluation expectations on the Mexodallar demand, based on the hypothesis of the lender-of-last-resort and on the assumption of loan quality (variable).

Several important factors [47] during the period prior to recent Asian economic crises might have made the financial system in that region more unstable. These factors may include the production of a magnificent amount of non-performing loans, which is a critical component in triggering speculative attacks on the central bank's foreign reserves. Therefore, as the ratio of the non-performing loan increases, the probability of a collapsing exchange rate regime would also rise. Thus, the inclusion of this factor in the model can better explain the current Asian economic crises. The accumulation of bad loans can be a serious current or future fiscal burden of a domestic government. Once agents recognize the worsening economic situation resulting from the interaction between the large stock of debt and the other crucial factors such as current and trade account deficits, or limited access to external credit, then they might get out of investments in domestic assets and into the foreign credit market by triggering speculative attacks on the foreign reserves held by the domestic central bank. Thus, although this component (N_t) may be viewed as an opportunity for the currency substitution, this factor can be, rather, considered as a more direct and powerful factor to explain one of main reasons, (i.e., speculative attacks) which might have caused the recent Korean currency crises.

(e) $$\frac{\partial \pi_t}{\partial(1/\lambda_1)} > 0 \quad \textit{and} \quad \frac{\partial \pi_t}{\partial(1/\lambda_2)} > 0$$

[47] For example, the factors could be as follows: borrowing too much from abroad and investing a lot in risky projects which turned out to be not profitable because of a moral hazard problem created by government' promises of a bailout, resulting in low profitability; also financing speculative demand of existing assets in fixed supply such as land, real estate and the outstanding stock of equity, resulting in a large stock of foreign debt due to the burst of the bubble caused by the above reasons.

The probability of collapse is positively correlated with the variability of domestic government deficits.[48] π_t is also positively correlated with the variability of available external credit under the condition, $1/\lambda_1 > 0$ and $1/\lambda_2 > 0$. The probability of collapse is threatened by the limit to external credit inflows as long as two shocks to domestic credit creation are uncertain.

(f) $$\frac{\partial \pi_t}{\partial (1/w)} > 0 \quad and \quad \frac{\partial \pi_t}{\partial \rho_t} < 0$$

The effect of relaxing purchasing power parity is represented through two deviation components: systematic (ρ_t) and random components (Ω_t) — the random effect is done through $1/w$, a variance of random disturbance. The more random deviation from purchasing power parity exists, the less demand for domestic real balances. So, this leads to a higher probability of collapse of the exchange rate regime. The condition for this relationship is $1/w > 0$. That is, as long as there exists a random price shock, the π_t is threatened to be collapsed.

As the long-run purchasing power disparity increases, the probability of collapse would decrease under the following sufficient condition, $\alpha > 0$. The logic behind this mechanism is as follows. An increase in P_t resulting from the more systematic deviation from the purchasing power parity raises the domestic price level (Q_t). This increase in Q_t causes the nominal money demand to rise by the transaction motives, alleviating pressure on the domestic exchange rate. The effect of this component depends on the share of

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[48] The sufficient condition is $\{[2A_2 + (A_2\lambda_2 + w)\ 1/\lambda_1][1/\lambda_2]\} / \{A_2 + (A_2\lambda_2 + w)\ (1/\lambda_1) + w\lambda_2\ (1/\lambda_1)^2\}^2 > [K_t(\lambda_1)^2 / (A_2\lambda_1 + w)\ (\lambda_1 + \lambda_2)]$, where $A_2 = \overline{S}\ a\alpha - (\alpha a_1 \theta B_0 / P_t^* \varpi + \alpha a_1 \theta B_t / P_t^* \varpi)$ and $K_t = \{(a + a_1 + a_3)\mu_t / a + D_{t-1} + Rc + (1/\lambda_2) - [\overline{S}\ a\alpha - (a_1 \theta B_0 / P^* \varpi) + (a_1 \theta B_t / P^* \varpi)]\ [P^* + \alpha\rho_{t+1} - (\alpha / w)]\}$.

non-traded goods and its degree of elasticity in the domestic consumption. With less consumption in the imported goods, the impact of the systematic price deviation decreases. Also, if the demand for such non-traded goods is relatively inelastic, and as non-traded goods become systematically more expensive relative to traded goods, then the pressure on π_t will be lowered because of an increase in the money demand for maintaining a higher transaction cost. The non-traded goods prices have shown upward trends, stemming from the overvaluation of the domestic currency which is in part caused by a difference in the inflation rates between Korea (or the other troubled Asian countries) and OECD group. Since the prices of non-traded goods do not have the same competitive pressures as those of traded goods (i.e., there is inertia in the non-traded goods prices compared to the traded goods prices), the non-traded goods prices remain above the world level.

(g) $\frac{\partial \pi_t}{\partial \alpha} < 0$

The π_t is negatively correlated with the magnitude of domestic consumption in non-traded goods (α) under the sufficient conditions of $\rho > 1/w$ and $a > 0$. During the periods leading to a currency crisis, there might have been big pressures on a devaluation and thus, also domestic currency might have been overvalued during that time. During the periods of more systematic deviation from the purchasing power parity (due to prolonged overvaluation of the domestic currency) relative to short-run variance of prices from the purchasing power parity, a reduction in the share of the imported goods in domestic consumption would lower the pressure on the exchange rate.

(h) $\frac{\partial \pi_t}{\partial B_t} < 0$

From equation (29), the sterilization can be operated only through a change in the domestic government bonds, B. As the monetary authority further sterilizes against the attacks on the central bank's foreign reserves (this indicates a decrease in B_t in terms of markets), π_t will rise. The sufficient conditions for this relationship are: α / w is not so large and $a > 0$. Under these conditions, the sterilization policy by the central bank's purchase of the government bonds enables the domestic credit to be maintained at the same level as before the speculative attacks. Thus, with an additional factor that can further create domestic credit (rather than pure credit creation to finance a government budget deficit), the collapse of the fixed regime will be hastened. When the financing of government deficits were set up as a priority to fixing the exchange rate, they could be inevitably conflicting and the time of collapse of that fixed regime would be earlier than it would be if there were no primary targets in the exchange rate.

3.6 Conclusion

The theoretical model developed in this chapter extends the previous studies of speculative attack which are largely based on the view of standard crisis models. However, the model of this chapter is also designed to incorporate several characteristics of both first and second generation models of currency crises in attempting a better description of the 1997 Korean crisis.

For this purpose, the model introduces several important factors that would have influenced the economic circumstances before/during the crisis period: a sterilization policy, a ratio of non-performing loans, a time-varying risk premium, and internal and

external credit shocks. In this context, this modified model provides some policy implications on the surrounding currency crisis by analyzing the change in the probability of the regime collapse in accordance with the movements of the variables and shocks: especially the sterilization operation increases the collapse probability by providing another source for creating domestic credit; and, the unstable external credit flows also increase the probability in the model.

Although this theoretical model is modified to better illustrate the Korean crisis, it may still have some limitations in describing all the features of the crisis because the model requires a number of strict assumptions. Regardless of these limitations, however, with the expectation of this model to provide better intuition in understanding of the recent currency crises, the empirical work will be performed by applying this extended model and then the Korean experience will be interpreted based on the empirical findings.

CHAPTER 4

The Behavior of the Central Bank's International Reserves and the Level of the Reserve Floor

4.1 Survey on the Critical Reserve Floor

The assumption[49] of a critical lower bound on the level of the central bank's foreign reserves, which can trigger a speculative attack on the domestic currency, plays a crucial role in the literature on the balance-of-payment crises as shown in the previous chapter.

The reason why the level of the reserve floor is a crucial factor in deriving the collapse probability of the fixed exchange rate regime is well analyzed in the study of Cumby and van Wijnbergen (1989; p118).

> "The assumption that the authorities adhere to the crawling peg until some unknown reserve level, R_c, is reached is less restrictive than it may first appear. The decision rule about the change in the exchange rate regime made by the monetary authorities may depend on other factors and may be considerably more complex than the adoption of some critical reserve level. In the monetary model employed here, what matters to agents is the exchange rate (and therefore the money supply) that is expected if the crawling peg is abandoned. Since only the money supply matters to agents and since domestic credit creation is exogenous, agents care only about the stock of reserves that will remain once the peg is abandoned and not directly about any other factors that may enter the authorities' decision rule. We therefore focus on the reserve level prevailing upon collapse rather than on other possible central bank decision rules."

[49] This assumption can be found in so-called standard speculative attack models. See, for example, Krugman (1979), Flood and Garber (1984), Flood, *et al.* (1996), Blanco and Garber (1986), Cumby and van Wijnbergen (1989), Willman (1988,1989,1991), and Goldberg (1994).

Blanco and Garber (1986) assumed that the reserve limit equals a constant R_c (the level of reserve floor) multiplied by an index of U.S. import prices. They, however, used only R_c with multiplying an index of U.S. import prices in order to derive the unconditional forecast of the exchange rate in their theoretical section.[50] This alternation in their empirical examination accounts for the decreasing real value of the U.S. dollar and the increasing actual reserve level[51] due to the rapid growth of the Mexican economy throughout the sample period, 1973:Q4 ~ 1981:Q1. Since their minimum allowable net reserve level (R_c) was calculated ex post the materialization of fixed regime collapse, their R_c specification would be invalid if Mexico's access to external borrowing was increased such that Mexico succeeded in defending their exchange rate system.

Unlike commonly adopted critical reserve levels[52], Cumby and van Wijinbergen (1989) considered that the reserve floor may be either greater than zero or less than zero. This assumption is based on the fact that the monetary authority may give up maintaining the fixed exchange rate before the reserves are completely exhausted or may have access to the external credit so that *net* central bank's holding of foreign assets could be negative. Cumby and van Wijinbergen, therefore, set the upper limit for R_c as being no higher than the current level in case of no collapse. For the lower R_c, they assumed a negative value as in the Argentina case in February 1981 with the consideration of no additional foreign credits *during* a crisis but available *only after* policy reform such as a change in the exchange rate. In this case, the lower bound on R_c will be minus gross

[50] In their theoretical part, the initial R_c, is reestimated by minimizing the sum of squared residuals of the nonlinear future exchange rate equation until the parameter estimate for R_c converges.
[51] They assumed in the theoretical development that R_c remains constant, regardless of the evolution of the other variables of the model.
[52] For example, in Krugman (1979) and Flood and Garber (1984), the reserve floors are assumed to be zero at which the central bank will abandon the existing exchange rate peg.

foreign liabilities. In their study, the distribution for the critical value has the form of uniform over the lower and upper bounds.

Willman (1989) analyzed the speculative behavior with an unknown threshold level of foreign reserves. He assumed an uncertainty about the threshold reserve level that is drawn from a normal distribution. With this probability distribution, he sets up three cases to analyze the speculative behavior of the reserves: (1) the case of a new threshold level and risk-neutral investors (i.e., a new level is obtained from the known probability distribution in *each* period); (2) the case of a fixed but unknown threshold level and risk-neutral investors (i.e., a value for the threshold level is drawn from the known distribution *only once*); and (3) a combination of the first two cases (i.e., the investors do not know with certainty whether the threshold level is fixed or reconsidered at the end of each period). His results show that speculative behavior is quite sensitive to the specification of the process which produces the critical lower level of the foreign reserves.[53]

Although Willman systematically formalized the critical level of the central bank's foreign reserves in a situation in which domestic credit grows as steadily as standard balance-of-payments models, the limit of his method could be that he performed only simulation experiments by choosing certain numbers in order to estimate the parameters in the distribution function. That is, his method has no validation of the empirical work using real data.[54]

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[53] In the first case (i.e., the stochastic threshold levels), a speculative outflow of reserves occurs over several periods of time. In the second case with a fixed but unknown threshold level, there were repeated single period attacks on the currency with zero probability of devaluation between attacks. The results of the third case show the speculative attacks with non-zero probability of devaluation between attacks.

[54] However, it seems to be hard to derive a distribution function using real data because of the nonlinearities in the model.

Goldberg (1994) adopted a more ad hoc reserve floor level, ranging -200 million to 1 billion 1977 U.S. dollar. According to her, performing the empirical examination with this range may test more conservatively the out-of-sample predictive estimation of the model than the other studies did, in which they rely on the use of information available only ex post.[55]

As in Cumby and van Wijinbergen (1989), the minus reserve floor in the Goldberg (1994) study indicates the fact that the domestic monetary authority may have been in a good position to the available foreign credit in order to defend the exchange rate. Goldberg's (1994) empirical estimation shows that the pattern of the results are qualitatively robust regarding the choice of the critical reserve floor, but the estimated shadow exchange rates depend quantitatively on the values of the reserve floor. Consequently, this result implies that the estimated probabilities (that the estimated shadow exchange rates would exceed the previously announced exchange rates) cannot be also robust quantitatively.

While the above approaches to find the level of minimum reserves have their own advantages, we will, instead, adopt an equation of demand for reserves (rather than a nominal level of reserve itself) which incorporates the behavior of foreign reserves with the several macroeconomic variables that influence the determination of foreign reserves around the problematic period.

The structure of the estimated residuals from the reserve demand equation will give some useful information on the form and persistence of deviation from the desired long-run level of reserves if the estimated demand function truly characterizes the real desired

[55] In the literature on the standard balance-of-payments crisis models, R_c is assumed to be not available ex ante to the public until the exchange rate system actually collapses.

levels of foreign reserves. The regression result will also provide the speed of adjustment to shocks, implemented by the monetary authority.

4.2 Demand for Desired Reserves and Crisis

It could be said that a central bank holds international reserves[56] for two purposes: (1) for the international transactions such as the importation of goods and services; (2) for a buffer stock to stabilize the exchange rate between the domestic and foreign currencies through the financing of temporary imbalances in a country's external payments.[57]

As most economic theories in which the demand for any commodity is determined by a utility maximization procedure, the demand for reserves can be considered as an outcome of weighing the marginal benefits of holding reserves against the marginal cost of holding the additional unit of reserves. However, the theory of the demand for reserves may seem to be more complex because the benefits and costs of holdings of reserves are involved in the highly fluctuating variables of the economic system. In addition, the issue can be more complex due to the stochastic features stemming from the uncertainty of implemented policies. Thus, "under these circumstances any demand function for reserves can be considered a reduced form of a large macro-economic model" (Farzinvash, 1989; p 98).

The model used in the next section for estimating the demand for reserves is the partial adjustment model based on the optimization approach to the demand for

[56] The international reserves usually consist of gold, convertible foreign exchange, reserve position in the International Monetary Fund (IMF), and Special Drawing Rights (SDRs).

[57] Based on the monetary approach to demand for international reserves, there could be another motive of holding reserves, which is a speculative motive. Although investment of national wealth into foreign asset reduces capital loss or performs a portfolio diversification, there are no strong evidences or reasons for central banks to hold reserves for the speculative motives.

reserves.[58] In this approach, the demand for desired reserve is dependent on the government's welfare-maximizing under uncertain behavior. Clark (1970a), using a four-quadrant diagram, analyzed the relationship between the speed of adjustment (i.e., the speed of adjusting the gap between actual and desired levels of reserves) and the level of national income. The combination of a higher level of reserves and a lower speed of adjustment relates to a lower but more stable level of national income. On the contrary, a lower level of reserves with a higher speed of adjustment involves an increase in the volatility of the national income. To optimize the demand for reserves, the one point is selected, on which the trade-off between the level of income and the variability of income is most desirable.[59] By holding a higher level of reserves, national income may be sacrificed due to the opportunity cost of losing more productive investments. Stabilization from the external shocks, however, can be regarded as an advantage in the case of higher holdings of reserves. Holding a lower level of reserves enables a country to achieve a higher level of national income on average, but it may provide more unstable levels of income due to the difficulty in adjusting the income against the external shocks.

In the optimization approach, the average reserve holdings by the central bank are positively related to the income and the variability of the balance of payments, and inversely related to the opportunity cost of reserve holdings and the marginal propensity to imports.[60]

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[58] Heller (1966), followed by Clark (1970a,b), Kelly (1970), and Britto and Heller (1973), initiated this approach.

[59] In that point, the government utility function is tangent to the highest indifference curve. See Clark (1970a) for more detail.

[60] In the literature on the demand for reserves, two possibilities concerned with the sign of marginal propensity to import (MPI) can be proposed. First, when the MPI is used as a measure of the output adjustment to external trade disturbances, the MPI is inversely related to the demand for reserves. This relationship stems from the Keynesian fixed price model of foreign trade multiplier where the trade multiplier has negative movement with MPI. Second, if the MPI is considered as a proxy of the degree of

Until now, the precautionary motives for holding reserves have been focused on the demand for reserves. However, the transaction motive may not be overlooked since the models[61] used to estimate the reserve demand function include the factor as an independent variable, reflecting the transaction motives (for example, the scale of an economy). The study on the transaction motive demand for reserves is usually related to the level of imports and to the level of reserve-imports. Based on the application of the quantity theory of money to international trade, the demand for reserves is expected to increase with the higher level of trade. This theory, however, has been criticized on the ground that since reserves are needed only for adjusting the gap between payments and receipts they should be connected with the variability of international payments rather than to the level of import itself. This argument stems from the different view on the purpose of reserve holdings, focusing more on trading. Despite this criticism, many researchers have used total imports or total incomes as a measurement of a country's size (i.e., as a measurement of transactional demand for international reserves).

Furthermore, the transaction motive can be granted as an important factor to hold foreign reserves especially in many non-oil-producing countries where lots of portions of their incomes are allotted to the imports of crude petroleum or raw materials. The degree of openness measured by MPI can be regarded as a transaction as well as a precautionary demand for reserves. That is, the higher degree of openness indicates that a country is more willing to trade with other countries, and thus will need more transaction stock of

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openness rather than a proxy for the cost of output adjustment, the demand for reserves is positively related to the MPI. This relationship reflects that the higher the degree of openness to the external economies, the more vulnerable they are to the external shocks, so that the country will need a larger level of reserves.

[61] For instance, see Edwards (1983,1984, 1985) and Frenkel (1978, 1980).

reserves. Also, this means that a country with higher degree of openness is vulnerable to the external disturbances, and it will need a higher buffer stock of reserves.[62]

From the evidence of recent currency crises,[63] the importance of foreign reserves as a source of liquidity is growing under the current high movement of international capital. This fact implies that a country should increase the buffer stock of reserves regardless of its exchange rate system and regardless of the exchange rate systems of its major trading partners, faced by highly volatile international capital and weakness in the financial sector.[64] Especially in Asian countries, the growth rates of reserves have been less than that of GDP. Thus, to prevent future crises, each country should maintain a proper level of *net* reserves,[65] otherwise future disasters may be at hand due to the abrupt capital outflows which limit access to the foreign credit (liquidity problem).

Following the above explanations of demand for reserves, in the next section, the demand for international reserves will be estimated based on a model which has two concepts: first, the transaction demand for reserves to finance international trades; second, the precautionary motive for reserve demand against the external disturbances.

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[62] In the next section, the degree of openness is considered as a transaction motive rather than a buffer stock, even if the sign of this variable is expected to be positive regardless of the motives.

[63] These crises include the 1992-93 ERM crises, the 1994 Mexican peso crisis, and the 1997 Asian currency crises.

[64] In theory, a country is expected to hold a lower level of reserves under a flexible exchange rate regime than in the pegged system because of less need of reserves to maintain exchange rate under fixed regime. Also, in theory, a country with a fixed exchange rate system is exposed to greater variability of import payments and export receipts when trading with a country that adopts a more flexible exchange rate regime.

[65] In fact, the level of net reserves has much more important meaning than that of nominal reserves because one of the main factors to generate the recent currency crises can be attributed to the sudden capital outflows.

4.3 Estimation of the Desired Demand for Reserves

Theoretically when a country is faced with a run-out of reserves, that country devalues its currency as one method of adjusting for the balance of payments. Edwards argues that "the level of international reserves that trigger a devaluation should be measured in relation to the desired level of reserves, and not with respect to some absolute arbitrary level" (1983; p13). Connecting this idea to the critical level of floor reserves that triggers a collapse of fixed exchange rate regime, we can make use of a partial adjustment model based on the optimizing approach. This method has an advantage in finding R_c in that estimating reserve demand function incorporates the major macroeconomic variables with the level of reserve itself, and thus the estimation results can show the behavior of reserves. This, in turn, indicates that actual reserves have fallen under the desired level prior to a crisis. In addition, the estimated residuals will give information as follows: the residuals are expected to be negative prior to a crisis, meaning that reserves have indeed fallen under their desired levels when they approach a crisis period.

4.3.1 Model

Most studies on the dynamic behavior of international reserves have focused on the partial adjustment model that postulates that a country adjusts its current stock of reserves in portion to the discrepancy between actual and desired reserves. The partial adjustment model can be written as follows:

$$R_t - R_{t-1} = \pi (R_t^* - R_{t-1}) \qquad (4.1)$$

where $R_t - R_{t-1}$ is a change in reserves between period t and t-1, R_t^* refers to the stocks of desired reserves at period t, and π denotes the speed of adjustment which lies between zero and unity. On the other hand, $R_t^* - R_{t-1}$ is the discrepancy between desired and actual reserves at the beginning of the period. Since the desired level of reserves is not directly observable, we need to assume that the long-run desired level of reserves is determined by several explanatory variables. Following Bilson and Frenkel (1979), the desired reserve function takes the following form:

$$R_t^* = \alpha_0 + \alpha_1 Y_t + \alpha_2 API_t + \alpha_3 \sigma_t + u_t \qquad (4.2)$$

where Y_t is the value of national income; API is the average propensity to import which is used for a proxy for the marginal propensity to import (MPI); σ_t denotes the variability measure; and u_t is an error term.[66]

In the above equation, the validation of the transaction demand for reserves is measured by the size and the statistical significance of the coefficients of Y_t and API_t (i.e., α_1 and α_2, respectively). On the other hand, the importance of the buffer stock of holding reserves stems from the statistical significance of the coefficients of σ_t, α_3. It is assumed that the desired demand for reserves is expected to have positive relations with a scale variable (Y or GDP), a variable measuring the degree of openness of the economy (API), and a variable measuring the variability of international payments (σ_t), respectively. Substituting equation (4.2) into equation (4.1), we obtain:

[66] Some authors do not include the stochastic error term in equation (4.2). Some authors, however, add the error term to the equation, believing that if the former (i.e., the equation (4.2) without u_t) is truly an equilibrium relation, there is no scope for the error term, whereas the adjustment mechanism can be imperfect and may require the stochastic disturbance term in equation (4.2).

$$R_t = \beta_0 + \beta_1 Y_t + \beta_2 API_t + \beta_3 \sigma_t + \beta_4 R_{t-1} + \varepsilon_t \qquad (4.3)$$

where $\beta_0 = \pi\alpha_0$, $\beta_1 = \pi\alpha_1$, $\beta_2 = \pi\alpha_2$, $\beta_3 = \pi\alpha_3$, $\beta_4 = (1-\pi)\,\alpha_4$, and $\varepsilon_t = \pi u_t$.

Hence,

$$\hat{\pi} = 1 - \hat{\beta}_4, \quad \alpha_0 = \frac{\beta_0}{(1-\hat{\beta}_4)}, \quad \hat{\alpha}_1 = \frac{\hat{\beta}_1}{(1-\hat{\beta}_4)}, \quad \hat{\alpha}_2 = \frac{\hat{\beta}_2}{(1-\hat{\beta}_4)}, \quad \hat{\alpha}_3 = \frac{\hat{\beta}_3}{(1-\hat{\beta}_4)}, \qquad (4.4)$$

$$and \; u_t = \frac{\varepsilon_t}{(1-\hat{\beta}_4)}$$

Whereas equation (4.2) represents the long-run or equilibrium demand for reserves, equation (4.3) denotes the short-run demand for reserves because in the short run the existing reserve stock may not necessarily be equal to its long-run level. Once we estimate the short-run demand function, equation (4.3), we can derive the long-run demand function by simply using the above formulas and omitting the lagged reserve (R_{t-1}), which will, then, give equation (4.2).

4.3.2 Data

The empirical analysis is carried out using monthly seasonally adjusted data between February 1990 and April 1998 using International Financial Statistics (IFS) on CD-ROM.[67] The data series for each variable are listed in table 4.1.

The variability of external payments (i.e., variable σ_t) has often been approximated by using a trend-adjusted measure of changes in the stock of reserves. For example, in

[67] Instead of using dummy variables, an exponential smoothing technique is employed to eliminate the seasonal variations in the reserve holdings.

Frenkel (1978) and Edwards (1983,1984,1985), to calculate σ_T^2, the following regression is first run:

$$R_t = \alpha + \beta_T t + u \qquad \text{over } t = T\text{-}n, \ldots, T$$

where R_t is the level of reserves for year t and n is number of years over which the regression is run. Then using the estimated trend, β_T, σ_T^2 is defined as the variance of the trend-adjusted changes in the stock of international reserves as following:

$$\sigma_T^2 = \sum_{t=T-n}^{T} (R_t - R_{t-1} - \hat{\beta}_t)^2 / n$$

The variability measure is defined as σ_T. Other studies have used the standard deviation of export receipts or the balance of payments as the measure of variability.[68]

Table 4.1: Data for Reserve Demand Estimation

Exchange Rate: Won per U.S. dollar, end of period rate. Line ae, *IFS*.
Reserves: Total Reserves minus Gold, end of period, in millions of US dollars. Line 1l.d, *IFS*.
Imports: In millions of U.S. dollar. Line 71, *IFS*.
Income: Gross Domestic Product (GDP), in billions of won. Line 99b, *IFS*.

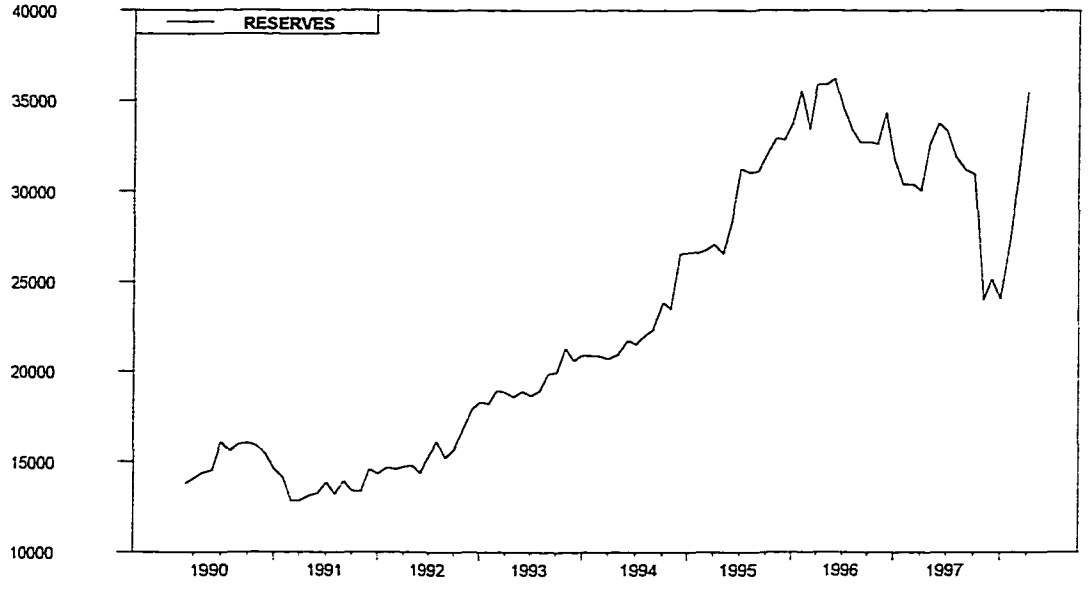
Note: GDP is converted to the U.S. dollar value using the above exchange rate.

Unlike previous studies,[69] the pure time series data are adopted to run regression for the reserve demand function in the next section. Many economic time series data do not have a constant mean and variance and they exhibit phases of relative tranquility

[68] See, for instance, Kenen and Yudin (1965) and Kelly (1970).
[69] Most previous studies have used cross-sectional data or pooled cross-sectional and time series data in regression of reserve demand function.

followed by periods of high volatility. Observing figure 4.1, these phenomena seem to be supportable. That is, there might exist evidence that the movement in the time-series of

Figure 4.1: Foreign Reserves (millions of U.S. dollar)



reserves is not stable, showing an upward trend which is interrupted by a decline, followed by a resumption of the positive growth and then sharply falling again. In fact, international reserve holdings by the bank of Korea during the sample period have been confirmed to be nonstationary time-series data, after performing several formal tests for nonstationarity.[70]

Under this background information, we model any tendency of variance in the reserve series by using an autoregressive conditional heteroscedastic (ARCH) or a

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[70] These include the tests using correlogram based on the autocorrelation and partial autocorrelation functions, Ljung-Box (LB) statistics, and Dickey-Fuller (DF) unit-root test. The result of the D-F test will be reported in a later section of this chapter.

generalized ARCH (GARCH) process in order to derive a variability variable which will be used as a proxy of that variable in the reserve demand function.

To describe the dynamic behavior of the reserve time series (i.e., to find a fitted *ARMA* process), the series must be stationary. Although the time-series data of reserves are not stationary, the first differenced values of the series are the stationary process with which the fitted model of reserve series can be found. Based on the Box-Jenkins methodology, the fitted model which describes the evolution of international reserves during the sample period is an autoregressive model, as shown in the following:

$$\Delta R_t = b_0 + b_1 \Delta R_{t-2} + b_2 \Delta R_{t-5} + \varepsilon_t \tag{4.5}$$

The next step is to find an appropriate ARCH (or GARCH) error process related to the above *AR* model. That is, estimating simultaneously the above model (equation (4.5)) and the various specifications of the error process, the following ARCH process is modeled as a proper description for the evolution of the variance in the time-series data of the first-differenced value of reserves.

$$h_t = a_0 + a_1 \varepsilon_{t-1}^2 \tag{4.6}$$

where h_t is the conditional variance of ε_t.

Finally, the series of variability which will be used as a proxy of the variability variable in the reserve demand equation is calculated by using the estimated coefficients of equation (4.5).[71]

$$\Delta R_t = \underset{(0.188)}{160.485} + \underset{(0.144)}{0.108\Delta R_{t-1}} + \underset{(0.000)}{0.302\Delta R_{t-2}} - \underset{(0.027)}{0.22\Delta R_{t-5}} + \varepsilon_t \tag{4.7}$$

$$h_t = \underset{(0.000)}{10057.68} + \underset{(0.029)}{0.748\varepsilon_{t-4}^2} \tag{4.8}$$

where the values in the parentheses indicates the significant levels (i.e., p-values).

4.3.3 Issues in Estimation

In order to estimate the reserve demand function, the method of ordinary least square (OLS) is performed. An OLS estimator is said to be the best linear unbiased estimator (BLUE), given the assumptions of the classical linear regression model (i.e., this is called *Guass-Markov Theorem*). However, when one or more of the assumptions does not hold, OLS does not provide BLUE estimators, though it still may give better estimates in some cases. In practice, two major types of problems arise in applying the classical linear regression model: (1) those due to assumptions about the specification of the model and about the disturbances; (2) those due to assumptions about the data. With respect to problems arising from the assumptions about the first category, two important issues are most often discussed; autocorrelation and hetroscedasticity. For the second

[71] This analysis has been performed using the RATS (4.20). The coefficients of equation (4.6), a_0 and a_1, have been obtained by guessing the initial values and then adopting an iterative technique using the maximum likelihood estimation.

type of problem, multicollinearity is most often referred to as one factor to destroy the BLUE property of OLS estimators.

If the regression residuals are serially correlated, the OLS estimators are no longer efficient, although they remain unbiased as well as consistent. In short, they are no longer BLUE. To detect the presence of autocorrelation in the estimation, the Durbin-Watson *d* statistic is most widely used. However, when an estimated model has one or more lagged dependent variables as regressors, the use of the Durbin *h* statistic is suggested to detect the autocorrelation.[72] When autocorrelation is detected in the original estimation, that problem can be remedied by the method of generalized difference equation (i.e., generalized least square or GLS). This method involves transforming the original data into the data set in which the error terms are independent.

The second problem in estimating OLS may come when the disturbances of the regression are not constant, called heteroscedastisity. Heteroscedastisity does not destroy the unbiasness and consistent properties of OLS estimators. But, these estimators are no longer minimum variance or efficient. That is, they are not BLUE. The presence of heteroscedastisity can be found by several formal methods. As noted above, the estimators in the presence of hetroscedastisity are no longer efficient and this lack of efficiency makes the usual hypothesis-testing procedure of dubious value. Therefore, remedial measures are clearly called for. Based on OLS residuals, one can guess at the likely pattern of heteroscedastisity and then transform the original data in such a way that

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[72] Durbin *h* statistic is $h = (1 - \frac{1}{2}d)\sqrt{\frac{n}{1 - n[\mathrm{var}(a)]}}$, where *n* is the number of sample size, and *var*(*a*) is the estimated variance of the coefficient of the lagged dependent variable. When the value of *n*[*var*(*a*)] exceeds unity, the Durbin *h* statistic cannot be used. In this case, the other technique such as the Breusch-Godfrey (BG) test may be used for testing autocorrelation.

in the transformed data there is no heteroscedastisity, which is called a method of weighted least square regression (or WLS).[73]

Another problem in estimating the classical linear regression model may stem from the existence of multicollinearity that refers to a situation where there is either an exact or approximately exact linear relationship among the independent variables. A moderate multicollinearity would cause no bias in the estimated coefficients, and it has little effect on the overall significance of the regression or on the estimates of any no-multicollinearity variables. In the presence of severe multicollinearity, however, coefficients will have a wrong sign or an implausible magnitude in spite of the facts that they are jointly highly significant and the R^2 in the regression is quite high.

One of the formal tests for the multicollinearity is the method of "Eigenvalues and Condition Index".[74] In general, the problem of multicollinearity can be reduced by (1) combining cross-sectional and time series data; (2) omitting a highly collinear variable; (3) transforming data; and (4) obtaining additional or new data. In short, if multicollinearity does not make the *t*-values change so much (i.e., multicollinearity makes the *t*-values unchanging in the significance), then regression using original data without solving multicollinearity problem may be the best way for the regression. That is, a remedy for multicollinearity needs to be considered when the presence of

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[73] White's (1980) heteroscedastic-consistent covariance matrix estimation can be applied to correct the estimates for an unknown form of heteroscedasicity. This procedure is useful if we are unsure of the precise nature or pattern of the heteroscedasticity. The formula for the covariance matrix is $var(\hat{\beta}) = n(X'X)^{-1} S_0 (X'X)^{-1}$, where $S_0 = \frac{1}{n}\Sigma e_i^2 X_i X_i'$. See White (1980), for more detail.

[74] The condition number of a matrix is the square root of the ratio of the largest to the smallest characteristic root, Condition Index (CI), where $CI = \sqrt{Maximumeigenvalue / Minimumeigenvalue}$.

multicollinearity makes the *t*-values change and makes the estimated coefficients (in)significant or unreliable.

Finally, the problem of the spurious regression can arise when one nonstationary time series is regressed on another nonstationary time series and if the two series are not cointegrated of the same order. In this case, the standard *t* and *F* testing procedures are not valid. However, in spite of being individually nonstationary, a linear combination of two or more time series can be stationary when the variables are cointegrated, in which case the traditional significant tests on the regression results can be applied because the regression is meaningful (i.e., not spurious). Engle-Granger, CRDW (Cointegrating Regression Durbin-Watson), and Johansen tests can be used to find out whether two or more time series are cointegrated.

4.3.4 Analysis of the Empirical Results

4.3.4.1 The Patterns of International Reserves along with Current and Capital Accounts

Due to the failure of managing the exchange rate as a means of adjusting the current account, Korea adopted a multi-currency basket peg system in February 1980. This system had advantages of maintaining the price competitiveness of goods and of stabilizing the exchange rate by pegging it to the SDR.

The Korean currency, the won, was sharply depreciated against the U.S. dollar between 1980 and 1986 by almost 40 percent.[75] However, the won was actually appreciated by 7 percent against the Japanese yen because the U.S. dollar appreciated

[75] During this period, however, the U.S. dollar also appreciated sharply against other major currencies.

over 30 percent against the yen between 1980 and 1984. The relationship between the rates of the won/dollar and the won/yen (or yen/dollar) implies that Korea was not put in a competitive position in exports over Japan during the mid 1980s, despite the sharp depreciation of the won against U.S. dollar.

In 1986, the won began to appreciate against the U.S. dollar,[76] whereas the yen/dollar rate and the Taiwan dollar/U.S. dollar rate declined 21 percent and 11 percent, respectively, in 1986. These trends lasted a few more years. Consequently, in spite of the appreciation of the won against the U.S. dollar, Korea was still able to keep a competitive position over its competitors such as Japan and Taiwan.[77] These movements of the currencies continued until 1987, and thus Korea was able to achieve high growth rates of exports to the U.S., despite the appreciation of the won. However, in the following year, the won was further appreciated by 13 percent under the pressure of the U.S. government which experienced the growing trade deficit during those 7 years. As a result, the growth rate of export began to decline in1988 and further in1989, which was enforced by the depreciation of the yen.

In the line of these currency movements, Korean economy faced a favorable environment within the world economy, which has been called the "three lows" or the "three blessings": low oil prices, low world interest rate, and low yen/dollar rate. The decrease in the oil price[78] in the late 1980s reduced the cost of energy imports. Since Korea does not produce even one drop of crude oil, payment for the imported crude oil

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[76] This appreciation against U.S. dollar was the first time in the history of the Korean exchange rate, and it lasted three more years until 1989.

[77] Since Korea has been highly dependent on imports from Japan, the growth rate of exports to the U.S. has been offset by the growth rate of imports from Japan. Therefore, under this specific trade relation with U.S. and Japan, the cross exchange rates among the three countries largely affect Korea's trade balance.

[78] The oil price dropped from $34.1 per barrel in 1981 to $13.9 per barrel in 1988.

has been a great burden on the country's economic growth. Thus, the fall in oil price led to a sharp decrease in the economic cost, lowering the price level. Under low oil prices, the price competitiveness of export products could be improved, leading to an increase in the national income. However, this affirmative effect was partially offset by the increase in the volume of imports with higher levels of income. According to Cho (1995), the current account surplus was affected mainly by the falling oil prices rather than the other two lows.

The second blessing, the low world interest rate, lowered the cost of external debt of the Korean government and banks. With low world interest rates, the government was able to achieve the budget balance, leading to an increase in the public consumption and investment expenditures. On the other hand, the Korean banks had easier access to the world credit market for investment purposes.

The last blessing, the strong yen, gave Korea an export stimulus and an increase in import price of capital goods from Japan. This mixed effect, nevertheless, resulted in the current account surpluses in the mid 1980s as noted earlier.

Along with the current account surpluses between 1986 and 1989, the domestic financial market has been progressively liberalized since 1984 when foreign direct investment (FDI) was partially freed. In 1984, direct portfolio investment (DPI) by foreigners was partially allowed, and investment in Korean stocks through investment funds was also allowed. The capital inflows into Korea, however, had moderately increased until the beginning of the 1990s when the Korean financial market was

Table 4.2 Current and Capital Accounts, Foreign Reserves, and Exchange Rate

Year	Current Account[1)]	Capital Account[1)]	Foreign Reserves[2)]	Exchange Rate[3)]
1980	-5.3	3.8	6.6	659.9
1981	-4.6	2.8	6.9	700.5
1982	-2.6	1.2	6.9	748.8
1983	-1.6	2.2	6.9	795.5
1984	-1.3	1.3	7.6	827.4
1985	-0.9	0.5	7.7	890.2
1986	4.6	-2.4	7.9	861.4
1987	9.8	-5.8	9.2	792.3
1988	14.1	-2.4	12.4	684.1
1989	5.0	-3.4	15.2	679.6
1990	-2.1	3.9	14.8	716.4
1991	-8.7	4.2	13.7	760.8
1992	-4.5	8.3	17.1	788.4
1993	0.3	6.9	20.3	808.1
1994	-4.5	9.2	25.7	788.7
1995	-8.8	13.5	32.7	774.7
1996	-23.7	17.2	34.0	844.2
1997	-8.2	-9.1	20.4	1695.0

Note: 1) Billion dollars.
2) Total Reserve minus Gold, billion dollars.
3) End of Period, won to U.S. dollars.
Source: Bank of Korea, *Monthly Bulletin*, various issues.

further liberalized. Therefore, during the period 1987-1989, the sharp increase in the stock of international reserves mainly stemmed from the current account surpluses rather than the capital inflows. At this time, the Korean monetary authority had implemented sterilization policy and repaid external debt in order to decrease the effect of the sharp increased liquidity on the domestic economy. The decline of international reserves during 1990-91 stemmed from this repayment of foreign debt caused by the four year consecutive surpluses in trade balance.

During the multi-currency basket system, there was a doubt that the exchange rate had not been considered properly in reflecting the supply and the demand for foreign exchange in the Korean exchange market. Furthermore, Korean monetary authority gave

an unfavorable impression to its major trading partners, especially to the United States, which had a suspicion of exchange rate manipulation by the Korean government so as to keep the favorable price competitive position against major trading partners. This suspicion may have stemmed from the fact that because of the consecutive current account surpluses, the won was not thought to be appreciated sufficiently against the U.S. dollar even though the surpluses were mainly thanks to the "three lows" at this period. Thus, Korea adopted the market-average exchange rate system in February 1990, which is one of the managed floating exchange rate systems. In this system, the exchange rate is determined by the supply and the demand for foreign exchanges in the domestic market. The advantages of this system are as follows: first, this system properly supports foreign transactions by promoting the price function of the exchange rate system; and second, the trade friction caused by the exchange rate policy is alleviated. This system differs from the "pegged to the multi-currency basket" in that exchange rate is determined by supply and demand for foreign exchange to some extent. This system is also different from the "pure floating rate" in that the monetary authorities can intervene in the foreign exchange market. The market-average exchange rate system was thought to be an outpost for transferring into the free floating exchange rate system.

At the beginning of the new exchange rate regime, the won began to depreciate against the U.S. dollar, which might have had negative effects on the trade balance until 1993 when the trade balance of Korea returned to a surplus again when a favorable movement in exchange rate returned (i.e., the advent of the strong yen).

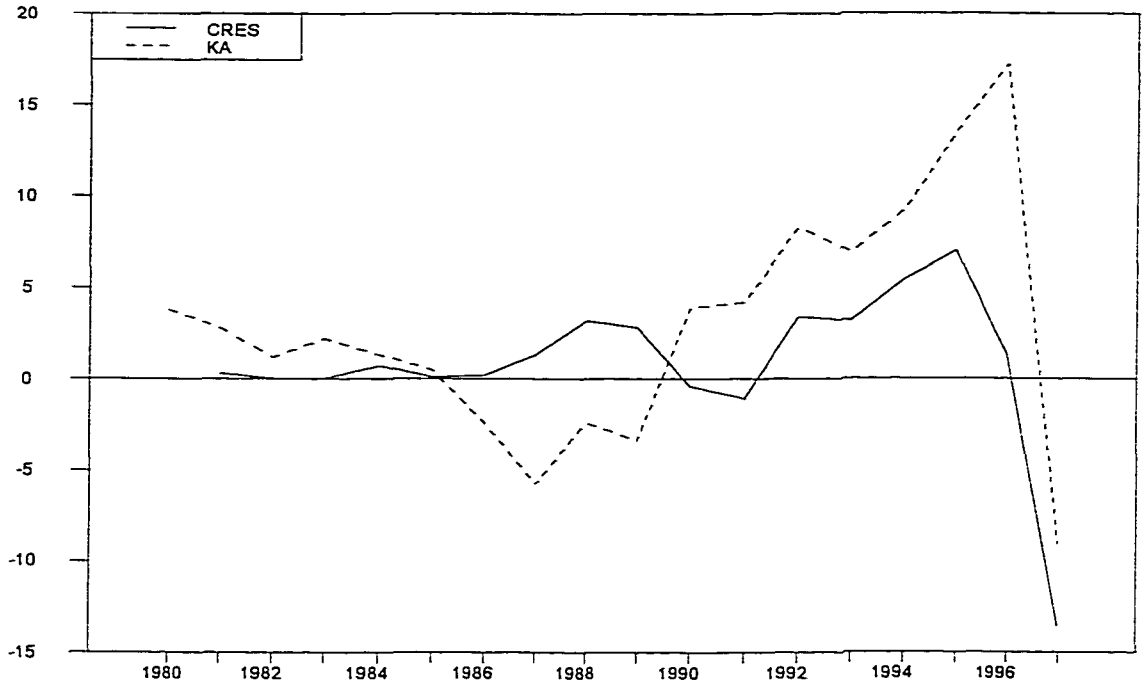
The persistent recession in most industrial countries in the early 1990s also alleviated Korea's export stimulus even with the continuing depreciation of the won. In

addition, the diminishing effect of the first two lows (i.e., low world interest rate and low oil price) among the "three lows" gave an unfavorable economic circumstance to the Korean export-oriented growth policy.

Even with trade deficits, foreign reserves continued to increase during the early 1990s due to the capital inflows.[79] During the period of 1994 and 1995, Korea achieved high economic growth as compared to the previous two years. This was due to the rapidly expanding exports thanks to the strong yen and increasing foreign demand. However, current account deficit marked $8.8 billion in 1995 because of a higher pace of imports than that of exports. On the other hand, as shown in figure 4.2, capital inflows soared continuously and were channeled to the international reserves, which have increased by about 120 percent in the last five years. In 1995, the capital account surplus increased to $13.5 billion from the previous year's surplus of $9.0 billion. These sharp capital inflows can be explained by external and internal factors. Key external factors are low interest rates that have prevailed in the U.S. and Japan during early 1990s. These low interest rates along with the persistent recessions in most developed countries have turned the attentions of investors to the high-investment yields and improving economic prospects of developing countries in Asia. An internal factor to attract capital inflows is the liberalization of the domestic financial market.

[79] For example, there was a capital inflow of almost $800 million during the first quarter of 1992 alone when the direct purchase of Korean stocks by foreigners was further allowed. In 1993, Korea had $9.6 billion in inflows and $0.7 in outflows for a balance of $8.9 billion long-term capital. Its short-term capital balance was $ 2.0 billion.

Figure 4.2: Capital Account (KA) and Change in Foreign Reserves (CRES); (billions of U.S. dollar)



The capital account surpluses sharply increased from $5.2 billion during the period of 1990-1993 to $17.4 billion during 1994-96. The main reason for the surpluses and large growth of the capital account was due to the fast increasing rate of the capital inflows under the liberalization of the domestic financial market. There was, however, more of a need of foreign credit to pay the foreign debt led by the increased current account deficits which have happened again since 1990.

In 1996, the Korean economic growth rate dropped to 7.1 percent from 8.9 percent in 1995. This fall in the economic growth was mainly due to sluggish exports and investments. The trade deficit and the current account deficit in 1996 marked a record high $15.3 and $23.7 billion, respectively, thanks to several factors. First, the sudden drop in unit export price and the sluggish growth in export volume were heavy blows to

Korea's export industries.[80] Second, the attainment of $10,000 per annual capita income brought with it an expending consumption trend. This, along with increased liberalization of imports, resulted in large-scale expansion and invited increased imports of luxury consumer goods. Although the growth in imports also decreased in 1996, the trade deficit showed a record high because of a drastic fall in exports. Third, the deficit in the trade balance was sharply expanded up to $15.3 billion.

On the other hand, the capital account balance increased by almost 25 percent in 1996 (from $13.4 billion to $17.2 billion). This increase was caused by a further opening of the Korean financial market,[81] an expectation of appreciation of the won/dollar rate by importers who tried to take advantage of large interest rate differential between domestic and foreign rates by taking out short-term foreign loans to finance their imports, and the investment by domestic firms with low world interest rates.

The won against the U.S. dollar depreciated by almost 9 percent during 1996 as compared to the previous year (1995). This weak won could be attributed to the deterioration in the balance of payment. That is, the enormous current account deficit was not offset by the capital account surplus because capital inflow during the second half of 1996 significantly decreased. The decrease was due to the unfavorable economic circumstance of the foreign investors such as the narrower gap in interest rates between the domestic and world financial markets, and it was also due to a decrease in the

[80] For instance, the prices of semiconductors (16MB DRAM chips), which consisted of 25 percent of Korea's total export combined with petrochemical products, sharply dropped from $45 in January to $8 in December due to the world-wide exceed of supply.

[81] The upper limit on aggregate stock holdings by foreigners was raised by 3 percent (from 15% to 18%) in April, which, in addition to the previous $3 billion, resulted in a capital inflow of $1.7 billion in April.

trade credits by Korean exports because of sharp depreciation of the won against the U.S. dollar.

Even though the capital inflow has risen by 25 percent more in 1996 than the previous year, the foreign reserve holdings by the bank of Korea decreased for the first time since 1990 due to the record high current account deficit. The holdings of international reserves by bank of Korea dropped by more than 10 percent from June to November in 1996.

During the first half of 1997, the Korean economy showed a GDP growth rate of 5.9 percent, which was a rate of less than 7.3 percent in the same period of the previous year. This was mainly caused by the slow down in domestic investment and consumption. However, as the growth rate of imports was reversed by that of exports, the current account deficit marked $11.1 billion during the first seven months, which was less than that of the same period in the previous year ($12.2 billion). The movement of the won/dollar rate showed a stable path at around 890 won since the second quarter, mainly due to the factors such as a decreasing current account deficit and increasing capital inflows. But, the won began to depreciate against the U.S. dollar because of the pessimistic future of the Korean economy by foreigners who had already observed the bankruptcies of large conglomerates (*chabol*) such as Hanbo, Sammi, Jinro, Dainong, and Kia motors (8^{th} largest conglomerate in Korea) and uprising concerns about contagion effect from the Southeast Asian crises. Consequently, the capital outflow rapidly increased by withdrawing foreign portfolio investments from the Korean stock market. In addition, with shrinking access to international credits in response to the sharp down-grading of Korea's long-term sovereign rating and of most commercial banks' credit

ratings by the foreign credit rating agencies such as Moody's and Standard & Poor's, the won was rapidly depreciated from the middle of October on through to the end of the year.

The value of the won precipitated in the end of November to 1,163 won per U.S. dollar, which value was a loss of 27.5 percent more than at the end of 1996. With the persistent current account deficit and the fall in reserve holdings by domestic money banks caused by the exhaustion of capital inflows, lots of companies and financial institutions had to rely entirely on the stock of foreign reserves held by the bank of Korea in order to avoid defaults on their foreign currency obligations. As the international reserve holdings of the bank of Korea sharply dropped in November, the bank of Korea stopped intervention in the foreign exchange market, and the Korean government requested the International Monetary Fund (IMF) for an emergency bail-out package on November 21 in order to avoid the national insolvency.[82] On December 3, 1997, Korea signed an agreement for IMF's financial aid package which amounted to $58.3 billion.

The won/dollar rate began to drop to around 1,500 won due to the substantial current account surplus, the resumption of capital inflows from foreign investments in the Korean stock market, and the success of the New York talks on rearranging the maturity of Korean financial sector debt.[83] Especially with the success of the New York talks for the roll-over of debt, the foreign reserves have begun to stabilize and to grow again. The

[82] The foreign reserves had run dangerously low, with its official reserve standing at $23.9 billion on December 2, down from $30.5 billion at the end of October. Of the $23.9 billion, $6 billion was "unusable funds".

[83] On January 28,1998, the Korean government and global creditors agreed to exchange about $24 billion of the Asian nation short-term debt for government-guaranteed loans. Under the deal, negotiated by 13 leading international banks, Korean banks can exchange their short-term non-trade credits for new loans with maturities of one, two, and three years. These loans will be guaranteed by the Korean government and will bear a floating interest rate of 2.25%, 2.5%, and 2.75% over the six-month London Interbank Offered Rate (LIBOR).

won against the U.S. dollar has moved between 1,500 and 1,600, and had been fluctuating around 1,700 after abolishing the daily floating limit on December 16, 1997 until end of January 1998.

4.3.4.2 Empirical Results on the Reserve Demand

Using the Dickey-Fuller(D-F) method, a unit-root test for stationarity is performed in this paper, and the results are presented in table 4.3. After showing that all time series are random walk processes and nonstationary, a cointegration test is proceeded using Engle-Granger (EG) procedure.

As shown in table 4.3, for the level variables, the Dickey-Fuller (D-F) test shows that all variables in the reserves demand function are unit-root processes and thus nonstationary time series since estimated *t*-values are smaller than the critical levels in absolute term. However, the first differences of the variables are stationary time series because we can reject the null hypothesis of unit root process based on the D-F test. These results are consistent in both models with and without time trend. Thus, all variables in the reserve demand equation are I(1).

On the other hand, table 4.4 presents the result of the Engle-Granger(E-G) cointegration test. The E-G test shows that the series of estimated residuals from the cointegrating regression of the reserve demand function is stationary because the *t*-statistics are larger than the critical levels as in table 4.4. This means that since the variables are cointegrated of order one (i.e., I(1)) and so the linear combination of the variables is stationary, we can use the estimated test statistics from the regression as in equation 4.3 in order to interpret the relations between the cointegrated variables.

Table 4.3: Summary of Unit Root Test

(No trend): $\Delta Z_t = \alpha_0 + \delta\, Z_{t-1} + \beta_i \sum_{i=1}^{p} \Delta Z_{t-i} + \varepsilon_t$

(Trend) : $\Delta Z_t = \alpha_0 + \alpha_1 t + \delta\, Z_{t-1} + \beta_i \sum_{i=1}^{p} \Delta Z_{t-i} + \varepsilon_t$

	Level			First Differences		
Variables* (Z_t)	Lag Length	Time Trend	t-statistics**	Lag Length	Time Trend	t-statistics***
Reserves	5		-0.4839	4		-5.1248
(R_t)	0	x	-2.1257	1	x	-4.3396
GDP	3		-0.4141	6		-6.2085
(Y_t)	2	x	-1.0187	6	x	-6.2926
MPI	0		-1.6251	0		-9.9120
(API)	0	x	-1.9655	0	x	-9.9206
VOL	2		-0.4924	1		-4.7291
(σ_t)	2	x	-1.5005	1	x	-4.9238
LAGRES	0		-0.9265	0		-14.0970
(R_{t-1})	0	x	-1.7974	0	x	-13.8410

Note: 1) The null hypothesis is H_0: $\delta = 0$ (i.e., unit root process) in both no trend and time trend models.
2)The critical values are –2.57(10%), -2.86(5%), and –3.43(1%) for no trend model, and –3.13(10%), -3.41(5%), and –3.96(1%) for trend model.
3) The variables come from equation (4.3): $R_t = \beta_0 + \beta_1 Y_t + \beta_2 API_t + \beta_3 \sigma_t + \beta_4 R_{t-1} + \varepsilon_t$
4) ** indicates insignificant at 10% level (i.e., unit-root process or nonstationary).
5) *** indicates significant at 1% level (i.e., no unit-root process or stationary).
6) Lag length is based on the lowest AIC (Akaike Information Criteria) values.

Table 4.4: Result of Engle-Grager Cointegration Test

Cointegrating Equation : $R_t = \beta_0 + \beta_1 GDP_t + \beta_2 MPC_t + \beta_3 VOL_t + \beta_4 R_{t-1} + u_t$

Residual Equation (i.e., Augmented *D-F* equation) : $\Delta\hat{u}_t = \alpha_1 \hat{u}_{t-1} + \alpha_i \sum_{i=2}^{p} \Delta\hat{u}_{t-i} + \varepsilon_t$

Variables	Time Trend	Lag Length	t-statistics	Critical Level
Residuals (u_t)		1	-4.6870*	-4.42**
	x	0	-8.7043*	-5.25***

Note: 1) The null hypothesis is H_0: no-cointegration (i.e., $\hat{u}_t$ series has a unit-root process).
2) * are significant at 1% level.
3) ** refers to a 5 % significant level.
4) *** refers to a 1 % significant level.
5) Lag length is determined by the minimum AIC value.

The estimated result of reserve demand equation is given in table 4.5. While there is no evidence of heteroscedasticity, moderate multicollinearity and serial correlation were detected in the OLS regression. Therefore, the serial correlation was corrected by using the Theil-Nagar modified *d* statistic, and these results are also presented in table 4.5.[84]

MPC, which was proxied by the variable of the average propensity to import (*API*), has a negative sign, contradicting the prediction of the price-adjustment model, consistent

[84] The interpretation will be based on the estimated values after correcting the serial correlation.

with the prediction of the standard Keynsian fixed price model. MPC insignificantly affects the level of reserve demand. GDP, used as a scaling variable for the size of economy, is highly significant and has expected positive sign.

Table 4.5 Estimation Result of the Reserve Demand Function

Constant	GDP	MPC	VOL	R_{t-1}	π
1.0865	0.0433	-9.8890	-0.0623	0.8865	0.1135
(0.4295)	(1.7661)	(-0.5787)	(-2.9363)	(0.0000)	
		Adjusted R^2: 0.9579		Durbin h statistic: 2.4412	
-2.5636	0.0775	-17.6150	0.0396	0.7786	0.2214
(-0.8235)	(2.6830)*	(-0.8434)	(1.9660)	(10.280)*	
		Adjusted R^2: 0.9619		Durbin h statistic: 1.8777	

Note: 1) Numbers in first row are coefficients of the variables before correcting serial correlation.
2) Numbers in parentheses in second row indicate t-ratios before correcting serial correlation.
3) Numbers in fourth row are coefficients of the variables after correcting serial correlation.
4) Numbers in parentheses in fifth row indicate t-ratios after correcting serial correlation.
5) There is no evidence of autocorrelation in the regression model based on the Durbin h statistic.
6) * : significant at 1 percent level, **: significant at 10 percent level.
7) π indicates the speed of adjustment.

The relatively high t-ratio indicates that there might be some economies of scale in the reserve holdings. As the scale of Korean economy grows, it conducts more international trade and so needs the larger volume of international reserves. This could be supported by the high economic growth along with the rapid growth in export and import during the sample period. The variability variable, *VOL*, has an expected positive sign, and it is significant at 10 percent level. This result indicates that one of the foreign reserve managements by the Korean government is to maintain the proper level of reserves, as recommended by IMF (i.e., the level of reserves equivalent to three months' imports),

considering the fluctuations in export receipts, for example, due to the sudden changes in the prices of raw materials and high fluctuations in the international markets. Based on the above results, the buffer stock motive of reserve holding is supported through the significance of variability variable (*VOL*), and the transaction motive is partially supported through the significance of *GDP* variable.

The speed of adjustment of actual to desired reserves is about 0.22 during the sample period. This indicates that, given the level of exchange rate flexibility, monetary authorities are willing to allow (or to be corrected) 22 percent of a disequilibrium in one period which is created by one unit shock in desired level of international reserves.

To find the desired reserve equation, we first need to write the short-run reserve function by using the estimated result:

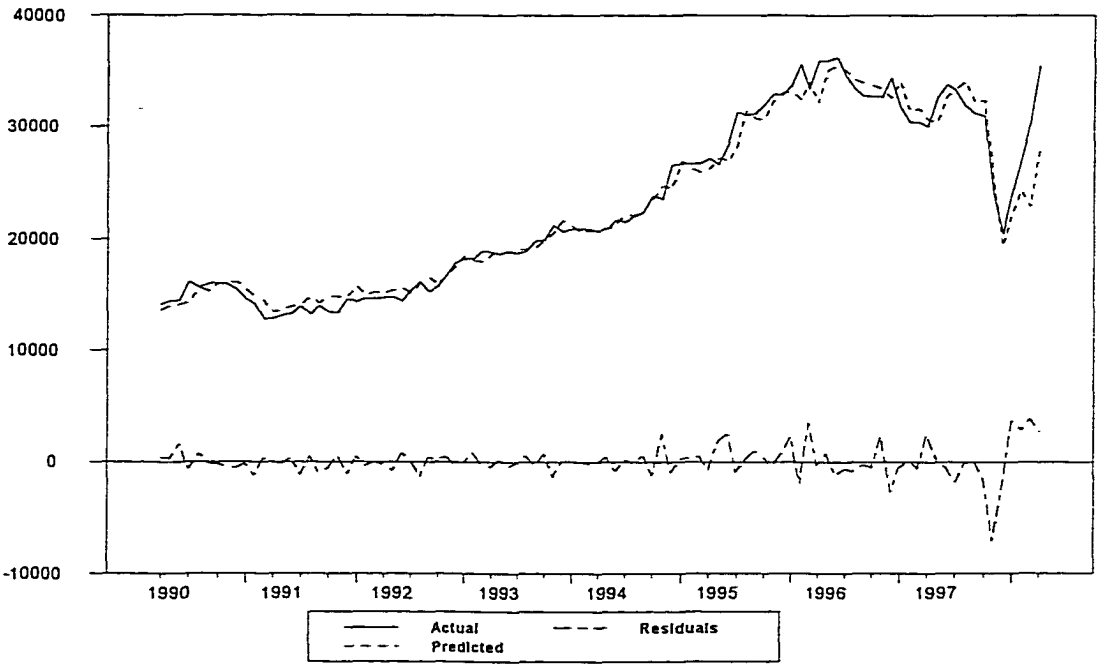
$$R_t = -2.5636 + 0.0775GDP - 17.6150MPC + 0.0396VOL + 0.7786R_{t-1} \qquad (4.9)$$

Then, applying equation (4.4), the long-run coefficients of the demand for reserves for Korea can be calculated. And the predicted long-run level of reserve equation is generated using:

$$R^* = -11.5790 + 0.35GDP - 79.5618MPC + 0.1788VOL \qquad (4.10)$$

Though the reserves bottomed out around $14 billion in 1990 during the entire sample period, this does not provide useful information about reserve floor since the currency crisis occurred in 1997. Furthermore, because the reserve movements generally show an

Figure 4.3: Actual and Long-Run Predicted Reserves with Estimated Residuals
(Millions of U.S. dollar)



upward trend during the sample period, it may be reasonable to find the reserve floor around the crisis period when plotted by observation. The reserve floor for Korea is slightly higher than $20 billion.[85] Since the level of actual reserve is close to the level predicted by the long-run reserve demand function (i.e., the sharp drop was forecasted by the demand for reserves framework), the framework of demand for reserves provides relatively useful information about the level of the reserve floor.

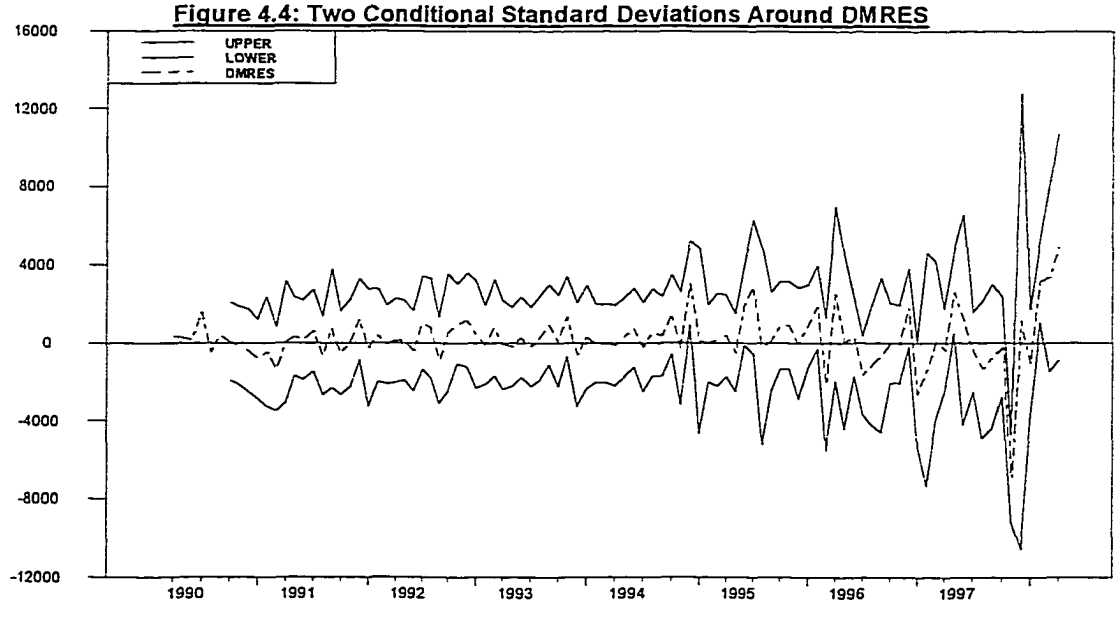
The residual structure from the estimated regression shows large negative shocks to the reserves around the end of 1997, which could explain the fact that there were large

[85] Observing the calculated values using the estimated equation, the predicted level of reserve is $20.1 billion in December 1997, whereas actual value is $20.4 billion.

capital outflows. Thus, the residual structure of reserve equation also gives useful information on the reserve floor or the timing of the crisis.

Incidentally, as an alternative way to analyze the movement of reserves to the shocks, we can observe in figure 4.4 the conditional standard deviations around the first differences of reserves which have been used as a variability variable for the reserve demand function. This figure contains DMRES series (i.e., first-differenced reserves) and the upper and lower band each equal to two conditional standard deviations (i.e., the square root of the conditional variance) from DMRES. We can observe that as DMRES becomes more volatile, the width of the bands also increases. Especially in the fourth quarter of 1997, the DMRES becomes highly volatile. At that time, the width of the bands expands dramatically. That is, as the values of the previous shocks (e.g., *continuous* capital outflows) increase, the current variance of DMRES as well as the current DMRES itself fluctuate further.

Figure 4.4: Two Conditional Standard Deviations Around DMRES



Note: DRES refers to a series of the first-differenced reserves (i.e., $R_t - R_{t-1}$).

CHAPTER 5

Empirical Test: Application to the Korean Experience

5.1 Introduction

The theoretical model solved in chapter three is applied to the empirical model for the recent economic experience of Korea. This application of the crisis model provides a series of collapse probabilities and shadow exchange rates, which are based on the one-period-ahead procedure. Especially, the probability of collapse will be estimated under the assumptions made in the theoretical section such as a model with full sterilization and a time-varying stochastic risk premium as well as under the assumption of a range of the reserve floor which is derived from chapter four.[86]

In addition to a stochastic risk premium, since three shocks appear both in the theoretical and empirical models, the system can be regarded as an uncertainty version of speculative attack, which is a departure from the first generation of speculative attack models.[87]

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[86] The other assumptions made in chapter 3 hold for the empirical model. They are deviation from PPP, two shocks associated with domestic credit creation and external credit shock, and the negative movement between money demand and the ratio of non-performing loans.

[87] With a time-varying stochastic risk premium, the model contains a nonlinearity in private behavior about the exchange rate. This nonlinearity can be another source of currency crisis, and consequently make a crisis to be a self-fulfilling one through the relationship between domestic interest rate and money demand because this connection from the nonlinearity can change the timing of attack even with any range of fundamentals. That is, the empirical application to the Korean crisis is tested only under the assumptions emphasized in the first generation models, such as worsening economic fundamentals with inconsistent economic policies, and fully sterilized operations at the attack time. Since a crisis can still arise from the inconsistent policies even with a stochastic model (i.e., a case of uncertainty in attacks), I don't focus on the multiple equilibria arising from the nonlinearity in private or government behavior which are emphasized by the second generation models of currency crisis. The fact that a crisis can still arise from the inconsistent policies even with a stochastic model (i.e., a case of uncertainty in attacks) does not mean that the model is necessarily a second-generation crisis model, but indicate that a modification of first generation attack models may have a property of second generation models such as multiple equilibria as argued in Flood and Marion (1998).

The remainder of this chapter is organized as follows. Section two specifies the empirical models and the variables, and provides a description of how to apply the models using a pre-obtained data set. Section three discusses the data and presents the estimation results. Section four concludes.

5.2 Econometric Models and Data Description

The following equations, which are originated form the theoretical models developed in chapter three, are employed to calculate shadow exchange rates and the probability of collapse of exchange rate regime by using econometric and a several-stage technique with a pre-obtained data set.

$$D_t - D_{t-1} = \mu_t + \varepsilon_t \tag{5.1}$$

$$\varepsilon_t = \gamma_t - \phi_t \tag{5.2}$$

where $\gamma_t = -\frac{1}{\lambda_{1t}} + v_{1t}$ with pdf $f_{v_1} = \begin{cases} \lambda_1 \exp(-\lambda_1 v_{1t}), & if\ v_{1t} \geq 0 \\ 0, & if\ v_{1t} < 0 \end{cases}$

and $\phi_t = -\frac{1}{\lambda_2} + v_{2t}$ with pdf $f_{v_2} = \begin{cases} \lambda_2 \exp(-\lambda_2 v_{2t}), & if\ v_{2t} \geq 0 \\ 0, & if\ v_{2t} < 0 \end{cases}$

$$\frac{p_t}{s_t} = p_t^* + \rho_t + \Omega_t \tag{5.3}$$

where $\Omega_t = -\frac{1}{w} + \omega_t$ with pdf $f_\omega = \begin{cases} w \cdot \exp(-w \cdot \omega_t), & if\ \omega_t \geq 0 \\ 0, & if\ \omega_t < 0 \end{cases}$

$$\frac{M_t}{Q_t} = a_0 - a_1 i_t + a_2 y_t - a_3 \left\{ (1-\pi_t) \left(\frac{\bar{s}^a_{t+1} - \bar{s}_t}{\bar{s}_t} \right) + \pi_t \left(\frac{{}_t\tilde{s}_{t+1} - \bar{s}_t}{\bar{s}_t} \right) \right\} - a_4 N_t \qquad (5.4)$$

(5.5)

$${}_t\tilde{S}_{t+1} = \frac{1}{a_t \left\langle p_t^* + \alpha_t(\rho_t + \Omega_t) \right\rangle} \left\{ \frac{a_t + a_1 + a_3)}{a_t} \mu_t - \frac{a_1 \theta (B_0 - B_t) \cdot (p_t^* + \alpha_t(\rho_t + \Omega_t))}{p_t^* \varpi} \right.$$

$$\left. + D_{t-1} + R_c + \gamma_t - \phi_t \right\}$$

where $a_t = a_0 - a_1 i_t^* + a_2 y_t - a_4 N_t + \dfrac{a_1 \theta \{B_0^* + (R_0 - R_c)/\bar{s}_t\}}{p_t^* \varpi}$

$${}_t\pi_{t+1} = \frac{w \lambda_2}{\left\langle \left\langle \bar{s} a_t \alpha_t - a_1 \alpha_t \theta (B_0 - B_t)/p_t^* \varpi \right\rangle \lambda_1 + w \right\rangle \{\lambda_1 + \lambda_2\}} \cdot e^{\lambda_1 k_t} \qquad (5.6)$$

where $k_t = \left\{ \dfrac{(a_t + a_1 + a_3)\mu_t}{a_t} + D_{t-1} + R_c - \dfrac{1}{\lambda_1} + \dfrac{1}{\lambda_2} \right.$

$$\left. - \left\langle \bar{s} a_t - a_1 \theta \left(\frac{B_0 - B_t}{p_t^* \varpi} \right) \right\rangle \left\langle p_t^* + \alpha_t \rho_t - \frac{\alpha_t}{w} \right\rangle \right\}$$

with

D_{t-1} : Lagged domestic credit.

μ_t : Trend ratio of domestic credit creation.

γ_t : First source of variability in μ_t.

ϕ_t : Second source of variability in μ_t.

$1/\lambda_1$: Standard deviation of error series γ_t.

$1/\lambda_2$: Standard deviation of error series ϕ_t.

c.f.) $1/\lambda_1$ and $1/\lambda_2$ series are computed in each period based on the regenerated error series ε_t using an one-step-ahead forecast technique.

P_t : Price index of domestically produced goods.

Q_t : Domestic aggregate price index.

α_t : Share of domestic goods in the price index Q_t.

$\bar{s}_t$: Exchange rate (won / US $).

ρ_t : Systematic deviation from purchasing power parity (PPP).

Ω_t : Nonsystematic deviation from PPP.

$1/w$: Standard deviation of error series Ω_t.

y_t : Output (Gross Domestic Product).

M_t : Money supply

θ : Speed of adjustment in asset markets or degree of asset substitutability.

B_t : Stock of domestic bonds denominated by domestic currency held by private sector (B_0 is the value of B_t in the base year of the sample period).

B_t^* : Stock of foreign bonds denominated by domestic currency held by private sector.

p_t^* : Foreign price index.

N_t : Ratio of non-performing loans to total loans in the domestic banking system.

ϖ : Worldwide liquid real wealth (regarded as a constant).

i_t^* : Foreign interest rate.

R_c : Floor level of foreign reserves.

R_0 : Level of foreign reserves held by the bank of Korea in the base year.

${}_t\tilde{S}_{t+1}$: One-step-ahead forecasts of shadow exchange rate.

${}_t\pi_{t+1}$: One-step-ahead forecasts of collapse probability.

$\bar{S}_{t+1}^a - \bar{S}_t$: Pre-announced change in the exchange rate.

5.2.1. Description of Equations

Application of the above models for the estimation of the money demand equation, the shadow exchange rate, and the probability of collapse requires forecast of each variable described in the previous section. The first step of this procedure is to apply the Box-Jenkins (BJ) methodology to choose an appropriate *ARIMA* process of each variable during the entire sample period. Once an *ARIMA* model is determined, that process is fit over each rolling sample of 20 months of data prior to and inclusive of period t, which sample is contained in the entire interval of sample.[88]

This procedure provides a final data set with which the money demand equation, the shadow exchange rate, and the devaluation probability can be estimated and calculated.

Equation (5.1) ~ (5.2)

The forecast of the expected trend in domestic credit, ${}_t\mu_{t+1}$[89], is calculated using a set of 20 months of rolling data. The domestic credit shock (or variability in the policy of credit creation), ε_t, is defined as forecast errors of μ_t (i.e., residuals of each estimation): ${}_t\mu_{t+1} = D_t - D_{t-1} + \varepsilon_t$.

The estimated credit shock is decomposed into two components. First, γ_t defines the source of variability in the policies of domestic monetary and fiscal authorities. Second, ϕ_t, in the errors of trend rate, reflects the variability in the external creditors. The relationship between these two shocks is orthogonal to each other as shown in equation

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[88] This method is a backward-looking forecasting procedure. The selected *ARIMA* processes are listed in the Appendix.

[89] In equations (5.1) ~ (5.6), since all the values of the variables are recalculated by using 20 months of rolling samples for the estimations of ${}_t\widetilde{S}_{t+1}$ and ${}_t\pi_{t+1}$, the t subscripts should be replaced by $t+1$ as in ${}_t\mu_{t+1}$ instead of μ_t. However, for simplicity of the expression, t subscripts will be used.

(5.2). Once the domestic credit shock, ε_t, is obtained, the shock of foreign creditors can be calculated by regressing external capital flows (FA) against the domestic credit residuals, such that $\varepsilon_t = - \beta FA_t$. The residuals from this regression imply *indirectly* induced shock by domestic authorities, which links the domestic credit shock to the flows of foreign capital. By the property of orthogonality, the net domestic credit shock is computed by $\gamma_t = \varepsilon_t - \phi_t$, which can be regarded as *directly* induced shock by domestic monetary or fiscal authorities.[90]

Finally, the standard deviations of the above estimated random components (γ_t and ϕ_t) are corresponding to the $1/\lambda_1$ and $1/\lambda_2$ as expected size of future disturbances,[91] where $\gamma_t \sim exp(0, 1/\lambda_1^2)$ for each t and $\phi_t \sim exp(0, 1/\lambda_2^2)$ for each t.

Equation (5.3)

This equation generates forecasted values of the systematic and random deviations from the purchasing power parity. Equation (5.3) needs to be rewritten as $p_t / s_t - p_t^* = {}_{t-1}\rho_t + \Omega_t$, where the subscript t-1 indicates the forecast of ρ_t using the one-period-ahead procedures, in order to reflect the expected patterns of long-run departure from PPP. As in equation (5.2), the standard deviations of the above estimated residuals

[90] Since these shocks are generated using the data which is created by one-step-ahead forecast of expected changes in those variables, the implicit expressions of these shocks are also ${}_t\varepsilon_{t+1}$, ${}_t\phi_{t+1}$, and ${}_t\gamma_{t+1}$, respectively.

[91] As argued in Goldberg (1994), if capital inflows are positively correlated with domestic credit creation, which is extremely probable in the real economy, the domestic monetary shock is biased downward and external credit shock is biased upward. Thus, this positive relation may generate biased estimation in calculating π_t. If the estimated π_t show a stable path when the foreign capital shock is not included, we may argue that the Korean exchange rate crisis was little affected by the external credit shock. The estimation results show that the estimated probabilities of collapse might not have been strongly affected by the change in $1/\lambda_2$ based on the counterfactual simulation results in the later section of this chapter. Thus, the degree of bias dose not seem to be large.

series serve as a predicted relative price shock (or short-run deviation from PPP) which is assumed to be exponentially distributed such that $\Omega_t \sim \exp(0, 1/w^2)$. P_t in equation is a domestic goods price index, which is calculated using the method described in the next section.

Equation (5.4) ~ (5.6)

These three equations are estimated using an iterative procedure until the parameters of money demand equation converge. In the first pass through the data, the time-varying risk premium is assumed to be zero,[92] and thus the expected change in the exchange rate is computed by the difference in the interest rates as follows:

$$i_t - i_t^* = \frac{Es_{t+1} - s_t}{s_t}$$

which is derived from the relationship

$$i_t = i_t^* + \left\{(1-\pi_t)\left(\frac{\tilde{s}_{t+1}^a - s_t}{s_t}\right) + \pi_t\left(\frac{\tilde{s}_{t+1} - s_t}{s_t}\right)\right\}$$

Then, the money balance equation becomes

[92] This is done by setting $\theta = 0$. The assumption of zero risk premium may cause bias in estimating the system of equations. That is, the derived shadow exchange rates and the collapse probabilities under this assumption would be biased downward (upward) if the risk premium in the initial pass is positive (negative). To some extent in which the capital inflows with high risk premium help the accumulation of foreign reserves and delay the speculative attacks, the collapse probability would be biased.

$$\frac{M_t}{Q_t} = a_0 - a_1 i_t + a_2 y_t - a_3 \left\{ (1-\pi_t) \left(\frac{\bar{s}^a_{t+1} - s_t}{s_t} \right) + \pi_t \left(\frac{\tilde{s}_{t+1} - s_t}{s_t} \right) \right\} - a_4 N_t$$

where $\bar{s}^a_{t+1}$ indicates nonzero announced changes in the exchange rate[93] and ${}_t\tilde{s}_{t+1}$ is the expected value of the shadow exchange rate. Since we don't know the first passes of π_t and ${}_t\tilde{s}_{t+1}$, the following equation is estimated instead of the above equation.

$$\frac{M_t}{Q_t} = a_0 - a_1 IRIV_t + a_2 y_t - a_3 (i_t - i_t^*) - a_4 N_t$$

where *IRIV* is an instrument variable for i_t to avoid possible simultaneity problem.[94]

OLS regression on the money demand equation gives the first estimates of a_0, a_1, a_2, a_3, and a_4, which are used to calculate the first pass of ${}_t\tilde{s}_{t+1}$ and ${}_t\pi_{t+1}$ series. The first pass of risk premium is computed by using the first passes of ${}_t\tilde{s}_{t+1}$ and ${}_t\pi_{t+1}$ series and by obtaining the value of θ (the θ is estimated by regressing the following equation).

$$i_t - i_t^* - \left\{ (1-\pi_t) \left(\frac{\bar{s}^a_{t+1} - s_t}{s_t} \right) + \pi_t \left(\frac{\tilde{s}_{t+1} - s_t}{s_t} \right) \right\} = \frac{\theta (B - B_t^*)}{sp^* \varpi}$$

Then the money demand equation is replaced by the following form.

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[93] For the values of $\bar{s}^a_{t+1}$, the upper limit band (to which the exchange rate is allowed to float) are used.

[94] The instrumental variable for i_t consists of the first, second ,and third lags of the interest rate.

$$\frac{M_t}{Q_t} = a_0 - a_1 IRIV + a_2 y_t - a_3 \left\{ (1-\pi_t)\left(\frac{\tilde{s}^a_{t+1} - s_t}{s_t}\right) + \pi_t \left(\frac{\tilde{s}_{t+1} - s_t}{s_t}\right) + \frac{\theta(B_0 - B_t)}{sp_t^* \varpi} \right\} - a_4 N_t \tag{5.7}$$

Once, we have second estimates for a_0, a_1, a_2, a_3, and a_4 from the above regression, these estimated parameters are inserted to the formulas such as equations (5.5) and (5.6), which generate the second pass of ${}_t\tilde{s}_{t+1}$ and ${}_t\pi_{t+1}$ series. Using these second-passes, the second pass of risk premium is estimated. With all these second passes of ${}_t\tilde{s}_{t+1}$, ${}_t\pi_{t+1}$, and risk premium, the money balance equation is reestimated for updating the values of a_0, a_1, a_2, a_3, and a_4. This iterative procedure continues until the parameters converge on their true values.[95]

5.3 Estimation

Since the theoretical model developed in chapter 3 is based on the worsening economic fundamentals, it is necessary to describe the evolutions of these fundamentals in order to select a proper sample period for the empirical analysis. Although there could be a number of economic factors which might have caused the Korean currency or debt crisis in 1997, we briefly examine only several factors that may be considered as main sources associated with poor macroeconomic fundamentals.

The current account imbalance started to increase again since 1994, reaching peak in 1996 about 5 percent of GDP. This current account imbalance was mainly the result of

[95] θ can be considered as a constant since its final value is determined along with the convergent parameters in the money demand equation in the final iteration.

a huge trade deficit, as observed in table 5.1. Although the current account deficit in 1996 could not be considered as so high as to directly cause the debt crisis, this imbalance may provide some evidence that it might have been related to currency overvaluation (i.e., meaning the loss of an external competitiveness which resulted in the accumulation of foreign debts). Even if the won against the U.S. dollar had been depreciated about 10 percent (from 774 won/$ in 1995 to 844 won/$ in 1996), since the dollar began to be rapidly appreciated against other major currencies,[96] the won, in fact, experienced more appreciation against the U.S. dollar than the Japanese yen.[97] This might have led to a worse position in the external competitiveness.

Table 5.1 Debt Structure in Korea

	1993	1994	1995	1996	1997
GDP Growth	5.8	8.6	8.9	7.1	5.0
Ratio of Current Account to GDP	0.31	-1.01	-1.81	-4.80	-3.30
Ratio of Trade Balance to GDP	0.20	-1.01	-1.40	-4.26	--
Ratio of Foreign Liabilities to GDP*	13.6	16	18.2	22.4	41.8
Ratio of Foreign Liabilities to Foreign Asset*	297	297	332	363	320
Ratio of Short-term Liabilities to Total Liabilities*	--	72	70	68	68**
Ratio of Short-term Liabilities to Foreign Reserves*	141	154	170	213	300**

Note: 1) All numbers indicate percentage.
2) * refers to the ratio *toward BIS Reporting Banks*.
3) ** are the values as of the mid 1997.
Source: 1) Bank of International Settlements (BIS).
2) Bank of Korea, *Monthly Bulletin*, various issues.

[96] The yen/U.S. $ rate went from 80 in the spring of 1995 to 125 in the 3rd quarter of 1997, which is the equivalent of 56 percent depreciation of the yen.
[97] As noted earlier, though Korea adopted a market-average exchange rate system, one of managed floats, the system was set up to give much weight on the U.S. dollar in calculating the daily exchange rate.

The GDP growth rate as in table 5.1 was still very high in 1996 about 7.1 percent, in spite of a slowdown from 8.9 percent in 1995. The large current account deficit in 1996 could have been more sustainable with a high rate of economic growth. However, unlike the previous currency crises of Chile and Mexico during the late 1970s and the early 1980s, the recent Asian crises show an inconsistent feature against the traditional view of unsustainability of the current account deficit and its concern with low economic growth. That is, the economic growth rate of most Asian countries that experienced a currency crisis in 1997 were very high compared to the rest of the world. As argued in Corsetti, *et al.* (1998), one possible factor to explain this paradoxical result (i.e., high economic growth before a crisis) is the overly optimistic expectations by domestic residents and foreign investors about the future domestic economy, which may lead to a consumption and an investment boom with huge capital inflows. Under this economic environment, a currency or debt crisis may occur when the optimistic expectation changes to a skeptical one about the future economy by any internal or exogenous shock, and thus results in large reversal of capital flows. Based on this view, the high economic growth preceding the periods of crisis may not be a sufficient condition to prevent the currency crisis.

Even though Korea does not appear to have been rationed until the 3rd quarter of 1997, the onset of the crisis period in the external markets, it could be said that there might have been the potential of credit-rationing because the percentage change of the share of world investments made in Korea sharply dropped in the third quarter of 1996. This rate dropped from 8.84 percent in the second quarter of 1996 to 1.62 percent and the rate generally tended to decrease until the crisis period. Furthermore, the average percent

change between the 3rd quarter of 1996 and the same quarter of 1997 is 2.8 percent,[98] which is a rate much less than that of the previous seven quarters (i.e., during 1994:QIV ~ 1996:QI), 6.2 percent. Coincidentally, the foreign reserves held by the bank of Korea began to decline at this time (i.e., the middle of 1996), though its drop was mainly from the large current account deficit.

Liabilities towards BIS banks as a percent of GDP also show an upward trend, especially in 1996 where the percentage change of the ratio is over 20 percent. Table 5.1 also presents the ratio of foreign liabilities to foreign assets toward BIS reporting banks. This ratio was 297 percent in 1993 and rose up to 360 percent in 1996. In the table, short-term liabilities towards BIS banks as a percent of total liabilities and as percent of foreign reserves tend to increase during the 1990s. Especially, the latter ratio peaked in 1996 to about 213 percent. This fact implies that the levels of foreign reserves held by the bank of Korea were not enough to cope with the liquidity crisis in case of a complete unwillingness by BIS banks to roll over short-term loans, as materialized in December 1997 in Korea as well as in Southeast Asian countries in the same year.[99]

We can discuss the low profitability of the domestic firms and the increasing rate of non-performing loans of domestic financial institutions in terms of reflecting the worsening situation of the banking system. When the loans from Korean banks to domestic firms became non-performing due to poor investment or bad management by banks or firms, the domestic banks that borrowed from foreign banks were confronted

[98] If the 4th quarter of 1997 (crisis period) is included, the rate of percentage change drops sharply to 0.44 percent.

[99] The crises had occurred even before the need to service principal on the long-term debt and interest on all debts.

with large short-term foreign currency debt, and this mechanism could be one of the major factors to illustrate the recent debt crises in Asia.

Based on the above information about the evolution of the Korean economy, the crisis model could be appropriately applied during the second half of 1996 and the end of the sample, the first half of 1998, in computing the probability of collapse of the exchange rate regime. However, we may compare before/after periods of worsening fundamentals by including the period before the middle of 1996. Therefore, we employ monthly data from January 1995 to June 1998 as a sample for empirical work.

5.3.1 Description of Data

Table 5.2: Description of Data

D_t : Domestic credit, in billions of won. *IFS* line 32.
R_t : Foreign reserves, in billions of won. *IFS* line 11.
M_t : Money supply, $D_t + R_t$
Q_t : Consumer price index, *IFS* line 64.
S_t : Exchange rate, end of period, won per U.S. dollar, *IFS* line ae.
y_t : Gross Domestic Product, in billions of won, *IFS* line 99b, Converted from quarterly data to monthly series.
i_t : Interest rate, Monthly market rate, *IFS* line 60b.
i_t^* : London Interbank Offer Rates (LIBOR) on one month U.S. dollar deposit, *IFS*.
p_t^* : Foreign price index (U.S. consumer Price Index). *IFS* line 64.
p_t : Price Index of domestically produced goods. Derivation in text, Base 1990 = 100.
IMP_t : Imports, in billions of won. *IFS* line 71..d.
EXP_t : Exports, in billions of won, *IFS* line 70..d.
$p_t^* s_t$: Imported goods price index, Base 1990 = 100, *IFS* line 76.x
R_c : Set by $20 billion, estimated in chapter 4.
N_t : Ratio of non-performing loans to total loans , proxied by dishonored bills. Bank of Korea, *Monthly Statistical Bulletin* (Various issues).
FA_t : Capital balance (Long term + short term), Bank of Korea, *Monthly Statistical Bulletin* (Various issues).
ϖ : World liquid real wealth. *BIS*, averaged from Jan. 1995 ~ Jun. 1998 and converted to trillions of won.
B_t : Stock of domestic bonds held by Bank of Korea, Bank of Korea, *Monthly Statistical Bulletin* (Various issues).
B_t^* : Stock of foreign bonds held by Bank of Korea, Bank of Korea, *Monthly Statistical Bulletin* (Various issues).

To derive the nontraded goods price index (p_t), the share of traded goods (α) in the consumer price index must first be calculated as follows:

$$\alpha = 1 - \frac{\mathrm{Im}\, p_t + Exp_t}{GDP_t}$$

Then, the price index of domestically produced goods, p_t, is derived as

$$p_t = \frac{\left\langle Q_t - (1-\alpha) \cdot p_t^* s_t \right\rangle}{\alpha}$$

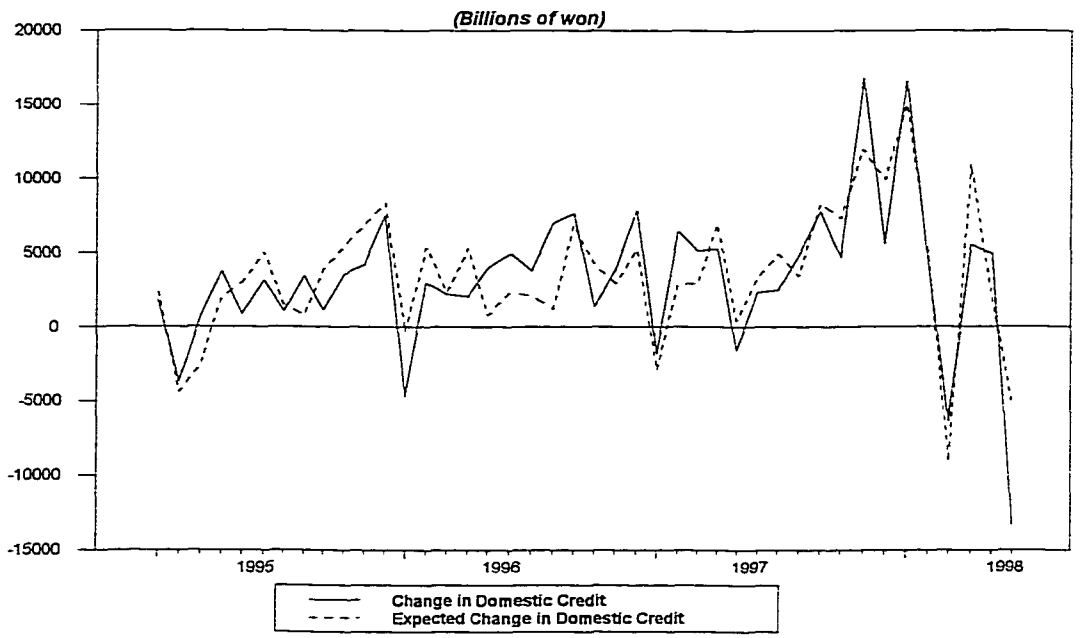
On the other hand, due to the availability of obtaining data for N_t (the ratio of non-performing loans), this variable is proxied by the dishonored bills. Since the replaced variable is directly related to the ratio of non-performing loans, the ratio of dishonored bills may be considered as a reasonable proxy.

5.3.2 Patterns in Domestic Credit and Prices

As shown in figure in 5.1, the path of domestic credit expansion, μ_t, shows stable movement around its mean value before the middle of 1997. During the second half of 1997, domestic credit sharply increased, reflecting the balance of domestic and foreign reserves in the monetary base. That is, as shown in figure 3.1, the domestic credit substantially expanded while foreign reserves sharply declined, led by the sterilization intervention by the domestic monetary authorities at the beginning of crisis. The expected change in domestic credit using the 20 month backward-looking forecast

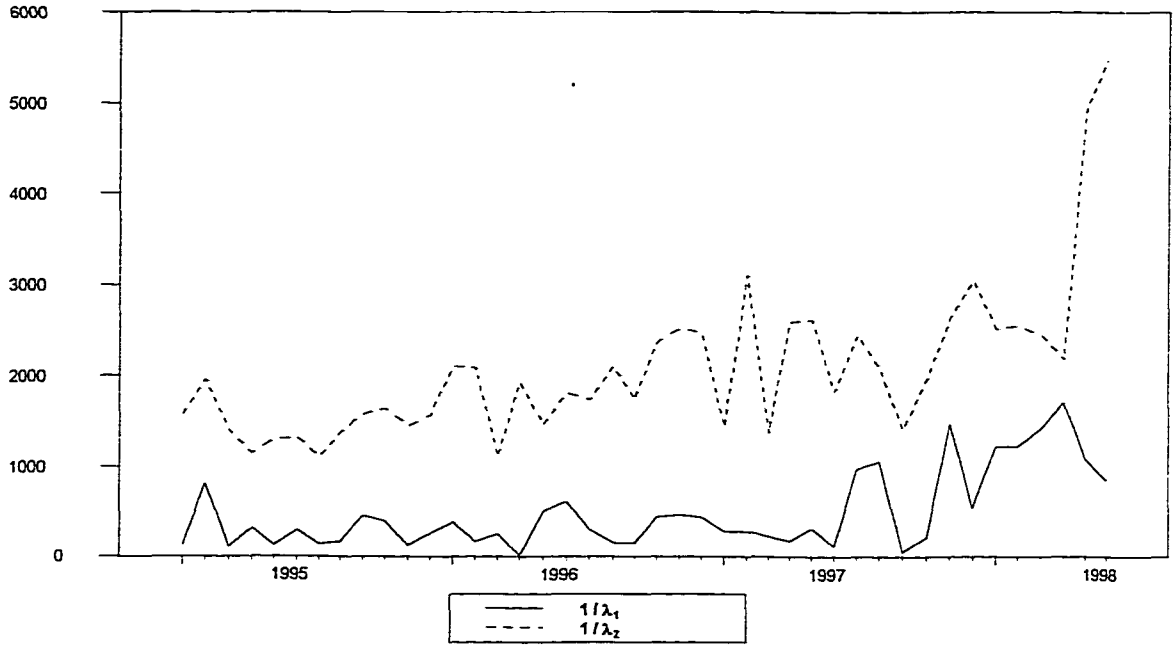
procedure, ${}_t\mu_{t+1}$, is also shown in figure 5.1. The real and forecasted values of μ_t move closely toward each other. Figure 5.2 shows the estimate of randomness about the trend of domestic credit creation and the estimate of externally induced credit variability, respectively.

Figure 5.1: Actual and Predicted Changes in Domestic Credit



The variability of shocks stemming from a pure source of domestic monetary policy shows no specific trend until the middle of 1997. After that, however, it largely fluctuates through the rest of the sample period. This movement in I/λ_I matches up well with the path of one-period-ahead forecast of domestic credit growth (${}_t\mu_{t+1}$). The variability of externally induced credit shows upward fluctuation from the middle of 1996

Figure 5.2: Domestic ($1/\lambda_1$) and Foreign ($1/\lambda_2$) Credit Shocks

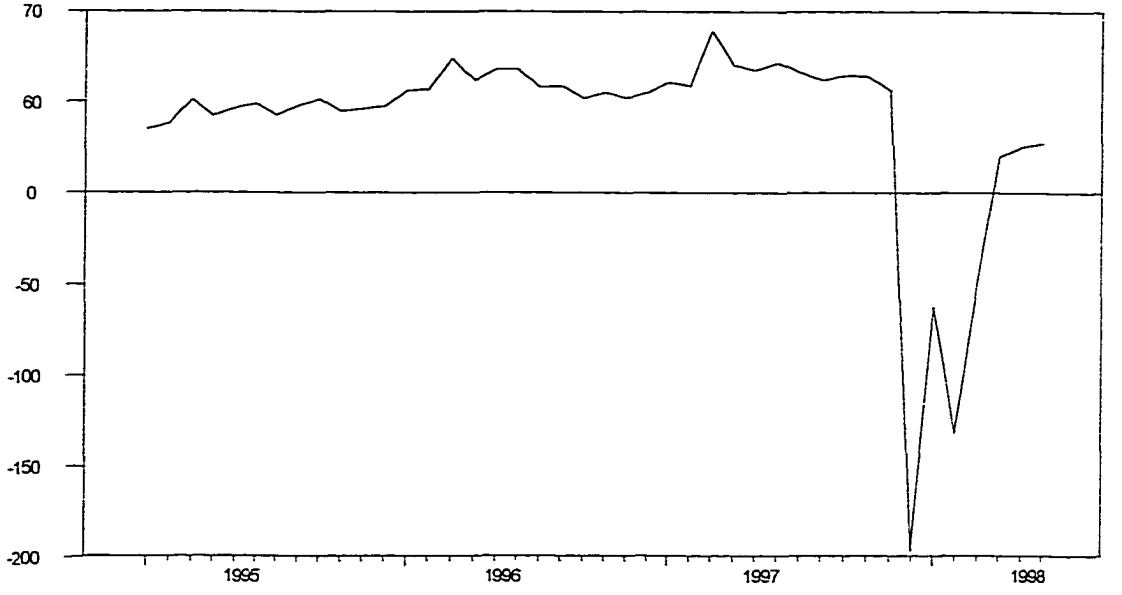


and larger fluctuation through the second half of 1997. This variability begins to sharply increase from the middle of 1997 to the end of sample period, during which time Korea experienced the currency crisis.

5.3.3 Patterns in Relative Price of Domestic Goods

The forecasts of the relative price of domestic goods, ${}_t\rho_{t+1}$, which is estimated using the Box-Jenkins forecasting method based on the *ARIMA* (1,1,1), is shown in figure 5.3. The path of relative price shows a steady upward trend until the middle of 1995. From the second half of 1995, the relative price increased at the time of currency appreciation, and began to decline in the middle of 1996 with a low level of depreciation. The relative price subsided in the beginning of 1997 from which period the currency has

Figure 5.3: Relative Price (ρ)



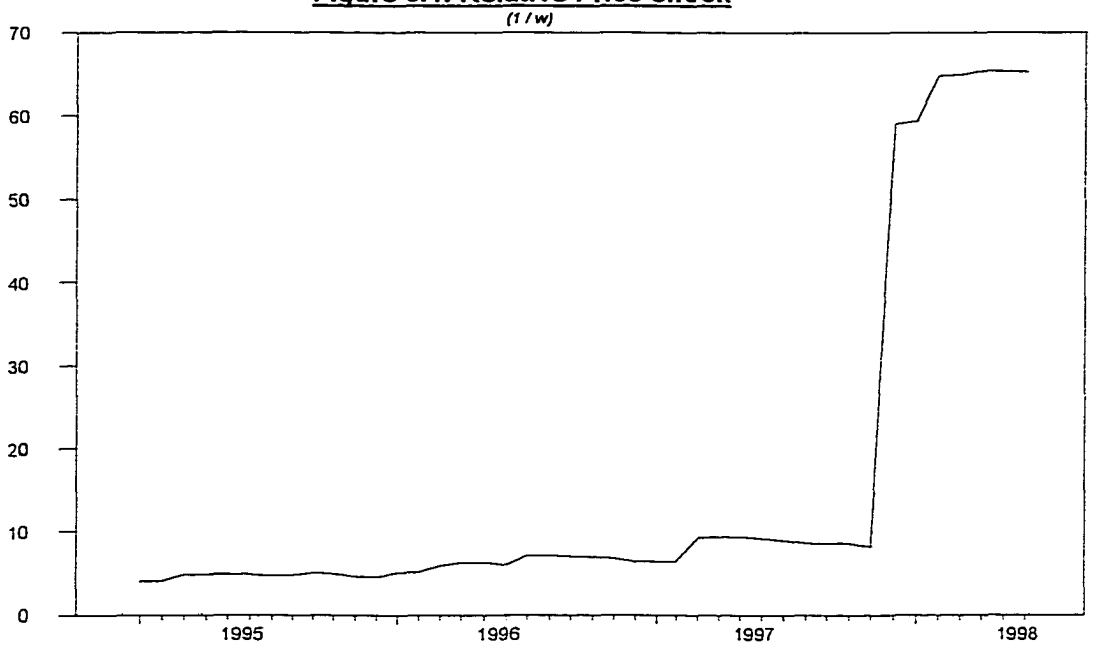
been largely depreciated, and substantially precipitated in the 4th quarter of the same year, implying a large loss of Korean currency value. The overall movement of ρ_t (relative price of domestic goods) reflects well the pattern of Korean currency, suggesting the low rate of currency depreciation and so the loss of competition in the world market led by overvaluation of the won during the sample period. Figure 5.3 also reflects that the systematic deviation from PPP exists, though it is not so large, due to higher rate of domestic inflation than that of foreign inflation through the sample period.[100]

Based on figure 5.4, which shows the shock of relative price (or random deviation from PPP), the market did not expect high risk about the relative price since the variability of the short-run deviation from PPP moved smoothly until the first quarter of

[100] The US CPI was used as a proxy for the foreign price level. This might lead to overvaluation of the won through the exchange rate because the Korean exchange rate system required much weight on the U.S. dollar in calculating the daily exchange rate.

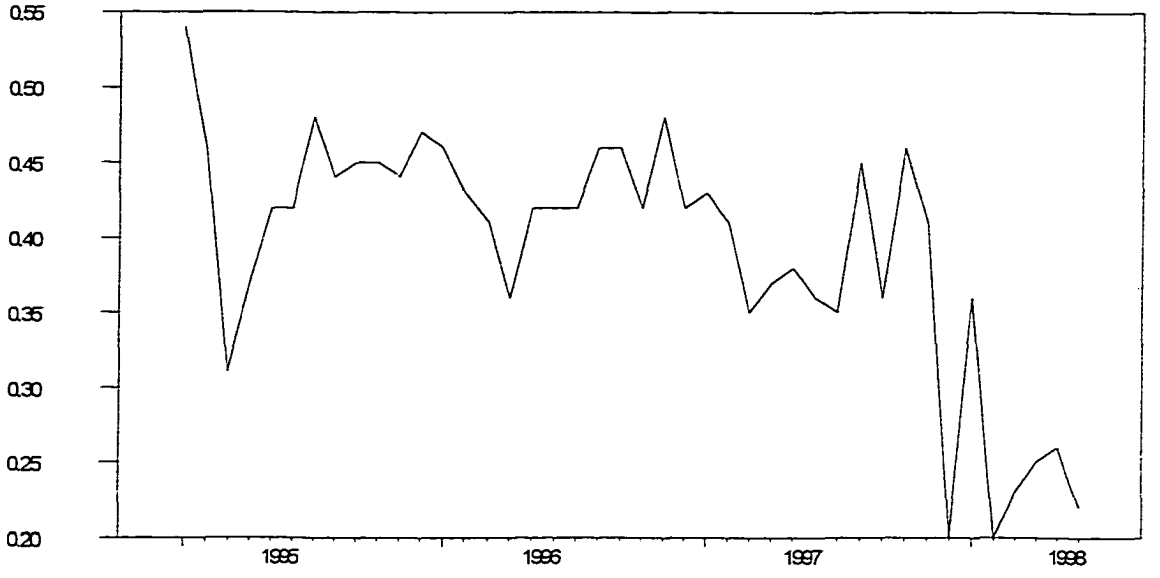
1997. However, the risk of relative price shocks sharply increased in the fourth quarter of 1997 and continuously rose, remaining at very high levels in the rest of the sample period along with a large loss in the value of the won.

Figure 5.4: Relative Price Shock



The share of nontraded goods(α) in the Consumer Price Index is shown in figure 5.5, which illustrates a downward trend through the sample period. It decreases from a high of 55 percent in early 1995 to a low of 22 percent in late 1997.

Figure 5.5: Share of Nontraded Goods (α) - percent



5.3.4 Estimation Results

Using an iterative estimation procedure, the system of equations provides one-period-ahead probabilities of collapse, shadow exchange rates, a money market equilibrium condition, and risk premia. The predicted probabilities and shadow exchange rates are presented in table 5.3, and the plots of these estimates are shown in figure 5.6 and 5.7, respectively. The market clearing rates can be regarded as a lower limit in which domestic monetary and fiscal policies are consistent with the existing exchange rate regime.

Table 5.3: Actual and Shadow Exchange Rates, and Collapse Probabilities (π_t)

Year	Actual*	Shadow*	π_t	Year	Actual*	Shadow*	π_t
1995:01	786.7	690.1	0.00019	1996:10	831.3	805.6	0.00031
1995:02	786.0	709.6	0.00003	1996:11	828.7	792.0	0.00038
1995:03	771.5	721.6	0.00055	1996:12	844.2	805.8	0.00026
1995:04	761.8	720.8	0.00012	1997:01	861.3	941.8	0.00078
1995:05	760.1	743.0	0.00041	1997:02	863.9	963.3	0.00087
1995:06	758.1	750.1	0.00015	1997:03	897.1	925.2	0.00077
1995:07	756.5	745.9	0.00084	1997:04	892.1	918.3	0.00297
1995:08	771.1	765.9	0.00040	1997:05	891.8	918.0	0.00154
1995:09	768.4	750.1	0.00017	1997:06	888.1	920.9	0.00063
1995:10	765.5	736.6	0.00021	1997:07	892.0	912.4	0.00195
1995:11	769.2	752.6	0.00117	1997:08	902.0	894.6	0.00072
1995:12	774.7	767.4	0.00018	1997:09	914.8	939.6	0.05702
1996:01	784.3	779.0	0.00021	1997:10	965.1	901.7	0.39078
1996:02	780.7	779.4	0.00084	1997:11	1063.8	948.2	0.74167
1996:03	782.7	806.8	0.00054	1997:12	1695.8	1714.8	0.40517
1996:04	778.7	816.2	0.02388	1998:01	1572.9	1654.3	0.17139
1996:05	787.9	812.8	0.00023	1998:02	1633.0	1674.2	1.00000
1996:06	810.6	794.8	0.00011	1998:03	1383.0	1398.1	0.87143
1996:07	813.3	811.4	0.00025	1998:04	1336.0	1164.2	0.05810
1996:08	819.4	809.4	0.00100	1998:05	1407.0	1197.6	0.03229
1996:09	821.2	808.0	0.00092	1998:06	1373.0	1233.2	0.04776

* won / U.S. dollar exchange rate

The collapse probabilities remained at very low levels through the first half of 1996, which were smaller than one percent. An exception during this period occurred in April 1996 when the estimated probability marks 2.4 percent and the market clearing rates exceeded the actual exchange rates around this time. However, no profitable speculations against the won seemed to take place during this period because the market perceived that Korea was not rationed in the external credit, which ration would have been critical in sustaining the existing exchange rate system. Based on the estimated probabilities and

shadow rates, the markets continued to expect no certain atmosphere of speculation on the foreign reserves in the second half of 1996, though the won was continuously depreciated at this time.[101]

Figure 5.6: Collapse Probability of an Exchange Rate Regime

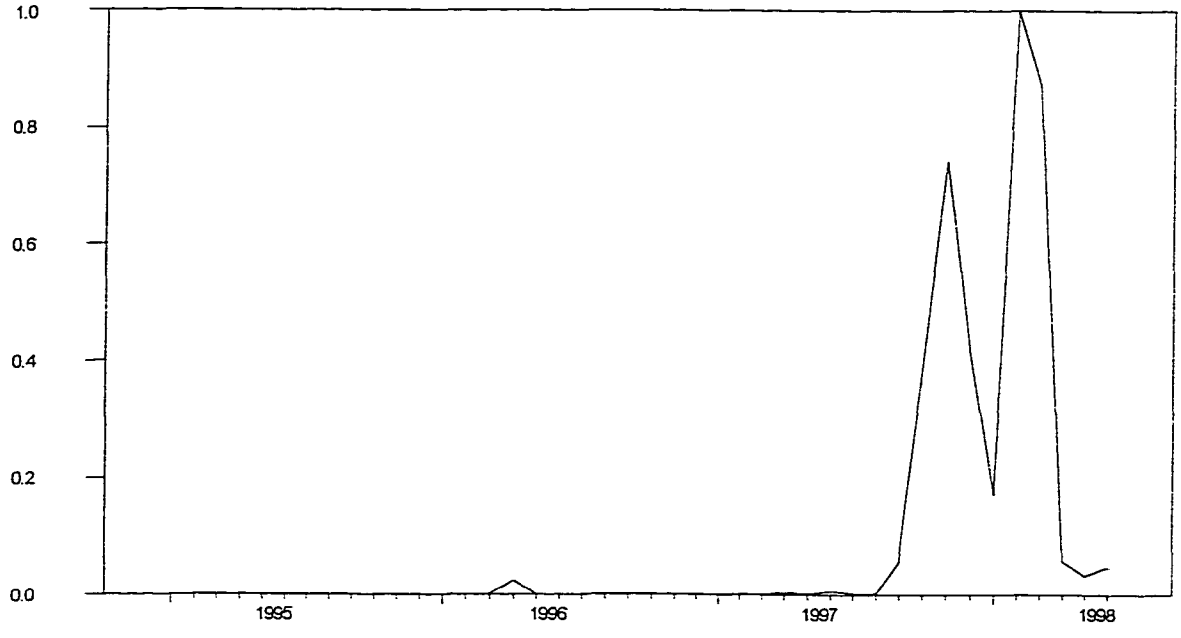
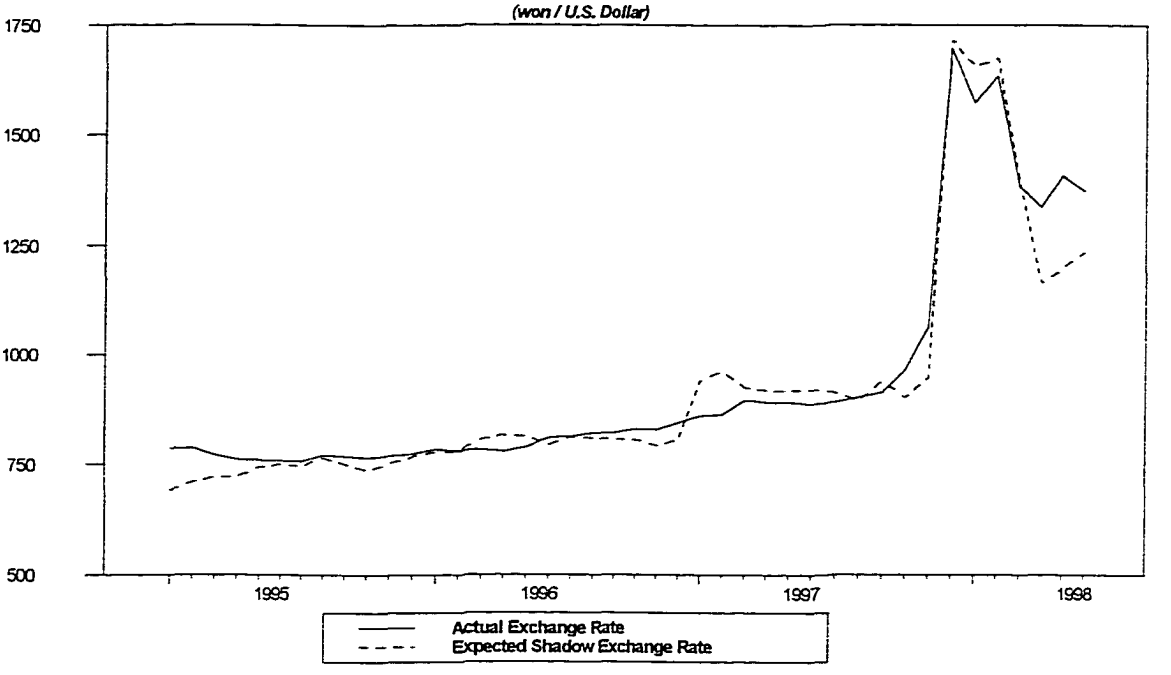


Figure 5.7 suggests that the actual exchange rates were overvalued through 1997 according to the market clearing rates. This implies the continuous depreciation of the won was not enough to achieve market equilibrium, and so the collapse probabilities began to rise through the third quarter of 1997. In October and November 1997, while the market equilibrium levels of exchange rates (solved in the system of models) were

[101] Even if the exchange rate system adopted by Korea during the sample period was not a pure fixed system, it could be regarded as a crawling peg since the exchange rate was controlled such that it was allowed to move within the announced band. Thus, under this system, the successful attack could make profits as in the model.

still exceeded by the actual exchange rates, the predicted probabilities of collapse increased dramatically with precipitately falling foreign reserves held by the bank of Korea caused by the obviously profitable speculations. Ultimately, in December 1997, the existing exchange rate regime collapsed and the Korean currency, the won, lost its value significantly (about 60 percent) compared with November 1997.

Figure 5.7: Actual and Predicted-Shadow Exchange Rates

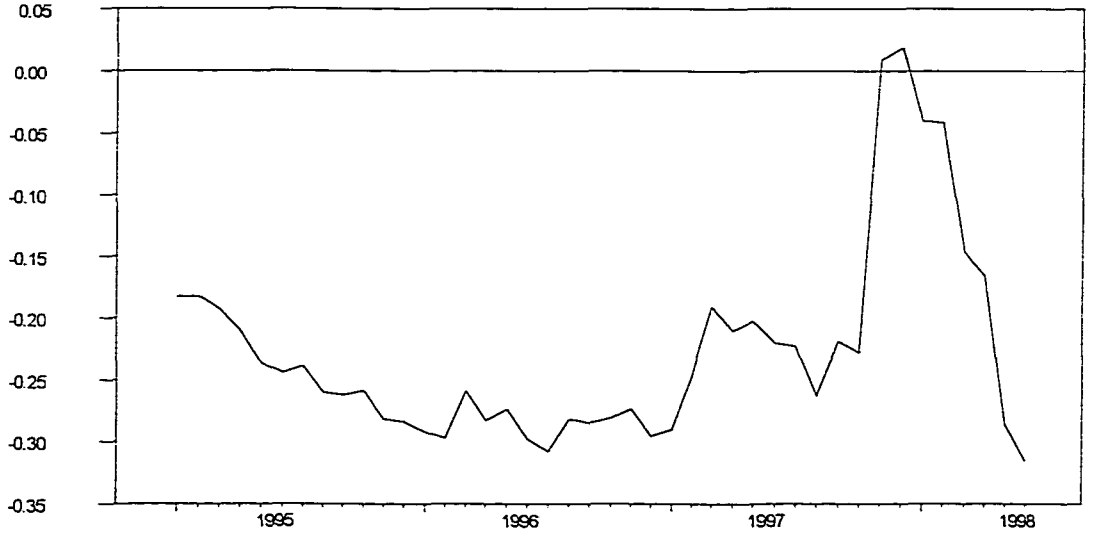


As the market clearing rates exceeded the actual rates through March 1998 and as the collapse probabilities peaked at this point, the market participants did not show confidence in the stability of the new policy of the exchange rate system in spite of new debt scheduling agreements with IMF. After that point, the collapse probabilities dropped sharply, though they remain still at relatively high levels, thanks to the market's

perceptions of enough depreciation of the won to retain the market equilibrium as suggested by the shadow rates and probabilities.

The risk premium is plotted in figure 5.8. According to the portfolio theory, domestic interest rates are expected to reflect the risk feature of the domestic assets. The risk premium varies over the sample around its mean value until the middle of 1997, indicating that there exists a certain fluctuation in the expected exchange rate changes. In the end of 1997, the changes in risk premium became large enough to reflect the readjustment of a portfolio of desired asset holdings. With this result, we may conclude that interest rates reflected the expected rate of depreciation in the won to some extent and so there may have existed the breakdown of the interest parity condition.

Figure 5.8: Risk Premium



Finally, the estimated coefficients of the parameters in the money demand equation, computed by an iterative procedure, are presented in table 5.4 with *t*-value of each

variable in the equation.[102] The parameter on the GDP has the correct sign and significantly affects the money balance function. The currency substitution negatively affects the money demand, as expected, but its impact is not significant. On the other hand, introducing the ratio of non-performing loans also gives a significant influence on the money demand, although positively signed.[103]

Table 5.4: Money Demand Equation

a_0	a_1	a_2	a_3	a_4	R^2
217.06	20.7544	0.03831	-150.8355	256.3470	0.8058
(1.5419)	(3.2639)*	(8.6536)*	(-0.5802)	(2.8801)*	

Note: 1) Numbers in parentheses are t-ratios.
2) * is significant at 1 percent level.

5.3.5 Analysis of the Causes of the Korean Exchange Rate Crisis.

In this section, we analyze the impacts of changes in domestic credits shocks, external credit shocks, purchasing power parity shocks, and sterilization policy on the probability of collapse. This study is performed by increasing or decreasing the levels of shocks, given the money demand parameters which were already estimated in the previous section.[104]

[102] The number of iteration taken in the procedure was seven, and the estimated value of θ was 0.00032.
[103] The regression coefficients of the money demand equation provided close results when the serial correlation was corrected using GLS estimation. One of the possible reasons of this result appears to come from the property of the iteration since the estimated parameters are different before iteration but the results show very similar or same values between two regressions when the iterative regression is converged.
[104] This method is used in Goldberg (1994) where it is called counterfactual simulation.

The change in the externally induced shocks are positively related with the change in probability, though the size of changes in the probability is not so large. When the external credit shock is decreased by one-half, the collapse probability also drops by 14 percent in October 1997, and 12 percent in December 1997. The magnitude of the probability changes are trivial at other sample periods. However, based on the declined π_t during the above months, it could be said that smaller foreign credit shocks would have reduced or delayed the currency collapse around the end of 1997, to some extent, although the Korean crisis would have been unavoidable with only slightly reduced external creditor's shocks.

The next study is associated with the implications of how the change in the domestically induced credit shock influenced the speculative attacks on the won. When the uncertainty concerned with domestic monetary and fiscal behaviors is decreased by one-half, the collapse probabilities increased at the range of the sample period before November 1997 at which time the π_t declined by 30 percent. The increased magnitude in the probabilities between December 1997 and January 1998 is about 34 percent in average. After that time, the size of changes in the probability is quite small.

This finding is an intuitively unexpected result and is similar to that of Goldberg (1994).[105] However, since the probabilities of collapse after January 1998 do not rise so largely (about 7 percent increase in average during this period), it could be said that decreasing the uncertainty around domestic credit patterns would not have led to higher

[105] This similarity seems to stem from the fact that the two models (i.e., the model developed by Goldberg and the model used in the chapter 3 of this paper) are based on the monetary and first generation speculative attack models that emphasize inconsistent domestic economic environment or fundamentals with the domestic credit behavior. Especially, the fact that a factor reflecting the uncertainty surrounding the patterns in domestic credit creation appears in one of two exponential terms of the derived π_t may make

speculative opportunities, unlike the analysis in Goldberg (1994; p.427) where she mentioned that "this theoretical possibility can arise when $1/\lambda_1$ is sufficiently large. In this case, further increases in $1/\lambda_1$ serve to decrease the expectation that the shadow exchange rate will exceed the announced controlled exchange rate." In fact, this inverse movement may occur when the sufficient condition for the positive correlation between π_t and $1/\lambda_1$ is not sustained. Following this interpretation, a negative relationship between π_t and $1/\lambda_1$ can also arise when $1/\lambda_1$ increases with the condition that the other two shocks (i.e., foreign creditor shock and random price shock) show inverse movement, based on the analysis of the theoretical model developed in chapter 3.

Although there exists a theoretical possibility which could lead to an inverse pattern in π_t and $1/\lambda_1$, the market's speculative moods on the won might not have been reversed by more weighting on the variability surrounding domestic credit behavior once the won slipped into the chaos.

Even though the impact of smaller variability in relative price shock ($1/w$) on the π_t declines, the size of changes in collapse probability is negligible in the whole range of the sample period. These insignificant changes in π_t could come from the continuous depreciation of the won since the middle of 1995, which might have reduced the substantial relative price shock in the fourth quarter of 1997. Therefore, according to the above relationship between π_t and $1/w$, we may conclude that the other small levels of realignments of the currency before and/or during the crisis period would not have much alleviated the speculative atmosphere on the won around December 1997.

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it possible for the π_t to move inversely with $1/\lambda_1$. In short, this negative relationship may be regarded as a particular property of the models which emphasize the domestic monetary policy.

As another factor, rather than shocks, which would have affected the collapse probability during the crisis period, we can consider the role of sterilization policy adopted by the Korean monetary authority. The sterilization operation is performed through the purchase and sale of domestic and foreign bonds by the central bank. Based on the previous chapter's theoretical model, as the monetary authority further sterilizes against the attacks on the central bank's foreign reserves[106], π_t is expected to rise. This mechanism of positive relationship between π_t and sterilization is based on the model which emphasizes the conflict between two economic policies, for example, such as the policy of continuous domestic credit creation and the policy of sustaining a fixed exchange rate regime, faced with exhaustion of foreign reserves. Here, the sterilization against the attacks on the central bank foreign reserves can be an additional source that can further create domestic credit.

The pattern of changes in π_t is not so large. When the amount of domestic bond held by the bank of Korea declined by one-half, the collapse probabilities also lowered about 10 percent between September 1997 and December 1997. During January 1998 and end of sample, however, the changes in π_t with the lower level of B_t are quite small. Even though the influence of sterilization policy on the collapse probability, viewed in the light of the estimated model, is not substantial, the positive relationship between π_t and B_t could imply that the credibility and the sustainability of the existing Korean exchange rate system would have been undermined by the market's uncertainty on the government policy to sustain the system, faced with weak economic fundamentals such

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[106] In both theoretical and econometric models, foreign bonds (B_t^*) do not appear in the derived π_t. Therefore, whether or not the sterilization policy affects the collapse probability is examined only through the change in the domestic bonds (B_t). A sterilization operation indicates an increase in the domestic bonds.

as low levels of foreign reserves. Therefore, on the grounds of the above estimates of π_t, we may conclude that if the sterilization operation by the Korean monetary authority during the fourth quarter of 1997 had been one-half of that actually performed, the collapse probability would have been lowered, to some degree, by decreasing one of sources which might have increased domestic credit creation.

5.4 Conclusion

The collapse probabilities and shadow exchange rates which were estimated using the econometric model based on the theoretical section give some implications on the Korean experience during the period of 1997-1998.

Though the forecasts of the shadow exchange rates did not anticipate the expectation of profit by attacking the won in a certain sample period, the estimated shadow rates foretold the continuous speculative atmosphere between December 1997 and the first quarter of 1998, along with increasing probabilities of collapse. Especially, the probabilities were sharply climbing since November 1997 when the level of foreign reserves began to drop precipitately due to the speculative attacks on the won, along with additional sources exhausting the reserves by sterilization operation. Thereafter, the remaining of the shadow rates at high levels gives a suggestion that the market's expectation about the government's exchange rate policy was still uncertain even with the government's debt rescheduling agreement with international creditors in January 1998.

From the previous section's analysis on the influence of π_t when changing the levels of shocks and the magnitude of sterilization, given the money demand equation, we could trace out some causes of the Korean episode. The study suggests that the

Korean currency crisis would have been alleviated to some degree by lowering the uncertainty surrounding anticipated external credit shock and by reducing the scale of monetary growth which in part originated from the sterilization policy during the crisis period.

The increases in the forecasts of variability in the domestic credit creation lowered the probability of collapse before February 1998 to about 30 percent. It is, however, uncertain whether or not the increases in the uncertainty of the domestic credit policy would have reduced the speculative behavior because the estimated probabilities still remained at high levels after that point.[107] Even with smaller values of π_t along with lower relative price shocks, the small levels of realignments in the won before and/or during the crisis period would not have much reduced the speculative pressures against the won since the changed magnitude in π_t was negligible.

Based on the pervious section's results the crisis model predicted relatively well, although it did not fit quite well over the whole sample range. These less satisfactory results compared to previous work such as Goldberg (1994) seem to be mainly related to the highly stylized model used in chapter 3 (even if the model was modified from the standard models of currency crises in order to describe some characteristics of Korean crisis such as sterilization policy, adding the ratio of non-performing loans into the money demand equation).

[107] Another reason for the uncertainty of the change in π_t with the lower level of $1/\lambda_1$ requires the breakdown of the sufficient condition. The condition is found in the section of comparative statics in chapter 3 where the positive relationship between π_t and $1/\lambda_1$ is shown.

CHAPTER 6

Summary and Conclusions

This dissertation extends the theory on exchange rate and balance of payments crises and provides empirical evidence for the 1997 Korean currency crisis on the basis of the theoretical framework.

There exist two competing theoretical views in the literature on the speculative attacks and currency crises. The first view, so-called standard or first generation models of currency crises, stresses the relation between investors' speculation behavior and deteriorating macroeconomic fundamentals as a main source of the crisis. On the other hand, the second view, so-called second generation models of currency crises, attributes the main causes of the crisis to the market's abrupt speculative activity, rather than pre-crisis inconsistency between worsening fundamentals and the existing fixed exchange rate regime.

Even though these views have their own advantages in understanding a certain crisis, the recent Korean episode can not be explained on the basis of a merely one-side view. In this respect, the main purpose of this paper is to attempt to provide a better illustration of the 1997 Korean currency crisis.

For this purpose, following an introductory chapter which explained the necessity, the goal and the direction of this study, and following a literature survey in chapter 2, chapter 3 provided a theoretical framework in order to incorporate the first and second generation models by introducing several crucial assumptions that are stressed in both generation models, though the basic models come from the monetary model of exchange

rate determination which is a modified version of standard models such as Krugman (1979) and Flood and Garber (1984b) models.

The assumptions added to the model are as followings: (1) a relaxation of PPP; (2) an inclusion of income in the money demand equation; (3) a sterilization of the losses of foreign reserves during the speculative attacks; (4) an inclusion of external and internal credit shocks; (5) inclusions of currency substitution motive and the ratio of non-performing loans in the money demand function; and (6) an introduction of a time-varying risk premium to the interest parity condition. While the first four are added to the model to overcome the weakness of previous standard speculative attack models, the last two help the first generation models to incorporate second generation models.

Chapter 4 estimated the level of the reserve floor by using a partial adjustment model based on the optimizing approach. This method has the advantage of incorporating the behavior of foreign reserves with the several macroeconomic variables that influenced the determination of foreign reserves around the problematic period. This chapter illustrated the patterns of current and capital accounts along with the movement of international reserves. Also, this chapter presented the exchange rate system during the sample period in Korea and the patterns in the exchange rate surrounding the crisis period.

The predicted critical reserve floor that was used to calculate the collapse probability in chapter 5 was close to the actual nominal value of foreign reserves held by the bank of Korea during the time of the crisis. Furthermore, the long-run reserve demand function provided relatively useful information about the capital flows at the time of speculative attacks. That is, the residual structure from the estimated regression

shows large negative shocks to the foreign reserves in the fourth quarter of 1997, implying that the reserves indeed fell under their desired levels as the crisis was surfacing and there were also large capital outflows during this time.

In chapter 5, using an iterative estimation procedure, the system of empirical models which was developed and solved in chapter 3 provided one-period-ahead probability of a regime collapse, shadow exchange rates, money market equilibrium condition, and risk premium for the 1997 Korean experience. For the variables in the estimation models, monthly data during the 1995-1998 period was reobtained by using a backward-looking forecasting procedure, which is based on the Box-Jenkins methodology, to choose an appropriate *ARIMA* process of each variable.

On the basis of theoretical and analytical frameworks made in previous chapters, the empirical results provide the following conclusions. First, the actual exchange rates were overvalued through 1997 according to the estimated market clearing rates. This implies that the continuous nominal depreciation of the won in pre-crisis period was not enough to achieve market equilibrium. Thus, the collapse probability of the existing exchange rate regime began to rapidly increase from the third quarter of 1997. Moreover, the market participants' confidence in the new government policy of exchange rate was not recovered through March 1998, in spite of new debt scheduling with IMF and other foreign creditors, since the actual exchange rates were continuously exceeded by the shadow rates. However, the market's credibility on the Korean foreign exchange market began to restore after that time with market's perception of enough depreciation to retain the market equilibrium level as indicated in the patterns of shadow rates and the collapse probabilities.

Second, according to the counterfactual simulation results, the collapse probabilities decreased about 14 percent during the crisis time when the external credit shocks were lowered by one-half. Thus, the smaller foreign credit shocks could have reduced the possibility of regime collapse. This result implies that the timing of the crisis could have been delayed with more reserve holdings of the bank of Korea by buffering the external shocks to some degree, although the crisis in Korea would have still ultimately been unavoidable only with this amount of reduced external shock.

Third, since an increasing uncertainty surrounding domestic credit creation provides negative impacts on the collapse probabilities depending on the sample period, it is unclear whether or not the increase in uncertainty of domestic credit policy would have reduced the speculative behavior. Although there exists a theoretical possibility which could lead to an inverse pattern between collapse probability and domestic credit shock, the market's speculative moods on the won might not have been reversed by more weighting on the variability surrounding domestic credit behavior once the won slipped into the chaos, based on the counterfactual simulation result.

Fourth, even though the collapse probability moves in the same direction as relative price shocks, its scale in movement of the probability was negligible, following the result of counterfactual simulation. These insignificant changes in π_t could come from the continuous depreciation of the won since the middle of 1995, which might have reduced the substantial relative price shock in the fourth quarter of 1997. Therefore, according to the above relationship between π_t and $1/w$, we may conclude that the other small levels of realignments of the currency before and/or during the crisis period would not have much alleviated the speculative atmosphere on the won around December 1997.

Fifth, the influence of sterilization policy on the collapse probability, viewed in the light of the estimated model, is not substantial. The positive relationship between π_t and B_t, however, could imply that the credibility and the sustainability of the existing Korean exchange rate system would have been undermined by the market's uncertainty about the government policy to sustain the system, faced with weak economic fundamentals such as the low level of foreign reserves. Therefore, on the grounds of the above estimates of probability, we may conclude that if the sterilization operation by the Korean monetary authority during the fourth quarter of 1997 had been one-half of that actually performed, the collapse probability would have lowered, to some degree, by decreasing one of the sources which might have increased domestic credit creation.

Although the above conclusions give some policy implications for avoiding or delaying the currency crisis especially in the short-run (i.e., during the crisis), a more principle way to prevent a future crisis is for the Korean economic system to have stronger fundamentals such as running current account balance along with a more flexible exchange rate policy. In balancing the current account, the role of trade surplus should be more emphasized rather than the role of large capital account surplus. This is because balancing or running current account surplus in this way would prevent the currency crisis from being triggered by self-fulfilling speculative attacks (by decreasing the magnitude of short-term foreign debt) as well as by depletion of international reserves (by increasing usable foreign reserves). In this regard, we have a lesson from the 1997 Korean crisis, though it is needless to say, that the problem of income redistribution by holding large amounts of international reserves can be more than offset by the economic

and social costs of recovering the collapsed economy back to the pre-crisis level, as in Korea as well as other southeast Asian countries in 1997.

As another lesson, capital flows should be monitored by the government and by the private sector and be controlled by the government to avoid a moral hazard problem and thus to generate a more stable financial system. For this purpose, the disconnection between economic matter and political matter should be preceded, and then the economy be operated under the principal of the market economy system. All these efforts will give the market more credibility on the economic system. Finally the coordination with Asian countries as well as developed countries, and with international financial institutions (e.g., IMF, World Bank, and IBRD) is required to improve the weakness of the international financial system and so to prevent a future economic crisis.

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Appendix

Table A.1 : *ARIMA* Processes of the Variables

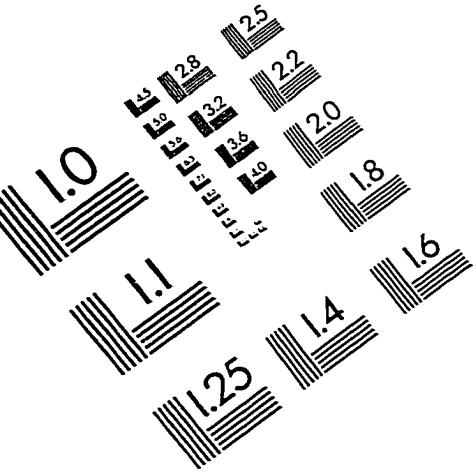
Domestic Credit – (D_t)	*ARIMA* (2,1,3)
Foreign Reserves – (R_t)	*ARIMA* (||1,4,5||,1,0)*
Money Supply – (M_t)	*ARIMA* (3,1,0)
Income (GDP) – (y_t)	*ARIMA* (2,1,3)
Domestic Interest Rate – (i_t)	*ARIMA* (2,1,0)
Foreign Interest Rate – (i_t^*)	*ARIMA* (3,1,3)
Consumer Price Index – (Q_t)	*ARIMA* (3,1,0)
Foreign Price Index – (p_t^*)	*ARIMA* (||1,2,3,7||,1,0)**
Capital Balance – (FA_t)	*ARIMA* (1,0,0)
Domestic Bonds – (B_t)	*ARIMA* (2,1,3)
Foreign Bonds – (B_t^*)	*ARIMA* (2,1,0)
Growth Rate of Domestic Credit – (μ_t)	*ARIMA* (2,1,3)
Ratio of Dishonored Bill – (N_t)	*ARIMA* (1,1,0)
Share of Domestic Goods in the CPI – (α_t)	*ARIMA* (2,1,3)
Systematic Deviation of Purchasing Power Parity – (ρ_t)	*ARIMA* (1,1,1)

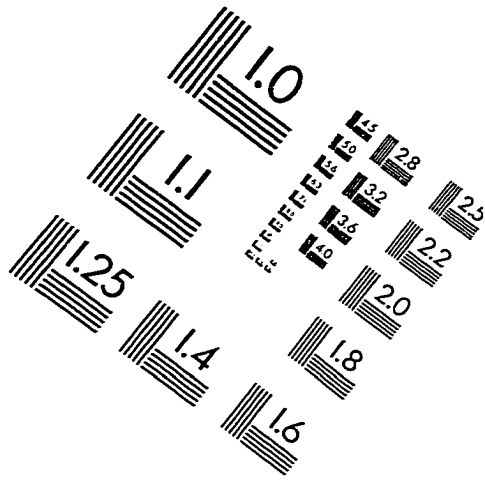
Note : * indicates a non-stationary process of foreign reserves such as $R_t = R_{t-1} + R_{t-4} + R_{t-5}$.

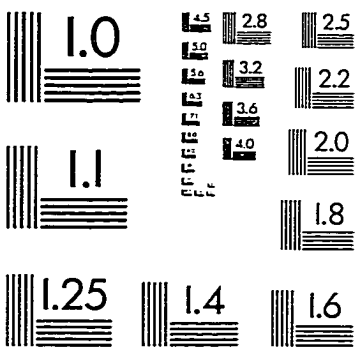
** refers to a non-stationary process of foreign price such as

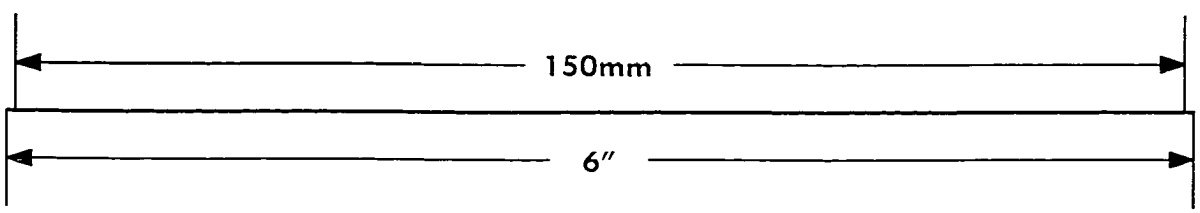
$p_t^* = p_{t-1}^* + p_{t-2}^* + p_{t-3}^* + p_{t-7}^*$.

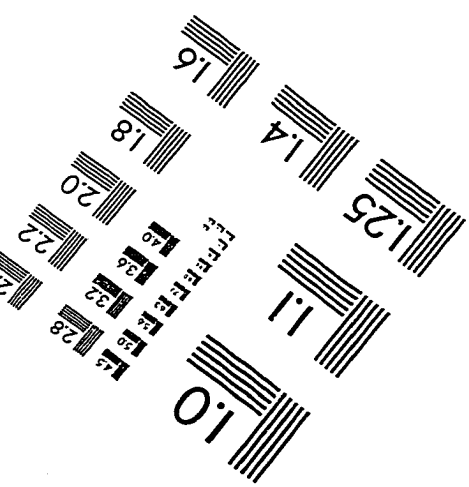
IMAGE EVALUATION TEST TARGET (QA-3)

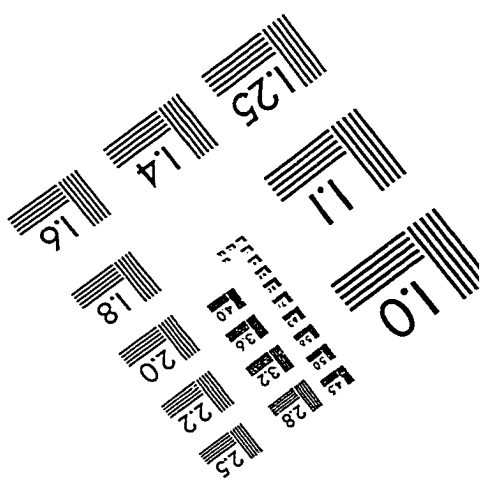












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