



ESSAYS ON REGIME CHANGES IN EXCHANGE RATE MARKETS

by

ISAMU KATO

A dissertation submitted to the Graduate Faculty in Economics in partial fulfillment of the requirements for the degree of Doctor of Philosophy, the City University of New York.

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Abstract

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by

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My dissertation is motivated by several events that occurred in the international financial markets during the 1980s and 1990s. Those events induced regime changes in exchange rate markets as well as their systems in many different senses. My dissertation investigates those regime changes from several different angles. The thesis consists of three essays.

The first essay analyzes the effects of three different categories of factors on the collapse of the currency regimes in East Asian countries: changes in speculators' expectations, domestic economic fundamentals, and external economic shocks. Constructing a three country framework of currency crises and applying the concepts of the first and second generation currency crisis models, I focus on the change in the devaluation probabilities of four Asian countries, Thailand, Malaysia, Indonesia, and Korea, between 1990 and 1997. The empirical results of this study confirm significant effects of the change in speculators' expectations on these countries. Declines in the domestic and Japanese capital returns and the depreciation of the Japanese yen against the US dollar also contributed to a rise in the devaluation probabilities in most of the countries.

The second essay investigates the factors determining the choice of exchange regimes (fixed, intermediate, and floating). I conduct the analysis using cross-country panel data of 138 countries from 1982 to 1999 with the multinomial logit model. The results show that an increase in inflation differential moves a country to an intermediate regime, while a decrease moves the country to a fixed regime. Unlike the previous studies that are inconclusive, I find that bank domestic credit and the current account balance explain regime changes to an intermediate regime.

The third essay tests the validity of the two-pole hypothesis, which assumes all regimes finally converge to either “peg” or “float”. I employ two different groups of economic variables: one relates to the optimal currency area (OCA) literature and the other relates to currency crises (CC) discussions, and examine how economic factors affect the selection of each exchange rate regime. The result confirms that support for the two-pole hypothesis depends on types of variables, their direction of changes, as well as sample periods of analysis. More recent data provides weak support for the two-pole discussion and it makes more difficult to argue that the intermediate regime is a disappearing state.

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Essay I

EXTERNAL SHOCKS TO ASIAN CURRENCIES:
A THREE COUNTRY APPROACH TO CURRENCY CRISES

“Like head-swivelling spectators at a tennis match, Asia’s finance officials avidly follow the daily to and fro between the US dollar and the Japanese yen. Yet though they may cheer or jeer from the sidelines, they are largely powerless to influence the outcome of the game, which has such a big impact on their fortunes.”

“Currency fears hit in Asia”: Financial Times, May 21, 2001

1. Introduction

Due to the surprising growth of their economies, East Asian countries had been favorably looked upon by foreign investors in the early and mid 1990’s. However, following the collapse of the Thai baht in July 1997, the currency crisis spread to neighboring East Asian countries in a very short period. As a consequence of massive speculative attacks, these countries had to abandon their currency regimes and their currency depreciated against the US dollar by 35% to 48 % by the end of 1997.

The Asian currency crisis of 1997-98 had several distinguishing features regarding causes of the crisis. In addition to domestic factors such as the weakness of financial sectors, many critics attribute the crisis to several external economic shocks from foreign economies, such as the depreciation of the Japanese yen against the US dollar. This type of common external economic shock is called a “monsoonal effect” (Masson, 1998), and such shocks played a unique role in the Asian crises in addition to what is termed as the “contagion effect,” which is a rapid spread of the speculative-expectation of currency collapse among regional countries.

This paper analyzes effects of three different categories of factors, domestic economic fundamentals, external economic shocks, and changes in speculators' expectations, on the collapse of currency regimes in the Asian countries. The paper focuses on the change in the devaluation probabilities of four Asian countries, Thailand, Malaysia, Indonesia, and Korea, between 1990 and 1997. The contribution of this paper is threefold. First, to investigate external economic shocks from two trade partner countries, the paper constructs a three country framework of currency crises. Second, combining the concepts of both the first and second generation currency crisis models, the paper theoretically explains the effects of the changes in speculators' expectations. Third, using the Markov switching model, the paper applies empirical analysis to the Asian currency devaluation focusing on three categories of factors mentioned above.

The empirical results of this study confirm significant effects of the change in the speculators' expectations for the Asian countries. The domestic and Japanese capital returns and the Japanese yen exchange rate against the US dollar also contributed to the variation in the devaluation probabilities in most of the countries. The paper also investigates the relationship between the external debts and the currency crises. The causality test result regarding the changes in the speculative-expectation between those Asian countries suggests that the Thai crisis played an important role as a wake-up call to other countries.

The rest of the paper is structured as follows: Section II introduces the standard theories of currency crises and provides a brief overview of the Asian currency crisis literature. Section III introduces the stylized facts regarding the Asian currencies. Section IV constructs a three country framework of currency crises. Section V presents results of empirical analysis on the Asian currencies, and Section VI is a conclusion.

2. The theoretical framework of currency collapse

2-1. First generation models

The first generation models were proposed in response to the currency crises caused by expansive domestic policies in Latin American countries from the late 70's to the early 80's (Flood and Marion, 1998).

Krugman (1979), which is the seminal paper of the first generation currency attack model, assumes that the fixed exchange rate regime requires a country to fix a nominal interest as well as money supply to maintain the interest rate parity. In his model, the money supply is the aggregate of the domestic credit and the foreign reserve, and an expansion of the domestic credit directly leads to a decline of the foreign reserve. Consequently, an expansionary domestic credit policy brings about the exhaustion of the reserve, and the government must abandon the pegged currency regime. In other words, deterioration of fundamentals, which is linked to the expansionary domestic credit policy, causes inevitability of the collapse of the fixed exchange regime. In addition, this collapse is foreseeable for investors with perfect foresight, and it results in speculative attack on the currency. The exchange rate would be devalued due to abandonment of the fixed regime; therefore, the investors sell off and exchange the currency to avoid any capital losses before the stock of the reserve declines below some critical level.

Because of non-linearity in the model, Krugman (1979) does not foresee the timing of the collapse; however, Flood and Garber (1984) develop a linear type speculative attack

model that provides a solution for this. The first generation model developed by Krugman, Flood and Garber is broadly rearranged and applied to empirical surveys.¹

2-2. Second generation models

The first generation model concludes that deterioration of fundamentals, in particular, an expansionary monetary or fiscal policy, is inconsistent with the long-term maintenance of the pegged exchange rate. In those cases, the fixed exchange rate is not sustainable and speculative attacks occur. However, the ERM crisis in 1992-3 and the Mexican peso crisis of 1994 were not effectively described by the standard type first generation model. Currencies like the Italian lira or Mexican peso suffered from real overvaluation [Jeanne (1997)], while other currencies like the French franc and the British pound were weakened by the combination of mounting unemployment and the high interest rates imposed upon them by the German monetary unification shocks [Jeanne (2000)]. However, most of them were running fairly disciplined macro policies when their currencies were attacked [Flood and Marion (1998)]. In addition to reconsideration of the role of fundamentals, a self-fulfilling aspect of speculative attacks arose regarding the ERM crisis because the timing of attacks did not necessarily coincide with deterioration of fundamentals. The second generation model was developed in response to those new empirical questions, and an escape clause approach is its main framework.

Policy rules with escape clauses are introduced by Flood and Isard (1989), and are applied to the fixed exchange rate regime by Obstfeld (1991).² Obstfeld (1994) is the first to

¹ A number of papers modify the first generation model. Agenor, Bhandari and Flood (1992), Obstfeld (1994), Garber and Svensson (1995) provide reviews and surveys of the first generation model.

² Obstfeld (1994) indicates that an escape clause arrangement of a monetary union allows members to shift to the flexible exchange regime in extreme situations, but also imposes a realignment cost on them.

arrive at a closed-form solution for an escape clause approach and to compare the model with the Krugman, Flood and Garber approach. The model of escape clause adopts the Kydland and Prescott (1977), and Barro and Gordon (1983a, 1983b) models of “Rules vs. Discretions” (the Barro-Gordon approach).

Instead of using output gap and inflation which are used in the Barro-Gordon approach, a loss function of the Obstfeld (1994) model includes; 1) devaluation rate of the currency controlled by a government, 2) output gap from a policy target, which is a function of “predetermined devaluation expectation of the market,” and 3) external shock on output. The other important element is “cost of escape clause,” which is a fixed cost imposed if the government abandons the fixed exchange rate regime. Like the Barro-Gordon approach, the Obstfeld model compares the values of the loss function for the fixed exchange rate regime with that of the flexible regime. Consequently, if the loss of the fixed regime exceeds that of the flexible, a country is supposed to abandon its fixed exchange regime.

In the Obstfeld model, the relationship between two loss functions varies in response to the negative shock of output. In case the output shock lowers the level of the economic fundamental, the loss of the fixed regime is supposed to exceed that of the floating regime. The other key factor, devaluation expectation, also makes the loss of the fixed regime greater than the floating regime when the devaluation expectation occurs among speculators. Accordingly, these assumptions also lead to the possibility of multiple equilibria in the exchange rate dynamic; one is “attack equilibrium” where the investors expect the possibility of collapse of the fixed regime and the sustainability of the fixed exchange rate would be pushed down; the other one is “no attack equilibrium” where investors don’t expect the

collapse of the regime, and the fixed exchange rate is more likely to survive than the former equilibrium.

The second generation model developed by Obstfeld is broadly modified and applied to empirical surveys.³ Jeanne (1997) researches whether speculation is self-fulfilling or motivated by fundamentals and estimates the change of devaluation expectation during the crisis of the French Franc of 1991-1993. Jeanne and Masson (2000) investigate devaluation expectations of speculators using the Markov-switching model. They find that the expectations are unrelated to the economic fundamentals.

2-3. Causes of crises in Asia

The Asian currency crises of 1997-98 had several unique features.⁴ Among them, “weakness of financial sectors”, “monsoonal effects”, and “contagion effects” and are broadly analyzed as causes of the crises.⁵

The last of these, the contagion effect, resulted when the panic in the financial sector of one country spread to neighboring countries in a short period, and this is argued to have been a crucial source of the crisis. Goldstein (1998) applies the “wake up call hypothesis,” which is introduced by Eichengreen, Rose and Wyplosz (1996), and postulates that the Thai crisis acted as a wake-up call for international investors, and triggered the crises in other countries. Kaminsky and Schmukler (1999), Baig and Goldfajn (1999) use daily data of the

³ A number of papers modify the second generation model. Isard (1995), Krugman (1996), Flood and Marion (1998), and Jeanne (2000) review the second generation model and compare it with the first generation approach.

⁴ Overviews of the Asian crises of 1997-98 are provided by Goldstein (1998), Radelet and Sachs (1998), Corsetti, Pesenti, and Roubini (1998).

⁵ Radelet and Sachs (1998), and Krugman (1998) point out that the moral hazard type over-borrowing increased the vulnerability of the Southeast Asian economies and became the source of the financial crisis. The problem of the local banking systems, which was one of the crucial causes of the Asian crises, is interpreted by a new methodology “the third generation approach to currency crises.”

financial markets to test the evidence of contagion among the Southeast Asian countries. They also study how the news triggered the contagious effect of the crisis. Cerra and Saxena (2000) analyze the Indonesian rupiah crisis of 1997 using the Markov switching model, which captures the change in the regime of the currency caused by a financial crisis of another country.

Masson (1998) provides one distinguished theoretical framework for the contagion effect on the Asian crises. He introduces three components of contagion that could trigger a contagion type crisis. The first one is major economic shifts in industrial countries, which are called “monsoonal effects.” The second category is called “spillover effect,” which is a result of changes in macroeconomic fundamentals of neighboring countries. Those changes spillover to the region through inter-regional trade. The third concept is defined as “pure contagion effect,” which originates from the change in expectations. Masson assumes that this pure contagion effect has a self-fulfilling aspect and generates “jumps” between multiple equilibria.

Regarding the monsoonal effects, which are major economic shifts in industrial countries triggering crises in emerging markets, there are several unique studies.⁶ Masson (1998) suggests that the appreciation of the US dollar against the yen (or the depreciation of the Japanese yen against the US dollar) in 1995-96 had this “monsoonal effect” on the Asian countries.⁷ Corsetti, Pesenti, and Roubini (2000) also point out that the sharp appreciation of the US dollar relative to the Japanese yen and the European currencies led to the

⁶ Masson and Mussa (1996) define them as “monsoonal effects”.

⁷ Masson (1998) categorizes rises in the German and the US interest rates, which caused the ERM and Mexican peso crises respectively, as the same kinds of common external shocks.

deterioration of cost-competitiveness in most Asian countries pegged to the US dollar. Their currencies consequently became more vulnerable.⁸

Cerra and Saxena (1998) take account of the depreciation of the Japanese yen as a common external shock that caused the contagious crisis in Asia as well as changes in the US and Japanese interest rates. They suggest that the swings in the dollar-yen exchange rates may have affected the export competitiveness of countries pegged to the dollar.

3. Stylized fact

Before discussing the framework of my currency crisis model, we briefly review the changes in the currency regimes that took place in East Asian countries over the last decade, the direction of trade and the relations of their currencies to the Japanese yen.

3-1. Currency regimes

The IMF *Exchange Arrangement and Exchange Restriction* presents that most of the East Asian currencies had been pegged or managed float against weighted baskets of currencies of their trade partners up to the Asian currency crisis of 1997.⁹ In those currency baskets, the US dollar had the most weight but the Japanese yen and the German mark were also included. Figures 1, 2, 3, and 4 display the movements of the nominal exchange rates of the Asian currencies, the Thai baht, Malaysian ringgit, Indonesian rupiah, and Korean won

⁸ Baig and Goldfajn (1999) also introduce the argument that the sustained depreciation of the Japanese yen against the US dollar could have external pressure on the Asian countries, similar to rises in the German and the US interest rates that caused the ERM and Mexican peso crises. However, they also point out the problems of this discussion, such as the time lag between the depreciation of the yen and the Asian crises.

⁹ The Thai baht was pegged, the Malaysian ringgit, the Indonesian rupiah, and the Korean won were managed float against weighted baskets of currencies at the end of 1996. The weights of the baskets were undisclosed.

against the US dollar respectively. The figures show that these currencies had been strongly tied to the US dollar in substance before the crisis occurred.

Then, in July 1997, when the Asian crises began, Thailand and Malaysia abandoned their fixed or managed regime and Indonesia expanded the trading band of the rupiah exchange rate. However, because of the massive speculative pressure, the Indonesian rupiah was also floated in the next month. In November, the Korean won was also exposed to the speculative pressure, and it was shifted to the floating regime in the same month. As a consequence of the abandonment of the fixed or managed regimes, the Thai baht, Malaysian ringgit, Indonesian rupiah, and Korean won depreciated against the US dollar by 45%, 35%, 47%, and 48% respectively by the end of 1997.

3-2. Direction of trade

Another noticeable issue regarding these countries is direction of international trade. Table 1 shows the direction of trade of Thailand, Malaysia, Indonesia, and Korea. The table shows that these countries had very close relationships with the United States and Japan. Although their currencies were strongly tied to the US dollar, the change in the Japanese economic condition could have had an equally serious impact on these countries as the US economy. The fluctuation of the Japanese yen exchange rate against the US dollar could also have had a strong impact on those Asian economies.

3-3. Fluctuation of the Japanese yen

Figure 5 displays the movement of the nominal exchange rate of the Japanese yen against the US dollar between 1990 and 1998. The figure shows the appreciation of the yen

against the US dollar during the first half of the 1990's and its sharp depreciation beginning in the middle of 1995¹⁰. Because of the depreciation of the yen against the US dollar, the Asian currencies pegged to the US dollar began to appreciate against the Japanese yen. Figures 6, 7, 8, and 9 show the appreciations of the Asian currencies against the Japanese yen in 1995, 1996, and the first half of 1997. These appreciations were supposed to eliminate the competitive edge of international trade in those countries.

4. Model

The following sections discuss a simple three country framework of currency crises to illustrate the role of external shocks from foreign countries.¹¹ To introduce the change of speculators' expectations, this paper applies the methodology of the second generation currency crisis model in addition to the framework of the first generation model.

My model is a stochastic, discrete-time, partial equilibrium model, which focuses on the balance of payment account of a home country, where output is given and prices are constant. We relax some of the restrictive assumptions of the previous models such as PPP and allow for imperfect capital mobility and substitution of assets. The final form of the model estimates the probability of currency devaluation.

The model starts with an assumption that a currency crisis occurs when the foreign reserve declines below some critical level. This trigger-concept of crisis is consistent with the standard type first generation model. We begin the discussion with a component of the change in the foreign reserve in a simple balance of payment framework.

¹⁰ The yen's depreciation in 1995 was caused by economic recession in Japan, and the change in the government policy that stimulated the capital outflow from Japan.

¹¹ This paper employs the classical type three country framework, such as Argy, McKibbin, and Siegfloff (1989). Masson (1998) uses the three country framework to analyze the contagion effect.

4-1. Balance of Payments

In this model, *the change in the foreign reserve* is defined as follows:

$$R_{t+1} - R_t = T_{t+1} + K_{t+1} \quad (1)$$

where R_t is the foreign reserve at time t , T_{t+1} is the trade balance at time $t+1$, and K_{t+1} is the capital account balance at time $t+1$.

Some of the second generation models, such as Masson (1998), introduce the foreign reserve into the model. The difference of my model from Masson's model is the introduction of the capital account term, and the broader focus on capital movements as compared with Masson's model, which analyzes the influence of an external debt and its interest payment.

The model defines *the trade balance* as:

$$T_{t+1} = T(Q_t^a, Q_t^b) = c_0 + c_a Q_t^a + c_b Q_t^b + \varepsilon_{t+1}^T \quad (2)$$

where c_0 and c_e are constant parameters, Q_t^a and Q_t^b are real exchange rates of a home country against foreign countries "a" and "b", the model assumes country "a" is the largest trade partner, and country "b" is the second largest trade partner. Since prices are constant in this model, Q_t^a and Q_t^b are equal to their nominal rates. ε_{t+1}^T is a stochastic error term which is assumed to be an i.i.d shock, and all the variables are in natural log forms. Thus, we can rewrite Eq. (2) as:

$$T_{t+1} = c_0 + c_a e_t^a + c_b e_t^b + \varepsilon_{t+1}^T \quad (3)$$

where e_t^a and e_t^b are nominal exchange rates of domestic currency against foreign countries “a” and “b” and they are domestic currency prices of foreign currencies.

Next, *the capital account* is defined as follows:

$$\begin{aligned} K_{t+1} &= K(r_t, r_t^a, r_t^b, \theta_t, \dot{e}_t^a, \dot{e}_t^b) \\ &= \alpha_0 + \alpha_r r_t - \alpha_{ra} r_t^a - \alpha_{rb} r_t^b - \alpha_\theta \theta_t - \alpha_{ea} \dot{e}_t^a - \alpha_{eb} \dot{e}_t^b + \varepsilon_{t+1}^K \end{aligned} \quad (4)$$

where r_t , r_t^a , and r_t^b are real returns on capital in home and foreign countries, θ_t is the risk premium of domestic currency, \dot{e}_t^a and \dot{e}_t^b are the expected devaluation rates of “ e_t^a ” and “ e_t^b ”, and ε_{t+1}^K is a stochastic error term which is an i.i.d shock. All the variables are in natural log forms except for the returns on capital.

Because investors take account of risks in this model, a risk premium component also affects the capital account. We follow the literature on the portfolio balance approach to define the risk premium θ_t as $\theta_t = D_t / (D_t^a + D_t^b)$. The standard PBA theories employ the outstanding stocks of government debts as determinants of the risk premium.¹² However, regarding the Asian currency crises, countries’ external debts may play a more important role than government debts, thus this model uses external debts for the determinants of the risk premium. Accordingly, θ_t depends on the outstanding stocks of external debts of a

¹² Flood, Garber and Kramer (1996), Flood and Marion (1996, 2000) introduce this risk premium term into their first generation models.

domestic country (D_t) and foreign countries (D_t^a and D_t^b), which are denominated by the US dollar.

Expected rate of devaluation and shift in the expectation

The capital account of this model includes the expected rates of devaluation \dot{e}_t^a and \dot{e}_t^b , which play an essential role in several currency crisis models. Some of the standard type second generation models (Obstfeld, 1996, Flood and Marion, 1998, Jeanne, 2000) assume that they are discrete shift variables such as $\dot{e}_t^a = 0$ or $\dot{e}_t^a = \dot{e}^a$, where \dot{e}^a is the expected amount of devaluation. The concept of this discrete shift is linked to an assumption of a discrete change in the expectations of private agencies.

Now, we suppose that the domestic currency is fixed to country a's currency, while it is floating against country b's currency. Regarding fixed exchange rate e_t^a , we assume that its expected rate of devaluation is determined as $\dot{e}_t^a = d_t \dot{e}^a$, where d_t is the devaluation expectation that is alternately $d_t=1$ for devaluation expectation occurring and $d_t=0$ for no devaluation occurring. \dot{e}^a is the expected size of devaluation.

Since exchange rates e_t^a and e_t^b are decomposed as:

$$\begin{aligned} e_t^a &= e_t^b + e_{b,t}^a \\ e_t^b &= e_t^a - e_{b,t}^a, \end{aligned} \tag{5}$$

we can assume that the expected change in floating exchange rate e_t^b is determined as $\dot{e}_t^b = \dot{e}_t^a - \dot{e}_{b,t}^a = d_t \dot{e}_t^a - \dot{e}_{b,t}^a$, where $e_{b,t}^a$ is the nominal exchange rate of country b's currency against country a's currency (domestic currency price of the foreign currency). If we suppose that a home country is some Southeast Asian country, then country "a" is the US and country "b" is Japan. In this case, $e_{b,t}^a$ is the exchange rate of the Japanese yen against the US dollar (or the yen price of one US dollar.)

Regarding the change in $e_{b,t}^a$, we assume that investors' expectations are formed as $\dot{e}_{b,t}^a = \beta[e_{b,t}^a - f(r_t^a, r_t^b)]$, where $f(r_t^a, r_t^b)$ is the exogenous determinant of the exchange rate that depends on current fundamentals (real returns of capital) of two countries.¹³ Accordingly, the expected change in floating exchange rate e_t^b becomes:

$$\dot{e}_t^b = d_t \dot{e}_t^a - \beta[e_{b,t}^a - f(r_t^a, r_t^b)] = d_t \dot{e}_t^a - \beta e_{b,t}^a + \beta f_a r_t^a - \beta f_b r_t^b$$

and Eq. (4) is rewritten as:

$$K_{t+1} = K_{f,t+1} - \alpha_e d_t \dot{e}_t^a \quad (6)$$

¹³ We modify the stochastic Cagan model for exchange rate expectations, introduced by Obstfeld and Rogoff (1996): $f_t - e_t = -\alpha(E_t e_{t+1} - e_t)$, where the expected change in the exchange rate ($E_t e_{t+1} - e_t$) is a function of current exchange rate e_t and exogenous fundamental f_t .

where $K_{f,t+1} = \alpha_0 + \alpha_r r_t - (\alpha_{ra} + \alpha_{eb} \beta f_a) r_t^a - (\alpha_{rb} - \alpha_{eb} \beta f_b) r_t^b - \alpha_\theta \theta_t + \alpha_{eb} \beta e_{b,t}^a + \varepsilon_{t+1}^K$ and $\alpha_e = \alpha_{ea} + \alpha_{eb}$. We can assume that the first part of Eq. (6), $K_{f,t+1}$, is a fundamental component, and the second part $\alpha_e d_t \dot{e}_t^a$ is an expectation component of the capital account.

Devaluation decision

Using components of the capital account in Eq. (6), Eq. (1) is changed to $R_{t+1} - R_t = T_{t+1} + K_{f,t+1} - \alpha_e d_t \dot{e}_t^a$. The basic assumption of the model is that a currency crisis occurs when the foreign reserve declines below some critical level. Assuming \bar{R} as a critical level of foreign reserve, we can suppose that a country would devalue its fixed exchange rate if $R_{t+1} < \bar{R}$. Accordingly:

$$\begin{aligned} R_{t+1} - R_t &< \bar{R} - R_t \\ T_{t+1} + K_{f,t+1} - \alpha_e d_t \dot{e}_t^a &< \bar{R} - R_t \\ T_{t+1} + K_{f,t+1} + R_t - \bar{R} - \alpha_e d_t \dot{e}_t^a &< 0. \end{aligned}$$

Letting:

$$b_{t+1} = T_{t+1} + K_{f,t+1} + R_t - \bar{R} \quad (7)$$

$$a = \alpha_e \dot{e}_t^a,$$

then if

$$b_{t+1} - a d_t < 0, \quad (8)$$

the country devalues its fixed exchange rate. This formula is identical to Jeanne's (1997) second generation model in which " b_{t+1} " is "gross benefit of the fixed peg" and " $b_{t+1} - ad_t$ " is its net benefit. In my model, similar to the Jeanne's model, " b_{t+1} " is a fundamental based variable, while " ad_t " is formed by expectations. This three country model starts with the same assumption as the first generation model that assumes the exhaustion of the reserve brings about a crisis; however, it has a similar characteristic to the second generation model.

4-2. Devaluation probability

Using (8), we assume that the probability of devaluation (π_t) is determined as follows:

$$\pi_t = \text{Pr ob}(b_{t+1} - ad_t < 0). \quad (9)$$

In line with Jeanne's (1997), we suppose that the fundamental b_{t+1} is defined as $b_{t+1} = E_t b_{t+1} + \varepsilon_{t+1}$, where $E_t b_{t+1}$ is an expected fundamental of b_{t+1} which is formed by private agencies at time t , and an innovation term ε_{t+1} is normally distributed with a mean of zero and a variance of σ^2 . Accordingly, Eq. (9) is rewritten as:

$$\begin{aligned} \pi_t &= \text{Pr ob}(ad_t - E_t b_{t+1} - \varepsilon_{t+1} > 0) \\ \pi_t &= \text{Pr ob}(ad_t - E_t b_{t+1} > \varepsilon_{t+1}) \\ \pi_t &= F(ad_t - E_t b_{t+1}). \end{aligned} \quad (10)$$

$F(ad_t - E_t b_{t+1}) = F(\cdot)$ is the cumulative distribution function of a normal distribution with a variance of σ^2 .¹⁴

4-3. Depreciation of the third currency and the probability of currency collapse

To analyze the effect of a depreciation of the second trade partner's currency, we reconsider the components of the trade balance in Eq. (3). Using Eq. (5), we can rewrite the equation of the trade balance (3) as:

$$T_{t+1} = c_0 + c_e e_t^a - c_b e_{b_t}^a + \varepsilon_{t+1}^T \quad (11)$$

where for simplicity, we assume $c_a + c_b = c_e$.

Eventually, substituting Eq. (11) for Eq. (7), we obtain the fundamental term " b_{t+1} " for the three country model:

$$b_{t+1} = (c_0 + c_e e_t^a - c_b e_{b_t}^a) + [\alpha_0 + \alpha_r r_t - (\alpha_{ra} + \alpha_{eb} \beta f_a) r_t^a - (\alpha_{rb} - \alpha_{eb} \beta f_b) r_t^b - \alpha_\theta \theta_t + \alpha_{eb} \beta e_{b_t}^a] + R_t - \bar{R} + \varepsilon_{t+1}$$

where $\varepsilon_{t+1} = \varepsilon_{t+1}^T + \varepsilon_{t+1}^K$, and the expected fundamental is:

¹⁴ The slope of the F curve is $Slope = \frac{\Delta F(\cdot)}{\Delta E_t b_{t+1}} = \frac{\Delta F(\cdot)}{\Delta(\cdot)} \cdot \frac{\Delta(\cdot)}{\Delta E_t b_{t+1}} = f(\cdot) \times (-1) = -f(\cdot)$, where $(\cdot) = (ad_t - E_t b_{t+1})$, and $f(\cdot)$

is the density function of $F(\cdot)$, which is $f(\cdot) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2} \left(\frac{ad_t - E_t b_{t+1}}{\sigma} \right)^2} > 0$ ($\pi = 3.141592\dots$). Consequently

$slope = \frac{\partial F(\cdot)}{\partial E_t b_{t+1}} < 0$, where $F(\cdot)$ is decreasing with $E_t b_{t+1}$, and there is a negative effect of the fundamental

component on the probability of the devaluation. In addition, Eq. (10) also indicates that an increase in ad_t , which is the higher devaluation expectation, raises the probability of a currency crisis. The possibility of multiple equilibria in this model is discussed in Appendix 1.

$$E_t b_{t+1} = b_{t+1} - \varepsilon_{t+1}. \quad (12)$$

We can now derive the effect of a depreciation of the second trade partner's currency on the probability of the currency collapse [Eq. (10)]:

$$\begin{aligned} \frac{\partial \pi_t}{\partial e_{bt}^a} &= \frac{\partial F}{\partial E_t b_{t+1}} \cdot \frac{\partial E_t b_{t+1}}{\partial T_{t+1}} \cdot \left(\frac{\partial T_{t+1}}{\partial e_{bt}^a} + \frac{\partial K_{f,t+1}}{\partial e_{bt}^a} \right) > 0 \quad \text{if } \frac{\partial T_{t+1}}{\partial e_{bt}^a} + \frac{\partial K_{f,t+1}}{\partial e_{bt}^a} < 0 \\ &< 0 \quad \text{if } \frac{\partial T_{t+1}}{\partial e_{bt}^a} + \frac{\partial K_{f,t+1}}{\partial e_{bt}^a} > 0. \end{aligned}$$

where $\frac{\partial F}{\partial E_t b_{t+1}} < 0$, $\frac{\partial E_t b_{t+1}}{\partial T_{t+1}} > 0$, $\frac{\partial T_{t+1}}{\partial e_{bt}^a} < 0$, $\frac{\partial K_{f,t+1}}{\partial e_{bt}^a} > 0$. If the competitive depreciation effect

($\frac{\partial T_{t+1}}{\partial e_{bt}^a} = -c_b e_{bt}^a < 0$) dominates the capital account effect ($\frac{\partial K_{f,t+1}}{\partial e_{bt}^a} = \alpha_{eb} \beta > 0$), the depreciation of e_{bt}^a

(increase in e_{bt}^a) raises the probability of currency collapse.

4- 4. Linearization of the probability equation

This section linearizes the probability equation (10) following Jeanne and Masson (2000).

Transition probability

First, we obtain a reduced form for the expected fundamental $E_t b_{t+1}$ by rearranging Eq. (12) with respect to all the economic variables:

$$E_t b_{t+1} = (c_0 + \alpha_0 - \bar{R}) + \alpha_r r_t - (\alpha_{ra} + \alpha_{eb} \beta f_a) r_t^a - (\alpha_{rb} - \alpha_{eb} \beta f_b) r_t^b - \alpha_\theta \theta_t + c_e e_t^a - (c_b - \alpha_{eb}) \beta e_{b,t}^a + R_t \quad (13)$$

Next, we take the constant term $(c_0 + \alpha_0 - \bar{R})$ from Eq. (13) and generate the following two variables:

$$A_t = ad_t - (c_0 + \alpha_0 - \bar{R})$$

$$M_t = \alpha_r r_t - (\alpha_{ra} + \alpha_{eb} \beta f_a) r_t^a - (\alpha_{rb} - \alpha_{eb} \beta f_b) r_t^b - \alpha_\theta \theta_t + c_e e_t^a - (c_b - \alpha_{eb}) \beta e_{b,t}^a + R_t \quad (14)$$

where A_t is a constant term depending on the expectations of private agencies, while M_t depends on the economic fundamentals. Accordingly, the probability equation (10) becomes $\pi_t = F(A_t - M_t) = F(A_t, M_t)$.

Next, we assume that s_t is the state variable and the transition across the states, i.e. $s_t=1$ (no devaluation expectation, $d_t=0$) to $s_t=2$ (devaluation expectation, $d_t=1$), follows a Markov process which is not correlated with the fundamentals. We also represent the state transition probability from current to the future as $\theta(s_t, s)$. For example, $\theta(1,2)$ stands for the probability from no devaluation expectation (current) to devaluation expectation (future).

Now, we can assume the devaluation probability is the sum of the two devaluation probabilities weighted by the two transition probabilities $\theta(s_t, 1)$ and $\theta(s_t, 2)$:

$$\pi_t = \theta(s_t, 1)F(A_1, M_t) + \theta(s_t, 2)F(A_2, M_t)$$

$$\pi_t = \sum_{s=1}^n \theta(s_t, s) F(A_s, M_t), \quad (n=2) \quad (15)$$

where $A_1 = -(c_0 + \alpha_0 - \bar{R})$ and $A_2 = a - (c_0 + \alpha_0 - \bar{R})$, and the devaluation probability depends jointly on the state and fundamental variables.¹⁵

Linearization

Next, we assume that the fundamental term M_t is characterized as $M_t = K' X_t + \eta_t$, where $K = (K_1, K_2, \dots)$ is a coefficient vector and $X_t = (X_{1t}, X_{2t}, \dots)$ is a vector of the economic fundamentals. η_t is an exogenous shock on the economic fundamentals which is assumed to be i.i.d. Assuming that the fluctuations of A_t and M_t are small and using a Taylor expansion, the probability equation (15) for π_t is linearized as $\pi_t = \mu_{s_t} - B' X_t + v_t$.¹⁶

We estimate the state dependent constant term μ_{s_t} by the Markov switching model (MSM).¹⁷

5. Estimation of the model

5-1. Data and variables

¹⁵ In this model, the transition process across the states is represented by the 2×2 transition probability matrix or the Markov matrix $\Theta = \begin{pmatrix} \theta(1,1) & \theta(1,2) \\ \theta(2,1) & \theta(2,2) \end{pmatrix}$.

¹⁶ The small fluctuations of A and M are given by the following assumption: $A_s = \bar{A} + \frac{dA_s}{dt}$, $M_t = \bar{M} + \frac{dM_t}{dt}$.

The Taylor expansion provides: $\mu_{s_t} = F(\bar{A}, \bar{M}) + F_A(\bar{A}, \bar{M}) \sum_{s=1}^n \theta(s_t, s) \frac{dA_s}{dt} - F_M(\bar{A}, \bar{M}) \bar{M}$, $B' = -F_M(\bar{A}, \bar{M}) K'$,

$v_t = F_M(\bar{A}, \bar{M}) \eta_t$. The detail of the Taylor expansion is in Appendix 2.

¹⁷ This paper uses the fixed transition probability (FTP) Markov switching model with an AR(1) process. To estimate the Markov switching model, we use the method of maximum likelihood estimated by the Solver function of the Microsoft Excel following the algorithms developed by Hamilton (1989) and Lam (1990).

The main data source of this analysis is the IMF international financial statistics. Regarding government debts of Japan, the data are collected from the BOJ web-site. The empirical analysis is based on monthly data and the experimental period is from January 1990 to December 1997. Accordingly, each country has 96 samples. The model attempts to analyze the currency crises of Thailand, Malaysia, Indonesia, and Korea. Since some of the variables are only available for quarterly base, the linear conversion procedure is applied for them.

Devaluation probability

In order to analyze the determinants of currency crises, the previous literature uses three different types of dependent variables, “estimated devaluation probability” (Jeanne and Mason, 2000), “composite index of market pressure” (Cerra and Saxena, 2000), and “0-1 type binomial variable expressing either crush or non-crush of currency”(Frankel and Rose, 1996).¹⁸ This paper uses the devaluation probability, which is computed by the drift adjustment method.¹⁹ Figure 3 shows the movements of the devaluation probabilities of the Asian countries between 1990 and 1997.

Explanatory variables

Regarding the fundamental term M_t , which is defined by Eq.(14), we assume that the nominal exchange rate e_t^a is fixed ($\Delta e_t^a=0$) and also set $e_t^a=0$. Accordingly:

¹⁸A number of researchers suggest that 0-1 type binomial variables do not reflect unsuccessful attacks on currencies. Regarding the composite index of market pressure, Eliasson and Kreuter (2001) point out that including international reserves into currency crisis measures is not relevant because reserve data tend to reflect fluctuations in monetary instrument or changes in reserves caused by non-crisis-driven events, such as repayments of external debts.

¹⁹ See Appendix 3 for the explanation of the drift adjustment method.

$$M_t = \alpha_r r_t - (\alpha_{ra} + \alpha_{eb} \beta f_a) r_t^a - (\alpha_{rb} - \alpha_{eb} \beta f_b) r_t^b - \alpha_\theta \theta_t - (c_b - \alpha_{eb}) \beta e_{b,t}^a + R_t,$$

where r_t, r_t^a and r_t^b are real returns of capital in domestic and foreign countries "a" and "b", $e_{b,t}^a$ is a nominal exchange rate of country b's currency against country a's currency, R_t is foreign reserve, θ_t is a risk premium (relative external debt) that is defined as $\theta_t = D_t / (D_t^a + D_t^b)$, where D_t, D_t^a , and D_t^b are outstanding external debts of domestic and foreign countries "a" and "b" denominated in USD.²⁰ All the variables are in natural log form except for real returns.

The expected effects of the variables are:

$$\frac{\partial \pi_t}{\partial r_t} < 0, \frac{\partial \pi_t}{\partial r_t^a} > 0, \frac{\partial \pi_t}{\partial r_t^b} > 0, \frac{\partial \pi_t}{\partial \theta_t} > 0, \frac{\partial \pi_t}{\partial e_{b,t}^a} > 0 \text{ (or } \frac{\partial \pi_t}{\partial e_{b,t}^a} < 0), \frac{\partial \pi_t}{\partial R_t} < 0.$$

In this analysis, as the previous section discussed, a home country is a small East Asian country, country "a" is the United States, and country "b" is Japan.

Regarding the Japanese capital return, we can also expect a negative sign with respect to its coefficient ($\frac{\partial \pi_t}{\partial r_t^b} < 0$) when $(\alpha_{rb} - \alpha_{eb} f_b) < 0$. If spillover effects that spread from Japan to East Asian countries occur, the value of α_{rb} tends to be small or can be negative. In this case, a decline in the Japanese capital return is more likely to raise the probability of capital outflow from these countries, as well as the probability of a currency crisis.

²⁰ External debts = Government external debts + Private external debts. Private external debt = Deposit bank foreign liabilities + Other financial institute foreign liabilities

We should note that the real interest rate, which is generally used as one of the independent variables in the previous studies, could have an endogeneity problem with components of the dependent variables. Therefore, the paper uses the MPK (Marginal product of capital) as a proxy estimated by the methodology introduced by Lucas (1990).²¹

Since the level of foreign reserves R_t is highly correlated with other variables, the paper also uses the ratio of foreign reserves to monthly imports for the remedy to the multicollinearity problem.

5-2. Estimated Results

Thailand

The first empirical analysis of the probability of devaluation uses the maximum likelihood estimation (MLE), which employs purely fundamental variables and one intercept. The results of the MLE for Thailand are shown in the second column of Table 2. It demonstrates that the Thai and Japanese capital returns, the relative external debt, and foreign reserves have the estimated signs in their coefficients, and both capital returns are statistically significant with a 5% level. The results show that decreases in both Thai and Japanese capital returns significantly increased the probability of devaluation of the Thai baht. It also indicates a significant influence of a spillover effect from the Japanese to the Thai economy. The top panel of Figure 4 shows the probability of devaluation estimated by the MLE. It seems to capture most movements of the actual probability obtained by the drift adjustment method; however, it does not effectively explain the actual probability during the speculative attack period in 1997.

²¹ This paper employs the modified version of MPK based on the discussion of Mankiw (2002). The methodology of estimation of the marginal product of capital is discussed in Appendix 4.

The second estimation of the probability of devaluation uses the Markov switching model. The second column of Table 3 shows the results of the estimation. The statistics for goodness-of-fit are much better than those of the MLE, such as lower mean squared error (MSE) and standard error (σ), and higher Log-likelihood. The estimated two intercepts, μ_0 for a non-devaluation state, and μ_1 for a devaluation state, have substantially different values, and the results indicate that the change in speculators' expectations increases the probability of devaluation by 58%. The estimated probability of remaining in a non-devaluation state [$Prob(00)$], vs. a devaluation state [$Prob(11)$] are 0.9926 and 0.9931. The numbers indicate that both states are adequately stable. The column also shows that all the economic fundamentals have the estimated signs for their coefficients and all of them are statistically significant with a 5% level. Similar to the MLE, the effects of the Thai and Japanese capital returns are most significant among them. The positive coefficient of the Japanese yen indicates that the significant effect of the yen's competitive depreciation raised the probability of devaluation of the baht. Remarkably, the sizes of t-statistics for all the variables are significantly higher than those of the MLE.

The middle panel of Figure 4 shows the estimated probability of devaluation, which effectively captures the movement of the actual probability including the speculative attack period in 1997. The bottom panel of Figure 4 shows the probability of state 1, and it indicates that the speculators' expectation for devaluation was high from July to December in 1997.

Malaysia

The results of the MLE for Malaysia are shown in the third column of Table 2. They have the expected signs for all the economic fundamentals except for the relative external debt, although none of them is statistically significant. The top panel of Figure 5 shows the estimated probability of devaluation, which does not capture the movement of the actual probability during the speculative attack periods in 1993 and 1997.

The estimated results for the Markov switching model are presented in the third column of Table 3. The estimated two intercepts, μ_0 and μ_1 , have substantially different values, and the results indicate that the change in the expectations increases the probability of devaluation by about 66%. The estimated probabilities [*Prob(00)*] and [*Prob(11)*] are 0.9785 and 0.3333, and the numbers indicate that the devaluation state is not as stable as the non-devaluation state. The table also shows that all the economic fundamentals, except for the relative external debt, have the estimated signs for their coefficients, and the Malaysian capital return and the Japanese yen exchange rate are statistically significant with a 5% level. Similar to the Thai case, most absolute t-values are higher than those of MLE. The positive effect of the Japanese yen indicates that the competitive depreciation of the yen raised the probability of devaluation of the ringgit.

The middle panel of Figure 5 shows the estimated probability of devaluation, which effectively captures the movement of the actual probability including the speculative attack periods. The bottom panel of Figure 5 shows the probability of state 1. Similar to the Thai case, the speculators' expectations for devaluation increased in August 1997. However, the Malaysian ringgit was also under speculative pressure at the end of 1993 when a natural tragedy (caused by a tropical storm) damaged the Malaysian economy.

Indonesia

The results of the MLE for Indonesia are shown in the fourth column of Table 2. They have the expected signs only for the relative external debt and none of the variables has statistical significance. The top panel of Figure 6 shows the estimated probability of devaluation, which does not capture the movement of the actual probability during the speculative attack period in 1997.

The estimated results for the Markov switching model are presented in the fourth column of Table 3. Similar to the previous two countries, the statistics for goodness-of-fit are better than those of the MLE. The two estimated intercepts, μ_0 and μ_1 , also have substantially different values, and the results indicate that the change in the speculators' expectations increases the probability of devaluation by about 76%. The estimated probability of the regime remaining in a non-devaluation state [$Prob(00)$], vs. a devaluation state [$Prob(11)$] are 0.9783 and 0.7500. The numbers indicate that both states are stable. The table also demonstrates that the economic variables do not effectively explain the devaluation probability unlike the two intercepts and the AR term. We can assume that the change in the speculators' expectations plays a more important role than these economic fundamentals in the Indonesian rupiah crisis.

The middle panel of Figure 6 shows the estimated probability of devaluation, which effectively captures the movement of the actual probability including the speculative attack period. The bottom panel of Figure 6 shows the probability of state 1. The speculators' expectation for devaluation increased in July and September 1997, and the devaluation state continued until December.

Korea

The results of the MLE for Korea are shown in the fifth column of Table 2. They have the expected signs for all the fundamentals, but none of them is statistically significant. The top panel of Figure 7 shows the estimated probability of devaluation, which does not effectively explain the movement of the actual probability during the speculative attack period.

The estimated results for the Markov switching model are presented in the fifth column of Table 3. Similar to the previous countries, the statistics of goodness-of-fit are better than those of the MLE. The estimated two intercepts, μ_0 and μ_1 , have substantially different values, and the results indicate that the change in the expectations increases the probability of devaluation by about 65%. However, the statistical significance of the two intercepts μ_0 and μ_1 is relatively low compared with the previous three countries, and it indicates that the speculative-expectation change does not convincingly explain the probability of devaluation. The estimated probability of remaining in state 0 [$Prob(00)$] is 0.9681, and the number indicates that the non-devaluation state is adequately stable, but the probability of remaining in state 1 [$Prob(11)$] is 0.0001, and it suggests that the devaluation state is extremely unstable. The table also shows that the results have the expected signs for all the economic fundamentals, and the Japanese capital return, the relative external debt, and the Japanese yen exchange rate are statistically significant. The spillover effect of the decline in the Japanese capital return and the yen's competitive depreciation effect are also confirmed. We can assume that the Japanese variables played important roles in the won crisis.

The middle panel of Figure 7 shows the estimated probability of devaluation, which effectively captures the movement of the actual probability including the speculative attack period. The bottom panel of Figure 7 shows the probability of state 1. The speculators' expectations for devaluation increased in October and December 1997, and it had a three-month lag behind the former three Southeast Asian countries. Unlike the former countries, the devaluation state did not last long, which was also indicated by the low probability of remaining in state 1. In addition to these 1997 movements, the Korean won was also under speculative pressure in the beginning of 1996, right after the Japanese yen started its rapid depreciation.

Over all, the empirical analysis using the Markov switching model finds significant effects of changes in speculators' expectations, which are indicated by the two substantially distinct intercepts. Declines in the domestic and Japanese capital returns, and depreciation in the Japanese yen against the US dollar contributed to increases in the probabilities of currency crises for most of the countries except for Indonesia. The results confirm the significant spillover and competitive-depreciation effects of the Japanese variables. The US capital return and the foreign reserves also had expected effects on the crises although they were not statistically significant. However, the relative external debt did not have the expected positive effect on the probability of crises occurring for half of the countries. The next section explores a possible reason for this finding.

5-3. Decomposition of external debt and contagion effects

The unexpected negative sign may be due to the fact that the debt measures are denominated in dollars. The change in the value of the currencies may be offsetting the change in the debt measures in domestic currency. We can see this argument by the external debt measure $\theta_t = D_t / (D_t^a + D_t^b)$, which is expressed in USD.

We now express this relative debt measure using domestic-currency-denominated external debts d_t , d_t^a , and d_t^b , instead of the US dollar-denominated external debts D_t , D_t^a , and D_t^b :

$$\theta_t = (d_t / e_t^a) / (d_t^a + d_t^b / e_{at}^b) \quad (16)$$

where d_t , d_t^a , and d_t^b are debt measures denominated by respective domestic currencies, e_t^a is the nominal exchange rate of a domestic currency against country a's currency, and e_{at}^b is the nominal exchange rate of country b's currency against country a's currency. Eq.(16) indicates that d_t has a positive effect and e_t^a has a negative effect on the relative external debt θ_t .²² Thus, a depreciation of a domestic currency (an increase in e_t^a) causes a decrease in the relative external debt measure. Therefore, even if the domestic-currency-denominated external debt d_t grows, the risk premium does not necessarily increase as long as the depreciation effect dominates the growth of the domestic-currency-denominated external debt. In fact, if the depreciation is strong enough, this risk premium measure could even decline.

Figures 8-11 graphically support this line of reasoning. In all countries, although the domestic-currency-denominated external debt continues to expand during the currency crisis

²² $\frac{\partial \theta_t}{\partial d_t} = \frac{1/e_t^a}{d_t^a + d_t^b / e_{at}^b} > 0$, $\frac{\partial \theta_t}{\partial e_t^a} = -\frac{d_t / (e_t^a)^2}{d_t^a + d_t^b / e_{at}^b} < 0$.

period (bottom panel of each figure), the risk premium term does not necessarily increase (top panel of each figure). In most cases, the depreciation effect (bold broken line in the middle panels) dominates the growth of the domestic-currency-denominated external debt (solid line in the middle panels). The figures thus give an indication to why the risk premium does not have a clear positive effect on the probability of a currency crisis for half of the countries.

Contagion effects and causality test

The estimated results of the Markov switching model in the previous section also provide a picture of the contagion effects among the four countries. The estimated changes in speculators' expectations (bottom panels of Figures 4, 5, 6, and 7) could demonstrate that during the 1997 crisis period, the speculative-expectation change began in Thailand at first, followed by Malaysia and Indonesia in the next month, and the change in the speculative expectation in Korea arose three months later.

To investigate causal relations of these expectation changes, we conduct Granger causality tests on speculative-expectation changes between these countries. The results confirm the causalities in the following direction: 1) from Thailand to Malaysia, Indonesia, and Korea, 2) from Malaysia to Indonesia and Korea, 3) from Indonesia to Malaysia (significant only for the lag 2 test) and Korea, 4) there is no causal relation from Korea to any country (Table 4).

These causal relations also support the discussions of the previous literature about the contagion effects on the Asian crises, which especially emphasize the role of the Thai crisis as a wakeup call to other countries in the region.

6. Conclusion

This paper attempts to analyze effects of three different categories of factors—domestic economic fundamentals, external economic shocks, and change in speculators' expectations—on the collapse of currency regimes in Asian countries. The paper constructs a three country framework of currency crises to investigate external economic shocks. Applying the concepts of both the first and second generation currency crisis models, effects of changes in speculators' expectations are theoretically explained.

The empirical analysis using the Markov switching model finds significant effects of changes in the speculators' expectations, which are indicated by two substantially distinct intercepts. The domestic and Japanese capital returns and the Japanese yen exchange rate against the US dollar also contribute to the variation in the devaluation probabilities in most of the countries.

The paper also conducts an investigation into the relationship between the external debts and the currency crises. It demonstrates that the rapid depreciation of domestic currencies could have offset increases in the domestic-currency-denominated external debts, and the risk premium of the currencies does not necessarily have a positive influence on the probabilities of the currency crises. These results provide an additional direction of research into the debt-related currency crises discussion.

The Granger causality test results provide a picture of the contagion effect spreading from Thailand to Malaysia, Indonesia, and Korea. These estimated speculative-expectations also support the discussions of the previous literature on the contagion and monsoonal effects on the Asian crises.

Appendix 1. Multiple equilibria

Assuming that ad_t stays the same in Eq. (11), Figure 12 shows the change in $F(\cdot)$ with respect to the change in the expected fundamental $E_t b_{t+1}$. The slope of the F curve is:

$$\text{Slope} = \frac{\Delta F(\cdot)}{\Delta E_t b_{t+1}} = \frac{\Delta F(\cdot)}{\Delta(\cdot)} \cdot \frac{\Delta(\cdot)}{\Delta E_t b_{t+1}} = f(\cdot) \times (-1) = -f(\cdot),$$

where $(\cdot) = (ad_t - E_t b_{t+1})$, and $f(\cdot)$ is the density function of $F(\cdot)$, which is:

$$f(\cdot) = \frac{1}{\sigma\sqrt{2\Pi}} e^{-\frac{1}{2}\left(\frac{ad_t - E_t b_{t+1}}{\sigma}\right)^2} > 0 \quad (\Pi = 3.141592\dots)$$

Consequently:

$$\text{slope} = \frac{\partial F(\cdot)}{\partial E_t b_{t+1}} < 0.$$

The figure also shows $F(\cdot)$ is decreasing with $E_t b_{t+1}$, and we can graphically confirm the negative effect of the fundamental component on the probability of the devaluation.

Next, we focus on the change of ad_t . Figure 13 shows the change in the $F(\cdot)$ curve with respect to different levels of ad_t , where $(ad_t)_1 > (ad_t)_2$. The figure also shows that the higher devaluation expectation, which is an increase in ad_t , raises the probability of a currency crisis. The next figure, Figure 14, indicates that the shift in the expectation term also generates the multiplicity of the solution for $F(\cdot)$ with respect to a given fundamental $E_t b_{t+1}^*$.

However, Figure 15 shows that the multiple solutions exist only if the expected fundamental is narrowed down between the two critical levels of the fundamental, $(E_t b_{t+1})_L$ and $(E_t b_{t+1})_U$, where $(E_t b_{t+1})_L < E_t b_{t+1} < (E_t b_{t+1})_U$. In regard to the discussion of equilibria, we can categorize the following three different levels of the fundamental:

- a) If $E_t b_{t+1} > (E_t b_{t+1})_U$, the country could maintain the fixed exchange rate regime regardless of the change in the expectations of private agencies.
- b) If $E_t b_{t+1} < (E_t b_{t+1})_L$, the country could not maintain the fixed exchange rate regime regardless of the change in the expectations of private agencies.
- c) If $(E_t b_{t+1})_L < E_t b_{t+1} < (E_t b_{t+1})_U$, the devaluation decision would depend on the change in the expectations of private agencies.

In case c), the fixed exchange regime would collapse in a self-fulfilling way. If the private agencies expect no-devaluation, the country could maintain the fixed rate; however, once they change their expectations to "devaluation," the fixed exchange rate would collapse. Consequently, there are two equilibria, $E_t b_{t+1} = (E_t b_{t+1})_U$, and $E_t b_{t+1} = (E_t b_{t+1})_L$, for the decision of devaluation.

Appendix 2. Taylor expansion

The original probability equation is:

$$\pi_t = \sum_{s=1}^n \theta(s, s) F(A_s, M_t), \quad (n=2)$$

Assuming:

$$A_s = \bar{A} + \frac{dA_s}{dt}$$

$$M_t = \bar{M} + \frac{dM_t}{dt}, \quad \left(\frac{dM_t}{dt} = M_t - \bar{M} = K'X_t + \eta_t - \bar{M} \right)^{23}$$

and using the Taylor expansion technique²⁴, we could linearize the probability equation as follows:

$$\pi_t = \sum_{s=1}^n \theta(s_t, s) F(A_s, M_t), \quad (n=2)$$

$$\pi_t = \sum_{s=1}^n \theta(s_t, s) F\left(\bar{A} + \frac{dA_s}{dt}, \bar{M} + \frac{dM_t}{dt}\right)$$

$$\pi_t = F(\bar{A}, \bar{M}) + F_A(\bar{A}, \bar{M}) \sum_{s=1}^n \theta(s_t, s) \frac{dA_s}{dt} + F_M(\bar{A}, \bar{M}) \frac{dM_t}{dt}$$

$$\pi_t = F(\bar{A}, \bar{M}) + F_A(\bar{A}, \bar{M}) \sum_{s=1}^n \theta(s_t, s) \frac{dA_s}{dt} + F_M(\bar{A}, \bar{M})(K'X_t + \eta_t - \bar{M})$$

$$\pi_t = F(\bar{A}, \bar{M}) + F_A(\bar{A}, \bar{M}) \sum_{s=1}^n \theta(s_t, s) \frac{dA_s}{dt} - F_M(\bar{A}, \bar{M})\bar{M} + F_M(\bar{A}, \bar{M})K'X_t + F_M(\bar{A}, \bar{M})\eta_t$$

Letting

$$\mu_{st} = F(\bar{A}, \bar{M}) + F_A(\bar{A}, \bar{M}) \sum_{s=1}^n \theta(s_t, s) \frac{dA_s}{dt} - F_M(\bar{A}, \bar{M})\bar{M}$$

$$B' = -F_M(\bar{A}, \bar{M})K'$$

²³ The formulas indicate that the fluctuations of the fundamental and expectation components are small.

²⁴ $f\left(x + \frac{dx}{dt}\right) = f(x) + f'(x) \frac{dx}{dt}$

$$v_t = F_M(\bar{A}, \bar{M})\eta_t$$

Eventually, the probability equation is linearized as follows:

$$\pi_t = \mu_{st} - B' X_t + v_t$$

Appendix 3. Drift adjustment method

This section presents a modified and simplified version of drift adjustment methodology introduced by Svensson (1993).

A spot exchange rate in the fixed or flexibility-limited regime can be expressed as:

$$e = c + x$$

where e is a spot exchange rate, c is a target exchange rate (or central parity), and x is deviation of the spot exchange rate from its target. Due to unavailability of data on central parity, we use the monthly average of the spot rate as a proxy of c .

The expected rate of change in the spot rate is:

$$E(\Delta e) = E(\Delta c) + E(\Delta x).$$

Accordingly, the change in the target rate, which indicates the rate of devaluation or revaluation, is:

$$E(\Delta c) = E(\Delta e) - E(\Delta x)$$

We assume that the expected rate of devaluation $E(\Delta c)$ can be described by:

$$E(\Delta c) = \text{Probability of devaluation } \pi \times \text{Expected size of devaluation } \delta$$

Therefore, $\pi = E(\Delta c) / \delta$.

Jeanne and Masson (2000) assume the expected size of the devaluation as 0.50 using the average realignment size of the French franc in the 1980's. Regarding the Asian currencies, the Korean won had a 2.25% intervention band, and the Indonesian rupiah had a 5% band before the Asian crises. We use those numbers for δ in terms of Korea and Indonesia. The Thai baht and the Malaysian ringgit did not have this kind of official band. Due to the similarity of the movement of the currencies to the Indonesian rupiah, the paper uses 5% for δ in terms of those two currencies.

In order to calculate the expected rate of devaluation $E(\Delta c)$, estimates for $E(\Delta e)$ and $E(\Delta x)$ are required. The drift adjustment method assumes uncovered interest parity and gets an expression for $E(\Delta e)$. However, the paper assumes imperfect capital mobility, which is more realistic assumption. Hence:

$$E(\Delta e) = f(i - i^*) = a_0 + a_1(i - i^*) + \varepsilon_{t+1}^a,$$

where i is a domestic nominal interest rate and i^* is a foreign nominal interest rate. To compute $E(\Delta x)$, the paper applies a simple OLS on $x_{t+1} - x_t$ defined as:

$$x_{t+1} - x_t = b_0 + b_1 x_t + b_2 x_{t-1} + \varepsilon_{t+1}^b$$

We use the domestic money market rate for i , and the US money market rate for i^* , the end of month spot exchange rate for e and the monthly average for c . We also obtain the OLS estimates to generate $E(\Delta e)$ and $E(\Delta x)$, using the most recent 60 month data.

The expected value of the probability could have outlier numbers such as greater than one ($\pi > 1$) or less than 0 ($\pi < 0$). Since we focus on the probability of devaluation, to make the estimated probability bounded between 0 and 1, we employ the following adjusted probability that is transformed by a simple logit equation:

$$\text{adjusted } \pi_t = \frac{e^{\alpha + \beta \pi_t}}{1 + e^{\alpha + \beta \pi_t}}$$

where α and β are parameters optimized with respect to the fit.

Appendix 4: Estimation of Marginal product of capital (MPK)

We suppose a Cobb-Douglas type production function with a constant return to scale at first:

$$Y = AK^\beta L^{1-\beta} \tag{1}$$

where Y , A , K , and L are output, technology, capital, labor force, respectively. The parameter β is the share of capital and $1-\beta$ is the share of labor. Next, we take a natural log of both sides of the equation:

$$\ln Y = \ln A + \beta \ln K + (1 - \beta)L \quad (2)$$

Assuming constant technology:

$$\Delta \ln Y = \Delta \ln A + \beta \Delta \ln K + (1 - \beta)\Delta L = \beta \Delta \ln K + (1 - \beta)\Delta L.$$

Since $\Delta \ln X \approx \frac{\Delta X}{X}$:

$$\frac{\Delta Y}{Y} = \beta \frac{\Delta K}{K} + (1 - \beta) \frac{\Delta L}{L} \quad (3)$$

$$\Delta Y = \beta \frac{\Delta K}{K} Y + (1 - \beta) \frac{\Delta L}{L} Y \quad (4)$$

where the marginal product of capital is:

$$\frac{\partial Y}{\partial K} = MPK = \beta \frac{Y}{K} \quad (5)$$

Next we rearrange Eq. (3):

$$\beta \frac{\Delta K}{K} = \frac{\Delta Y}{Y} - (1 - \beta) \frac{\Delta L}{L} \quad (6)$$

Multiplying both sides by $\frac{Y}{\Delta K}$:

$$\beta \frac{\Delta K}{K} \cdot \frac{Y}{\Delta K} = \beta \frac{Y}{K} = \frac{Y}{\Delta K} \left(\frac{\Delta Y}{Y} - (1 - \beta) \frac{\Delta L}{L} \right) \quad (7)$$

Letting

$$\Delta K = I(\text{investment}), \quad \frac{\Delta Y}{Y} = \hat{Y}(\text{OutputGrowthRate}), \quad \frac{\Delta L}{L} = \hat{L}(\text{PopulationGrowthRate})$$

and using Eq. (5) and (7), the marginal production of product of capital is eventually determined as:

$$MPK = \beta \frac{Y}{K} = \frac{Y}{I} [\hat{Y} - (1 - \beta)\hat{L}] \quad (8)$$

Accordingly, the real turn on capital (r) is:

$$r = MPK - \delta \quad (9)$$

where δ is a capital depreciation rate. The paper uses Mankiw's (2000) assumption ($\beta=0.3$, $\delta=0.04$) for these parameters.

Table 1. Direction of Trade

Direction of Trade (Mn US dollars; Annual Average)

Thailand

	1990-1998 Average	Weight
<i>Imports, Total</i>	51713.1	100.00%
1. Japan	14656.2	28.34%
2. United States	6296.0	12.17%
3. Singapore	3171.6	6.13%
4. Germany	2652.2	5.13%
5. Malaysia	2253.7	4.36%

	1990-1998 Average	Weight
<i>Exports, Total</i>	43565.6	100.00%
1. United States	8841.7	20.30%
2. Japan	7097.3	16.29%
3. Singapore	4805.6	11.03%
4. Hong Kong, China	2288.1	5.25%
5. Netherlands	1531.4	3.52%

Malaysia

	1990-1998 Average	Weight
<i>Imports, Total</i>	56049.3	100.00%
1. Japan	13857.1	24.72%
2. United States	9334.0	16.65%
3. Singapore	7782.4	13.88%
4. Germany	2366.4	4.22%
5. Korea, Republic of	2332.7	4.16%

	1990-1998 Average	Weight
<i>Exports, Total</i>	57192.0	100.00%
1. Singapore	11761.1	20.56%
2. United States	11157.6	19.51%
3. Japan	7320.4	12.80%
4. Hong Kong, China	2733.9	4.78%
5. United Kingdom	2158.8	3.77%

Indonesia

	1990-1998 Average	Weight
<i>Imports, Total</i>	32008.1	100.00%
1. Japan	6894.4	21.54%
2. United States	3929.4	12.28%
3. Germany	2344.0	7.32%
4. Singapore	2168.8	6.78%
5. Korea, Republic of	1922.9	6.01%

	1990-1998 Average	Weight
<i>Exports, Total</i>	40364.5	100.00%
1. Japan	11258.5	27.89%
2. United States	5518.6	13.67%
3. Singapore	3851.6	9.54%
4. Korea, Republic of	2492.8	6.18%
5. China, People's Republic of	1539.3	3.81%

Korea

	1990-1998 Average	Weight
<i>Imports, Total</i>	105708.4	100.00%
1. Japan	23699.0	22.42%
2. United States	23097.8	21.85%
3. China, People's Republic of	6119.8	5.79%
4. Germany	4758.0	4.50%
5. Saudi Arabia	4441.9	4.20%

	1990-1998 Average	Weight
<i>Exports, Total</i>	105570.0	100.00%
1. United States	20700.3	19.61%
2. Japan	13503.2	12.79%
3. Hong Kong, China	7968.7	7.55%
4. China, People's Republic of	7635.4	7.23%
5. Singapore	4220.6	4.00%

Data source: the Asian Development Bank "Economic Key Indicators"

Table 2. Maximum likelihood estimates of the one-state model

	Thailand	Malaysia	Indonesia	Korea
μ	1.019 (0.650)	-0.880 -(0.302)	2.440 (1.033)	-0.705 -(0.689)
ϕ_1	0.890 ** (2.557)	0.411 (0.356)	0.481 (0.913)	-0.283 -(0.425)
Γ	-1.345 ** -(2.603)	-1.015 -(0.758)	0.028 (0.081)	-0.349 -(0.778)
Γ_{US}	-0.141 -(0.484)	0.287 (0.634)	-0.517 -(1.131)	0.043 (0.198)
Γ_{JP}	-2.627 ** -(2.632)	-0.764 -(0.559)	0.900 (1.188)	-0.569 -(1.269)
θ	0.004 (0.041)	-0.060 -(0.196)	0.667 (1.502)	0.224 (1.610)
$E_{JPY/USD}$	-0.122 -(0.303)	0.191 (0.512)	-0.012 -(0.045)	0.393 (1.308)
R	-0.015 -(0.450)	-0.070 -(0.551)	0.036 (0.788)	-0.034 -(0.771)
σ	0.090	0.120	0.131	0.123
Log-Likelihood	94.420	67.325	59.035	64.984
MSE	0.003	0.004	0.007	0.028

Notes: The estimates are coefficients from the maximum likelihood estimation (MLE), which employs purely fundamental variables and one intercept (μ with AR1 (ϕ_1). The figures in parentheses are the t-statistics. *,** denote the significance at 10 and 5%, respectively. The coefficients in bold have predicted signs.

Table 3. Maximum likelihood estimates of the two-state model (Markov switching model)

	Thailand	Malaysia	Indonesia	Korea
μ_1	0.466 ** (2.306)	-0.951 -(1.184)	1.311 * (1.777)	0.305 (0.604)
μ_0	-0.117 -(0.579)	-1.616 ** -(1.986)	0.548 (0.735)	-0.344 -(0.680)
$\mu_1 - \mu_0$	0.583	0.664	0.763	0.649
ϕ_1	0.916 ** (24.435)	0.220 ** (2.320)	0.598 ** (6.704)	-0.283 ** -(4.269)
γ	-1.753 ** -(23.035)	-0.619 ** -(2.278)	0.156 (1.362)	-0.286 -(0.980)
γ_{US}	0.173 ** (3.731)	0.130 (1.133)	-0.090 -(1.008)	0.047 (0.270)
γ_{JP}	-1.515 ** -(14.047)	-0.626 -(1.564)	0.512 (1.304)	-0.538 ** -(2.692)
θ	0.054 ** (4.075)	-0.185 * -(1.921)	-0.063 -(0.658)	0.087 * (1.923)
$E_{JPY/USD}$	0.184 ** (3.701)	0.178 ** (2.434)	-0.155 -(1.274)	0.194 * (1.940)
R	-0.038 ** -(7.076)	-0.008 -(0.205)	0.003 (0.219)	-0.034 -(0.893)
σ	0.037	0.059	0.051	0.061
$Prob_{(11)}$	0.9931	0.3333	0.7500	0.0001
$Prob_{(00)}$	0.9926	0.9785	0.9783	0.9681
Log-Likelihood	117.668	123.310	137.625	119.545
MSE	0.003	0.004	0.003	0.004

Notes: The estimates are coefficients from the Markov switching model (MSM), which employs fundamental variables and two intercepts: μ_0 for a non-devaluation state, and μ_1 for a devaluation state, with AR1 (ϕ_1). The figures in parentheses are the t-statistics. *,** denote the significance at 10 and 5%, respectively. The coefficients in bold have predicted signs. $Prob(00)$ and $Prob(11)$ denote the probabilities of remaining in a non-devaluation state and a devaluation state, respectively.

Table 4. Granger causality test

(lag length = 1)

Causality Relation: Thailand --->

	F (1, 92)	Prob >F	chi2 (1)	Prob >chi2
Malaysia	19.08 **	0.00	19.70 **	0.00
Indonesia	51.17 **	0.00	52.84 **	0.00
Korea	35.53 **	0.00	36.69 **	0.00

Causality Relation: Malaysia --->

	F (1, 92)	Prob >F	chi2 (1)	Prob >chi2
Thailand	0.01	0.94	0.01	0.94
Indonesia	22.80 **	0.00	23.55 **	0.00
Korea	9.86 **	0.00	10.18 **	0.00

Causality Relation: Indonesia --->

	F (1, 92)	Prob >F	chi2 (1)	Prob >chi2
Thailand	0.00	1.00	0.00	1.00
Malaysia	3.70	0.06	3.82	0.05
Korea	53.25 **	0.00	54.99 **	0.00

Causality Relation: Korea --->

	F (1, 92)	Prob >F	chi2 (1)	Prob >chi2
Thailand	0.01	0.94	0.01	0.94
Malaysia	0.03	0.85	0.04	0.85
Indonesia	1.03	0.31	1.06	0.30

95% Critical F = 3.95

99% Critical F = 6.92

95% Critical chi2 = 3.84

99% Critical chi2 = 6.64

(lag length = 2)

Causality Relation: Thailand --->

	F (2, 89)	Prob >F	chi2 (2)	Prob >chi2
Malaysia	32.28 **	0.00	68.18 **	0.00
Indonesia	27.85 **	0.00	58.83 **	0.00
Korea	18.35 **	0.00	38.76 **	0.00

Causality Relation: Malaysia --->

	F (2, 89)	Prob >F	chi2 (2)	Prob >chi2
Thailand	0.01	0.99	0.01	0.99
Indonesia	11.76 **	0.00	24.84 **	0.00
Korea	11.37 **	0.00	24.01 **	0.00

Causality Relation: Indonesia --->

	F (2, 89)	Prob >F	chi2 (2)	Prob >chi2
Thailand	0.00	1.00	0.00	1.00
Malaysia	6.35 **	0.00	13.41 **	0.00
Korea	18.35 **	0.00	38.75 **	0.00

Causality Relation: Korea --->

	F (2, 89)	Prob >F	chi2 (2)	Prob >chi2
Thailand	0.01	0.99	0.02	0.99
Malaysia	0.12	0.89	0.24	0.89
Indonesia	0.84	0.44	1.77	0.41

95% Critical F = 3.10

99% Critical F = 4.85

95% Critical chi2 = 5.99

99% Critical chi2 = 9.21

Notes:

$$(1) \quad F = \frac{(SSR_r - SSR_u) / k}{SSR_u / (n - 2k - 1)} \sim F(k, n - 2k - 1) \quad Chi^2 = \frac{n(SSR_r - SSR_u)}{SSR_u} \sim Chi^2(k)$$

SSR_r=Sum of Squared Residuals of a restricted model, SSR_u= Sum of Squared Residuals of an unrestricted model, n=numbers of observation, k=length.

(2) *,** denote the significance at 95 and 99%, respectively.

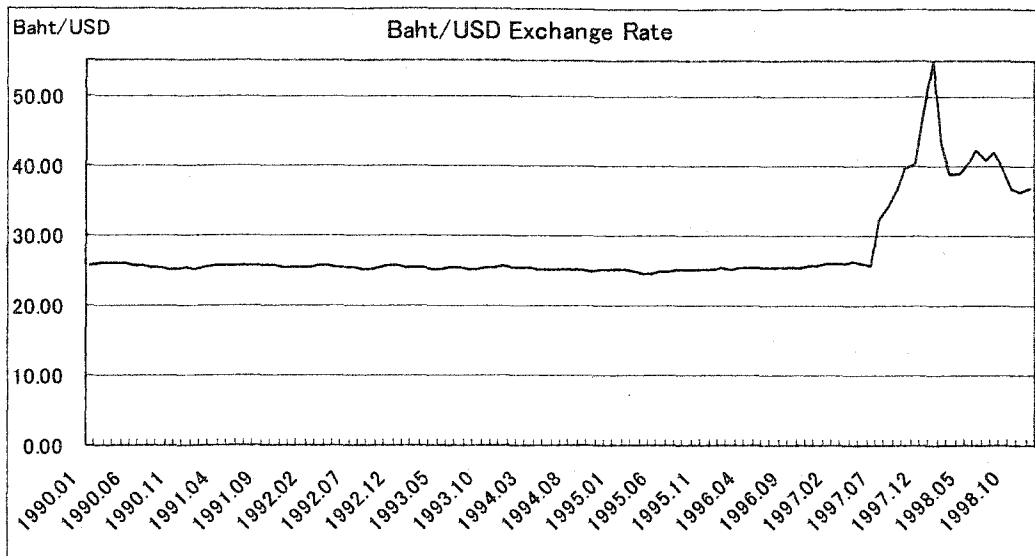
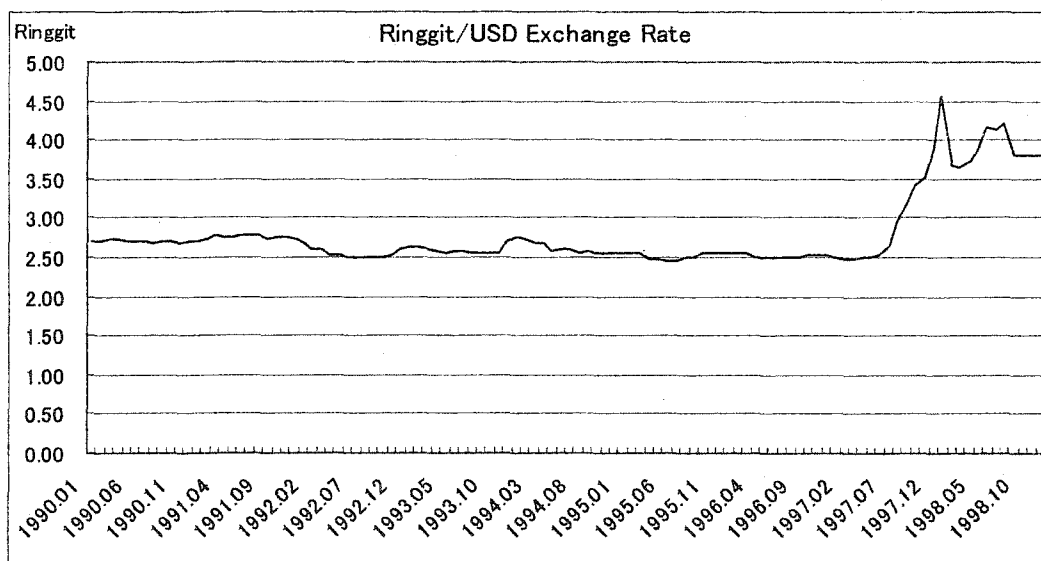
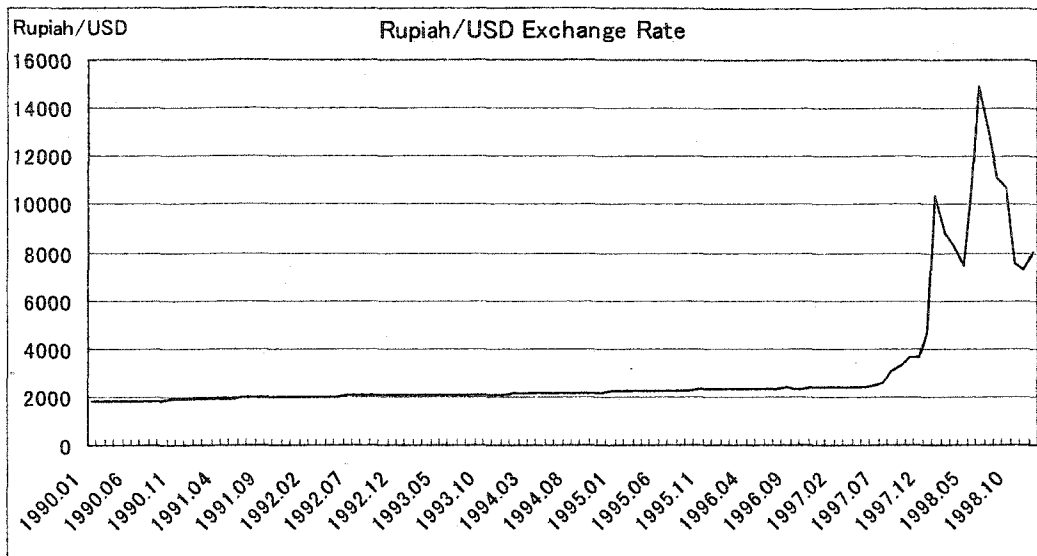
Figure 1. Exchange rates against USD**Thailand****Malaysia**

Figure 1. (Continued)

Indonesia



Korea

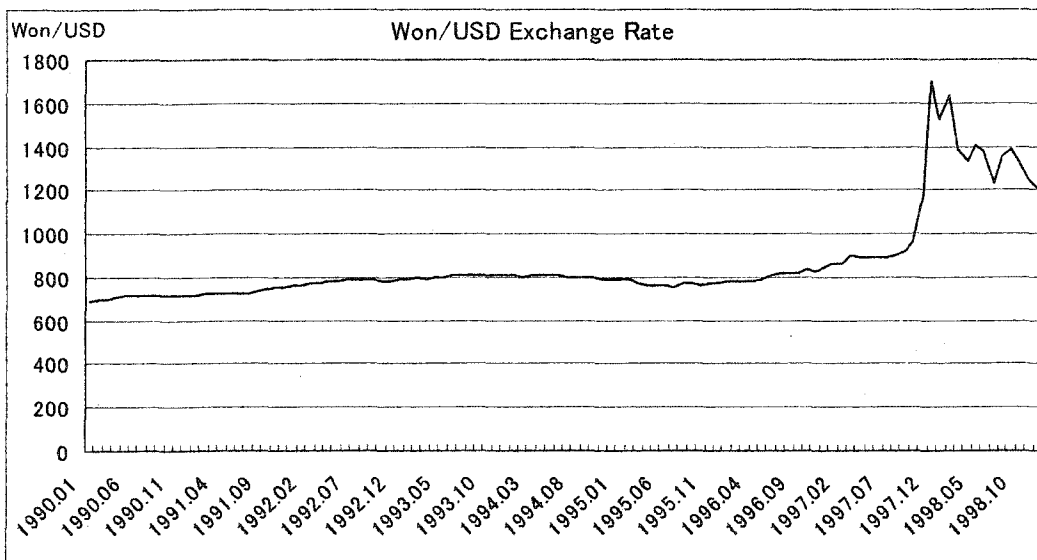


Figure 2. Exchange rate of the Japanese yen against the US dollar

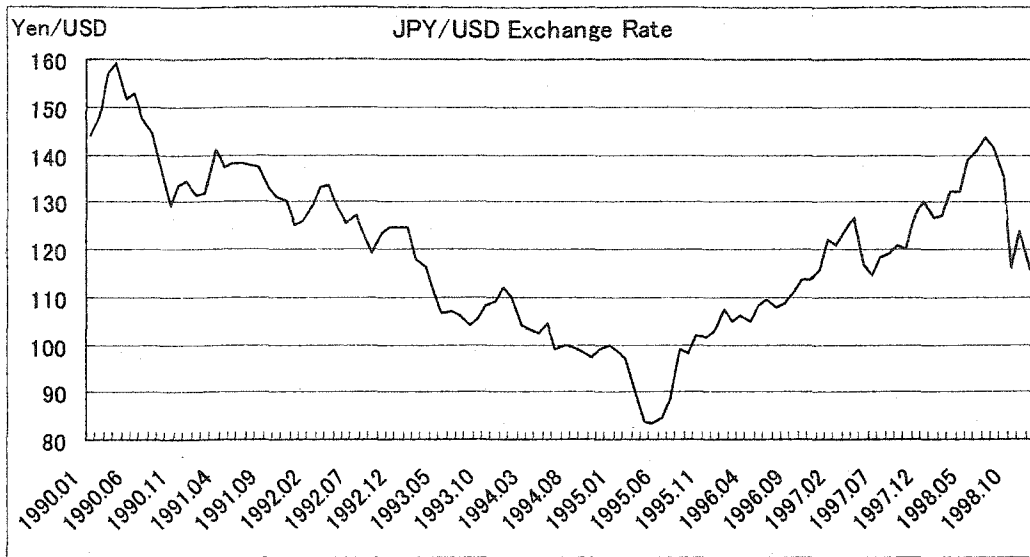
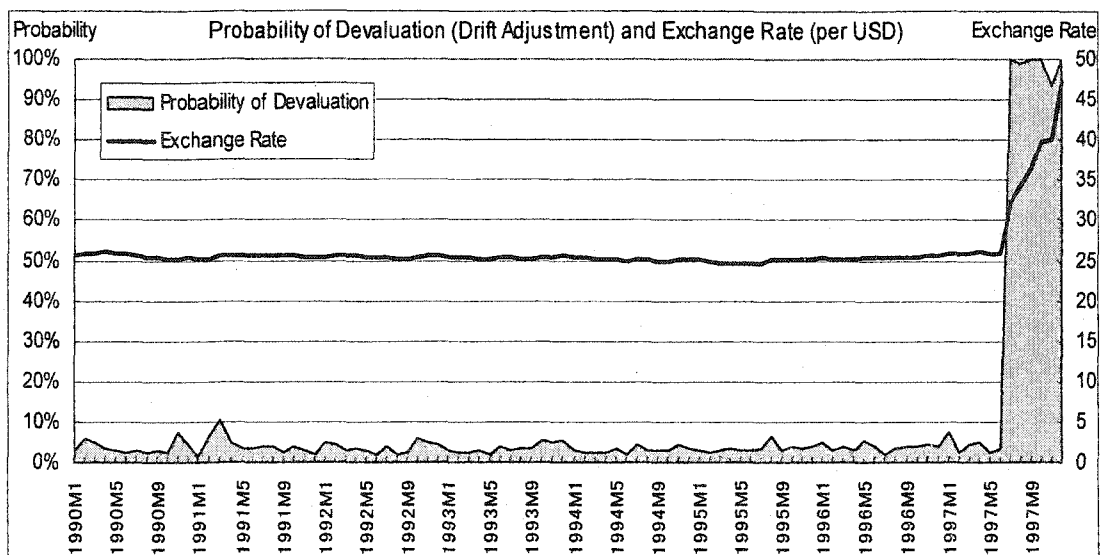


Figure 3. Probability of devaluation

Thailand



Malaysia

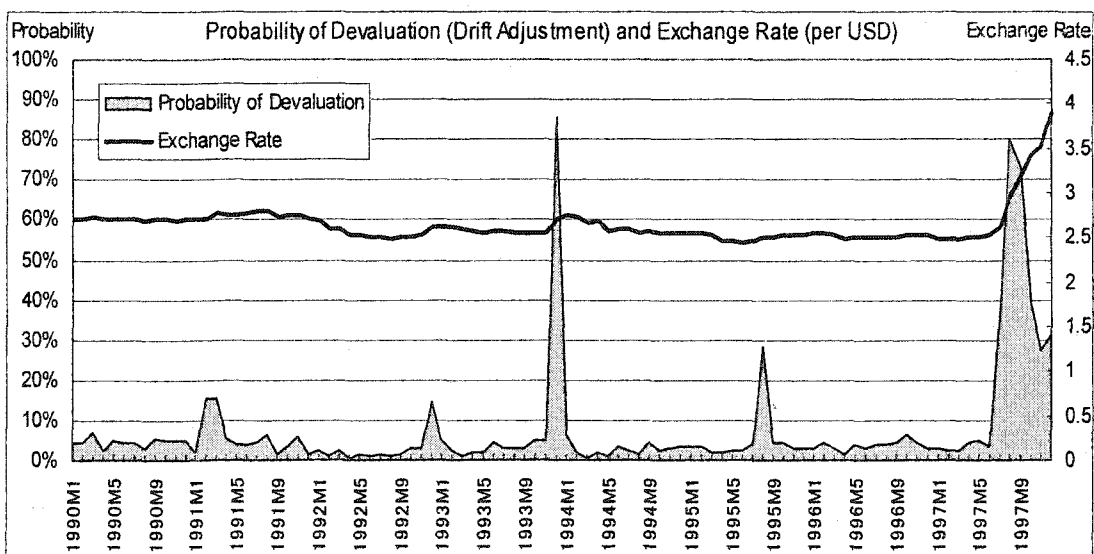
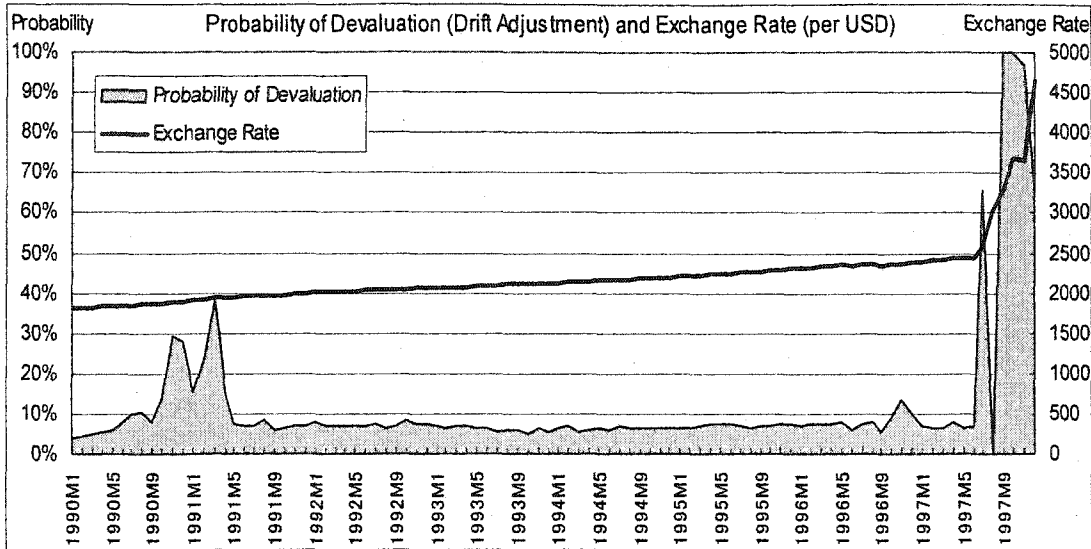


Figure 3. (Continued)

Indonesia



Korea

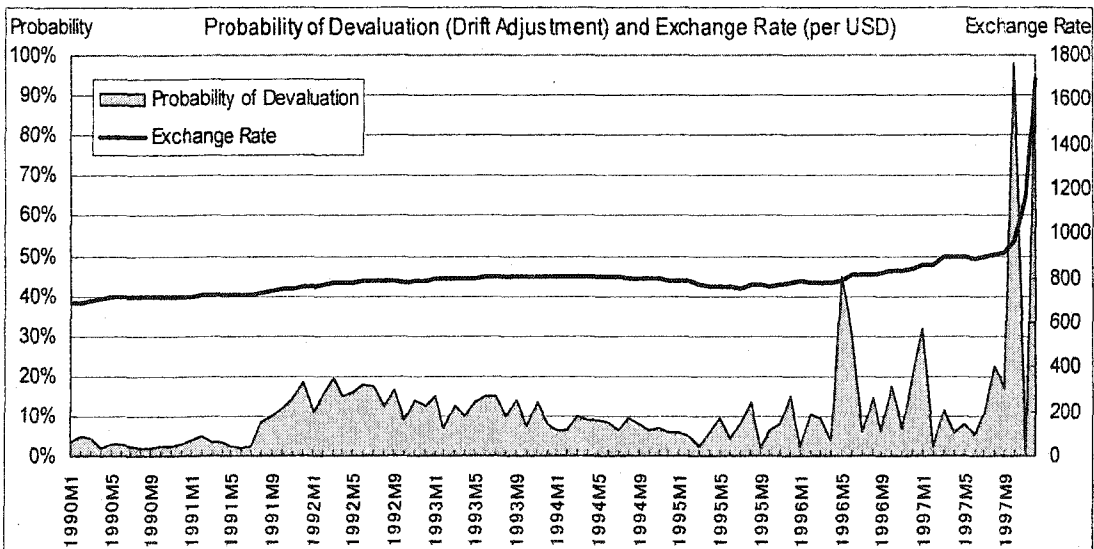


Figure 4. Estimated probabilities of devaluation: Thailand



Figure 5. Estimated probabilities of devaluation: Malaysia

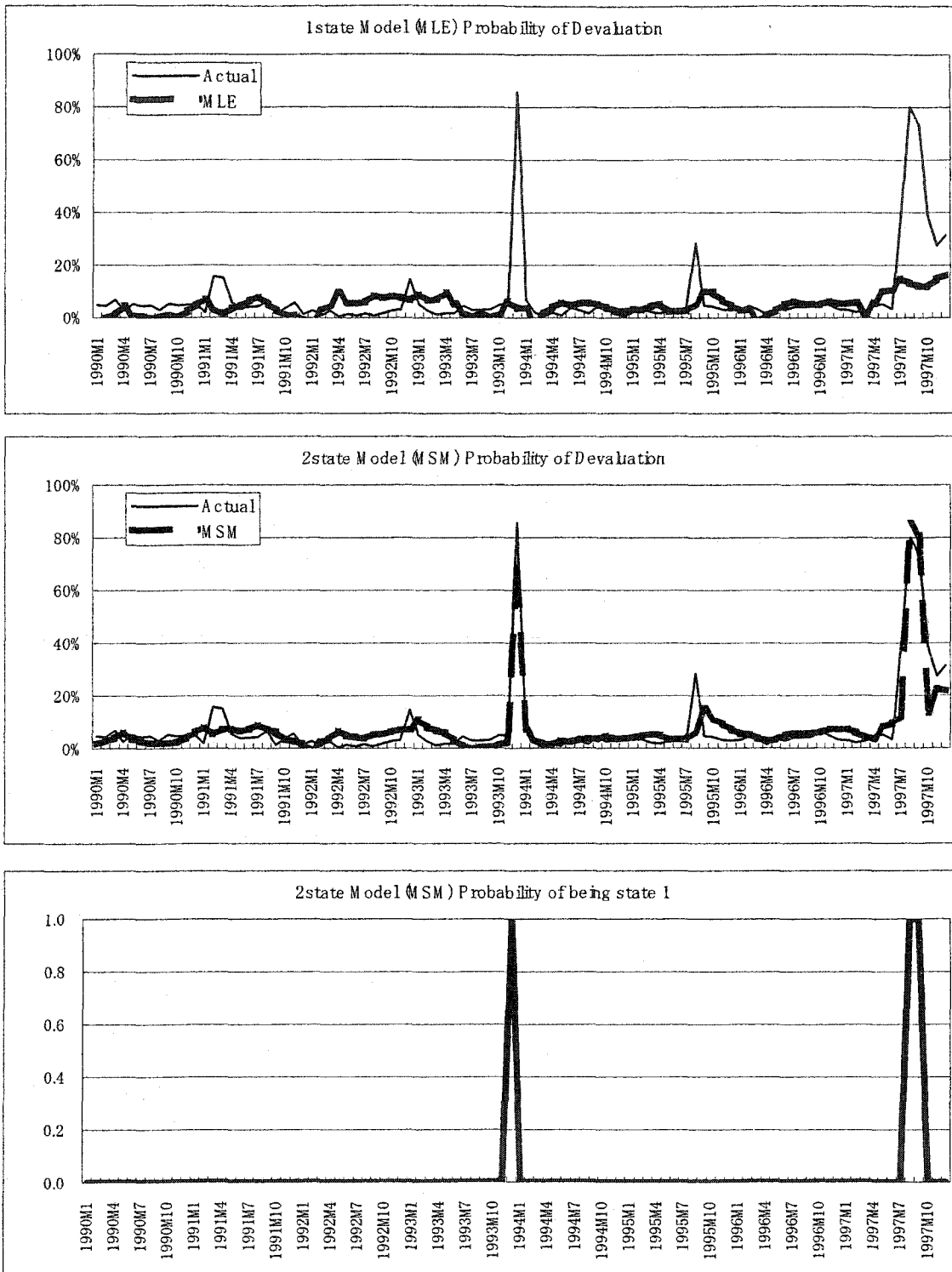


Figure 6. Estimated probabilities of devaluation: Indonesia

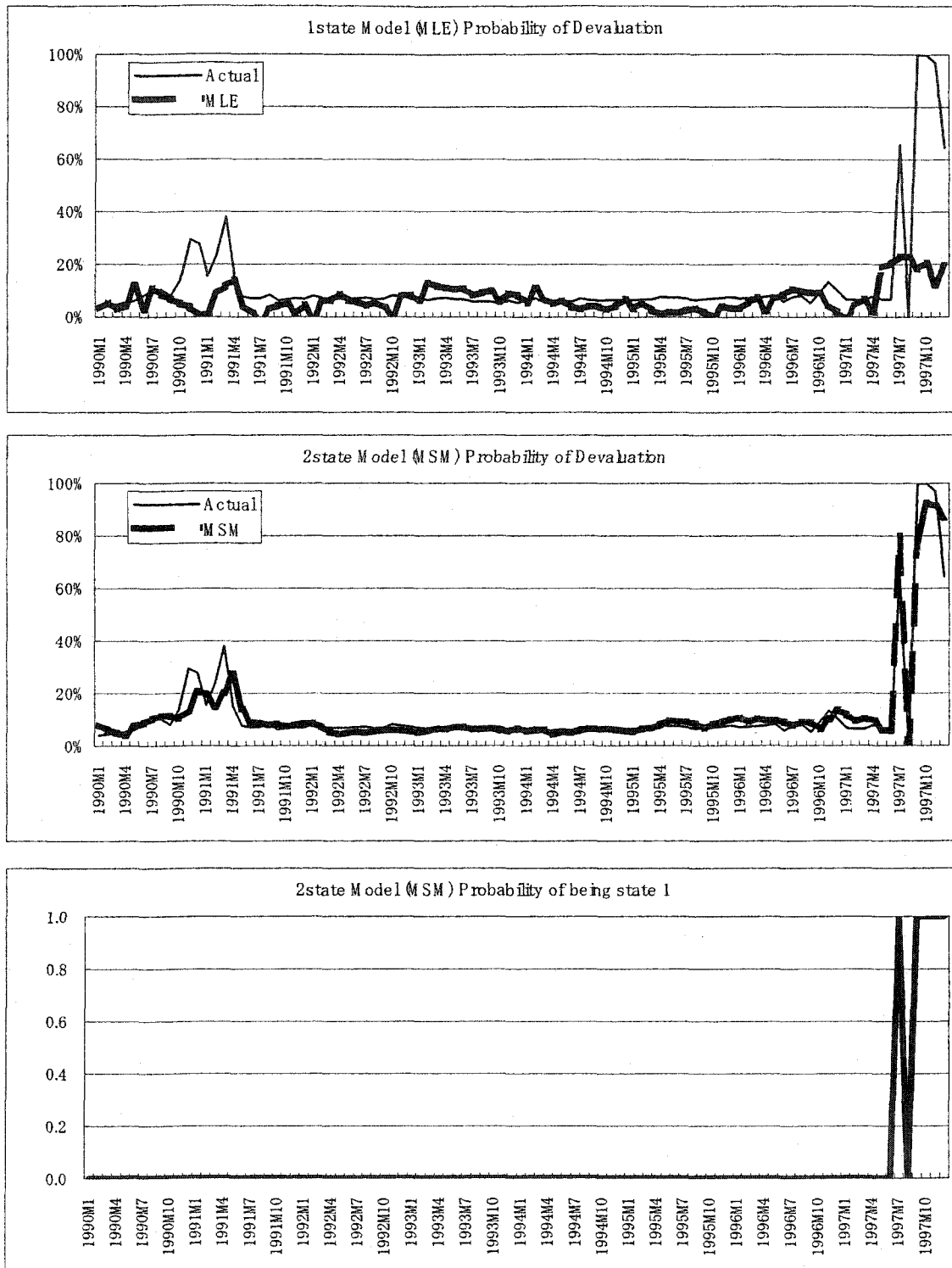


Figure 7. Estimated probabilities of devaluation: Korea

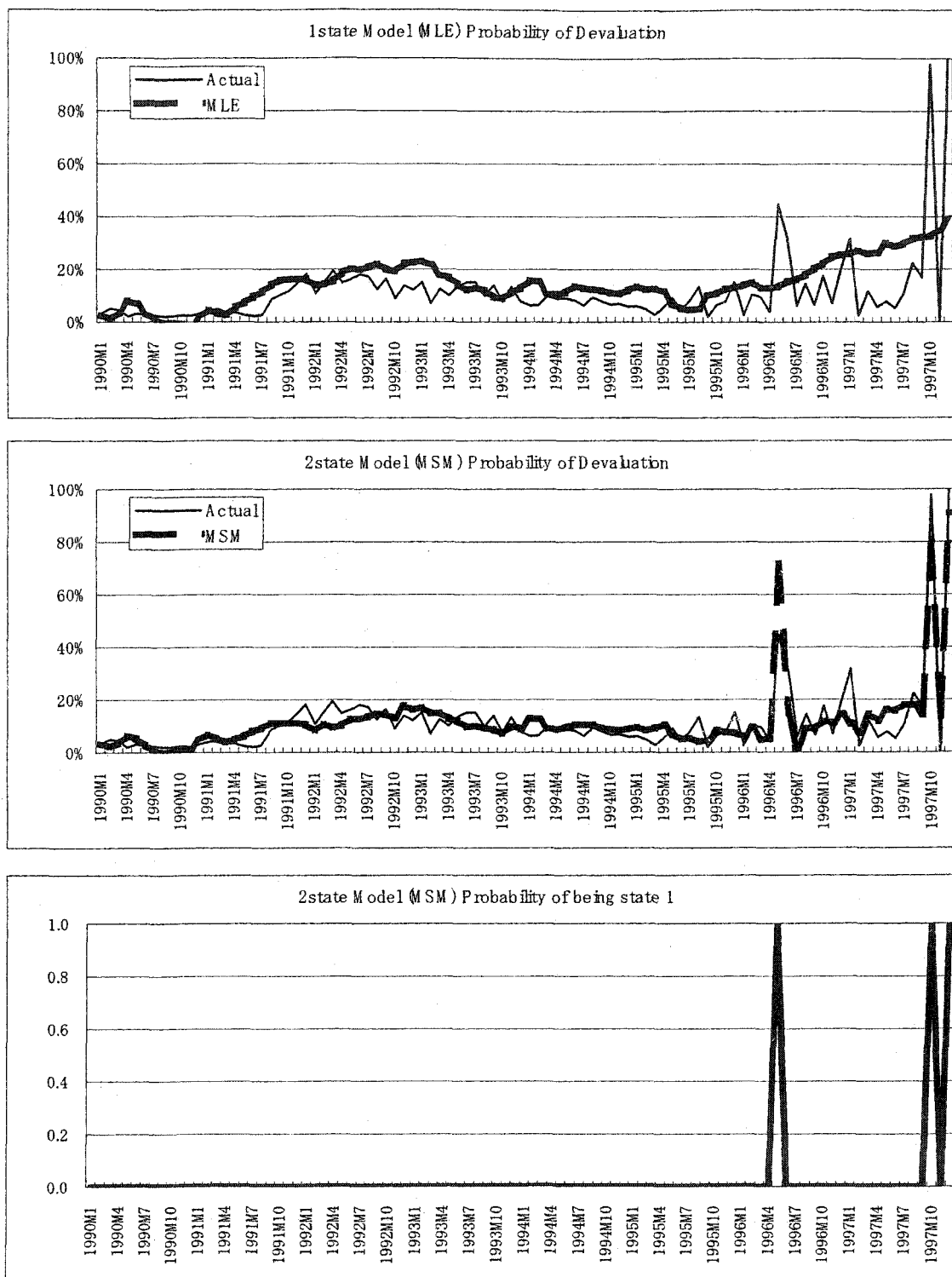


Figure 8. Decomposition of external debt: Thailand

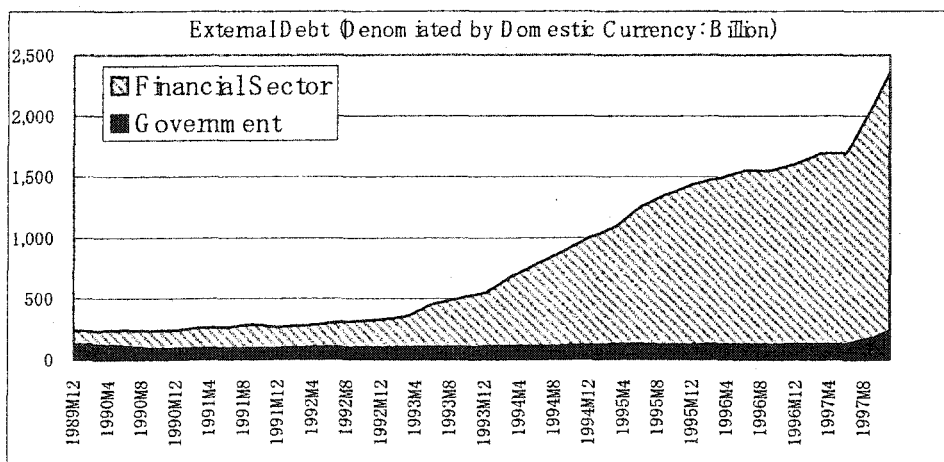
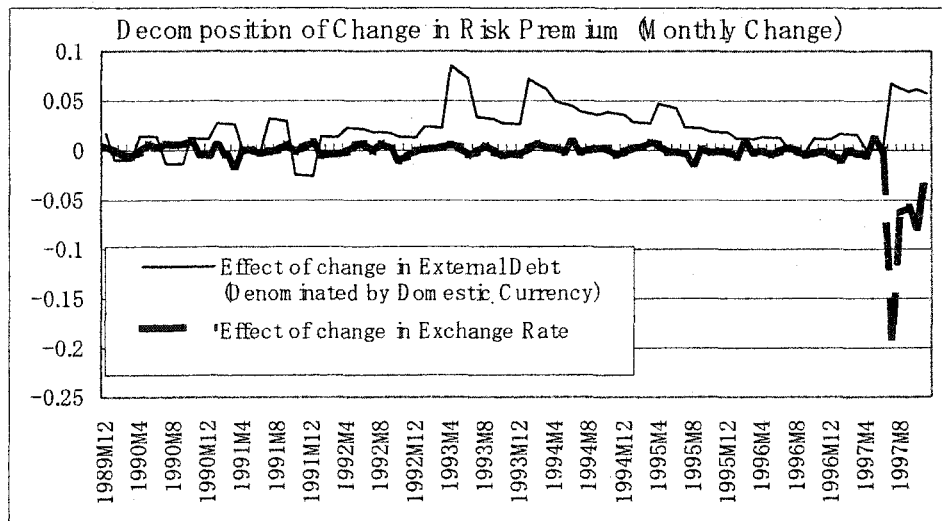
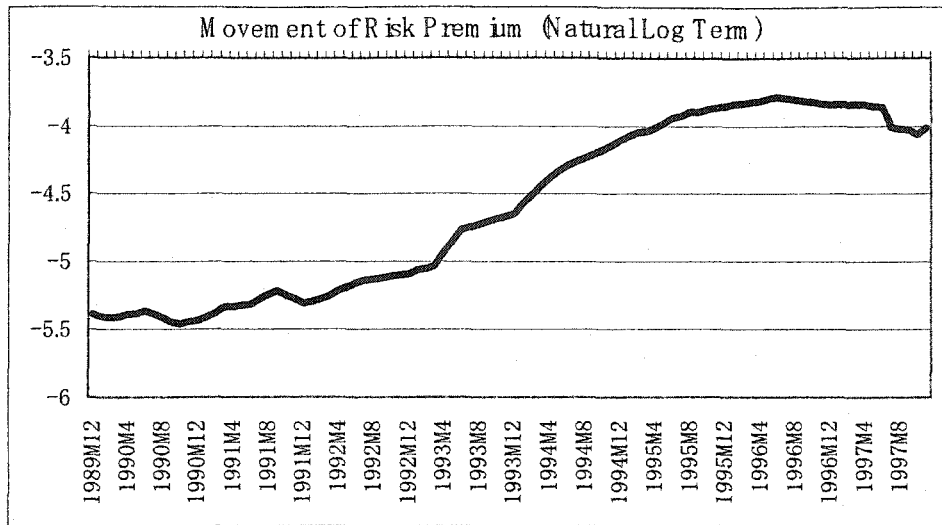


Figure 9. Decomposition of external debt: Malaysia

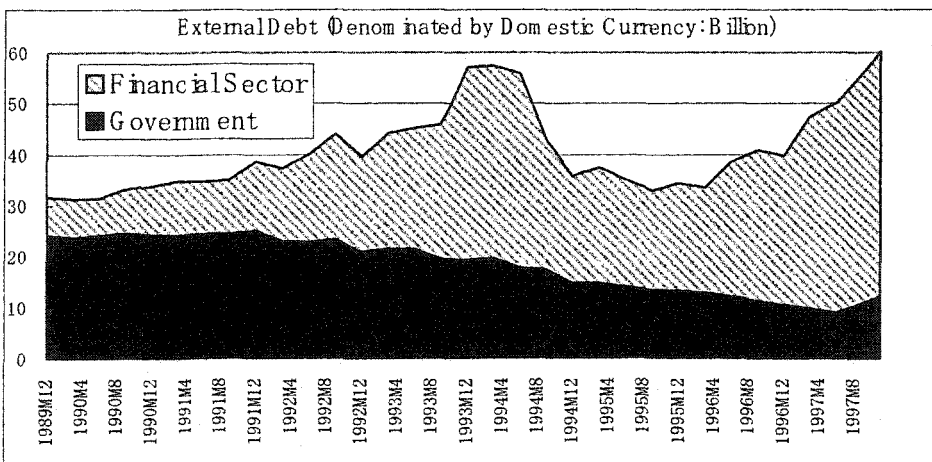
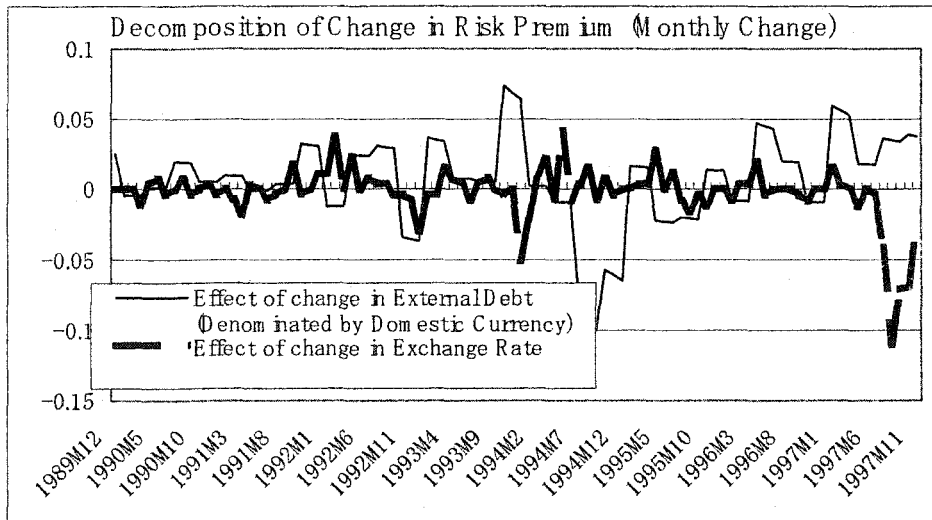
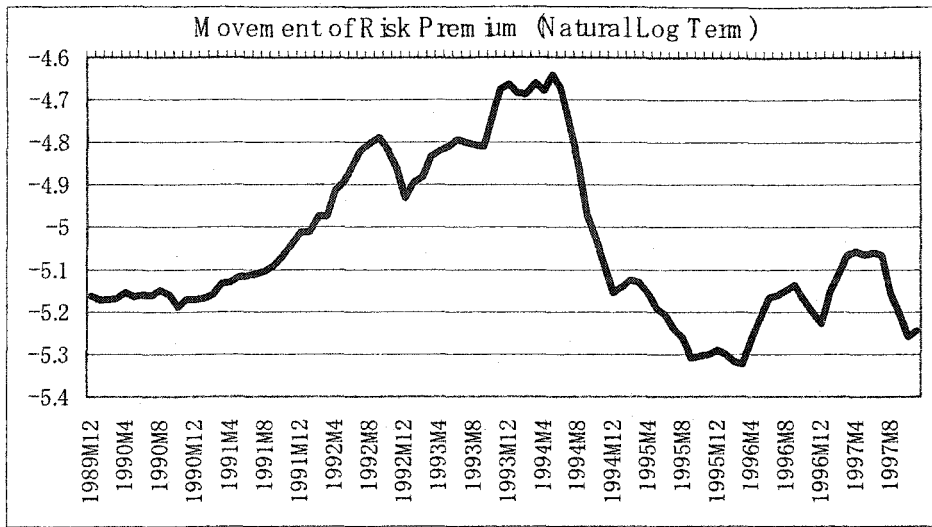


Figure 10. Decomposition of external debt: Indonesia

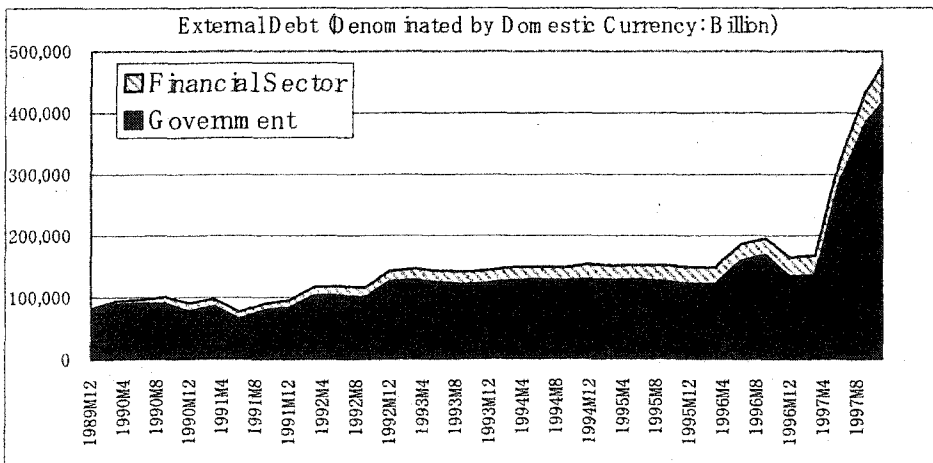
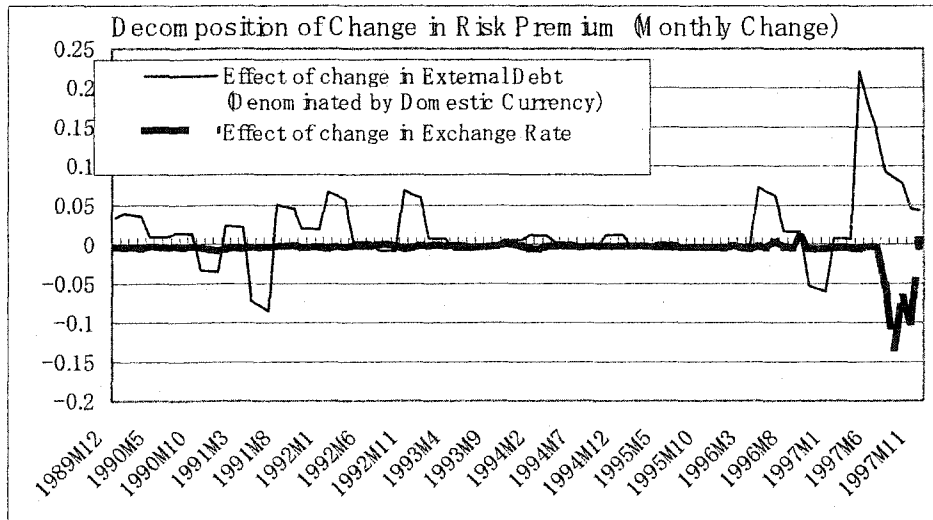
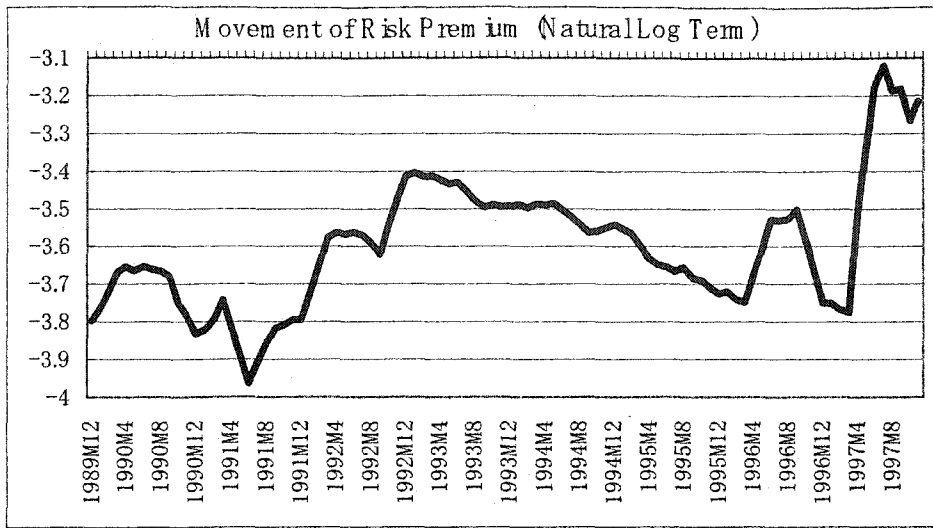


Figure 11. Decomposition of external debt: Korea

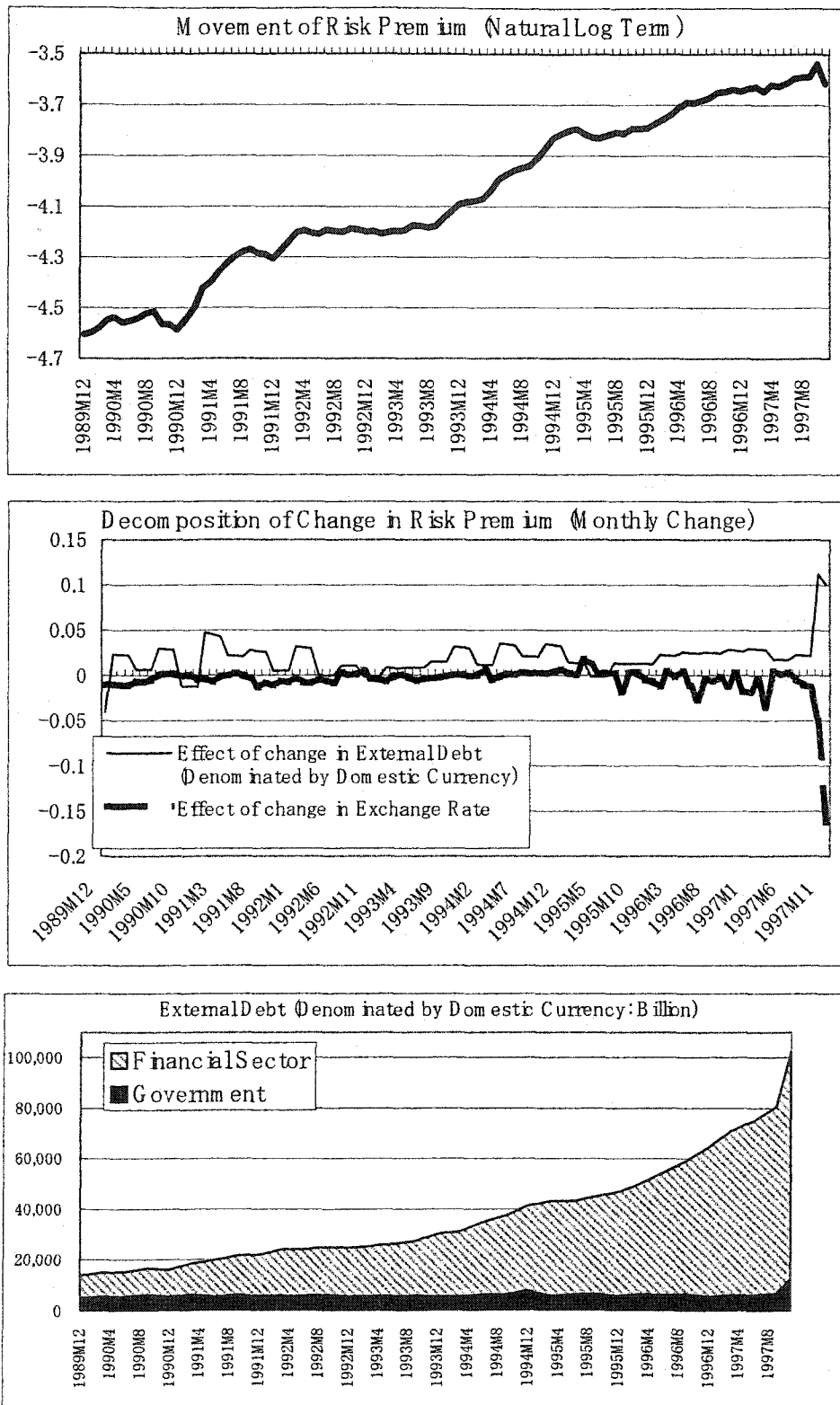


Figure 12. Change in $F(\cdot)$ with respect to the change in the expected fundamental $E_t b_{t+1}$

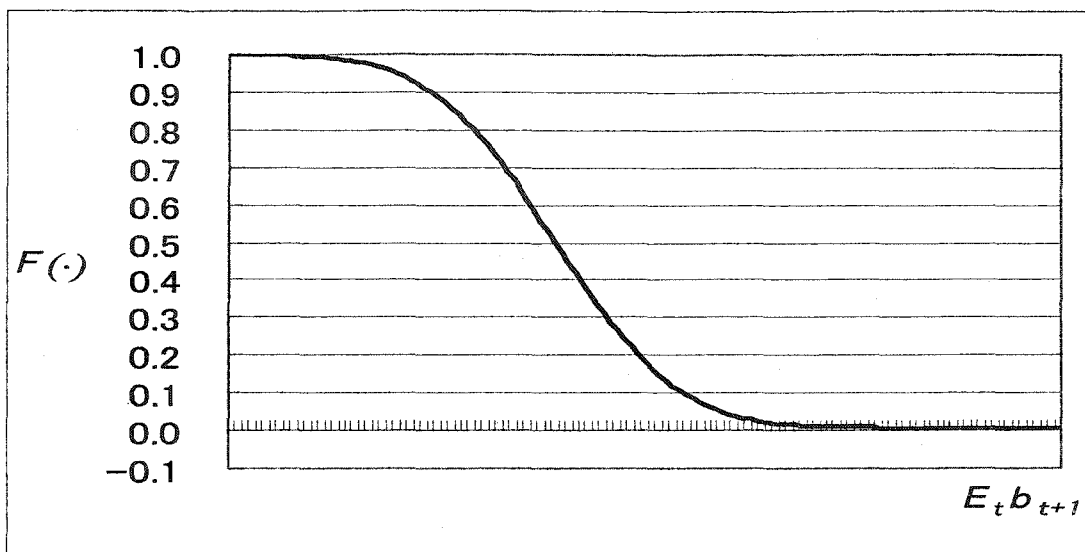


Figure 13. Change in $F(\cdot)$ curve with respect to different levels of ad_t

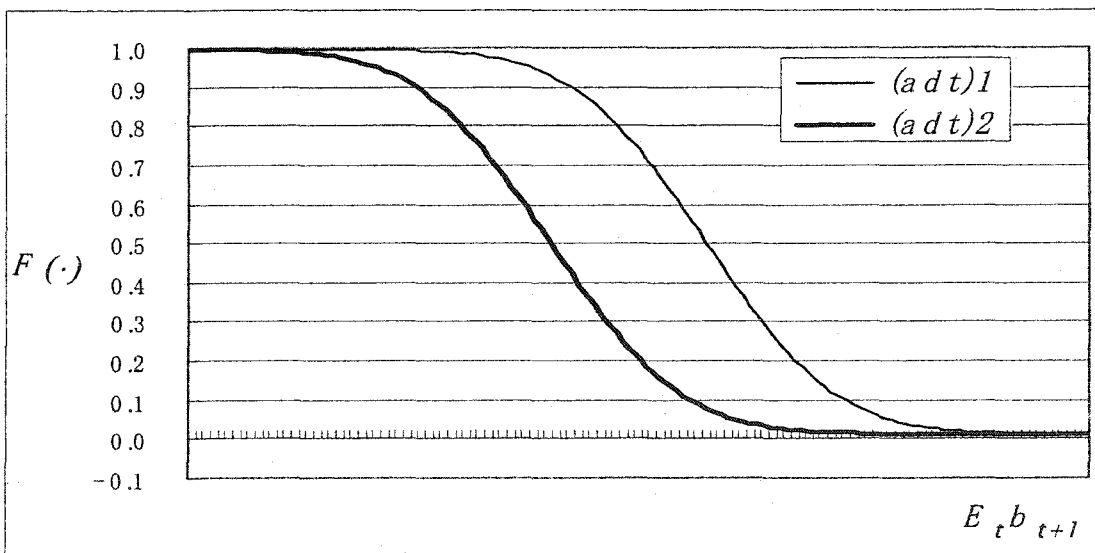


Figure 14. Multiplicity of the solution for $F(\cdot)$ with respect to a given fundamental 1

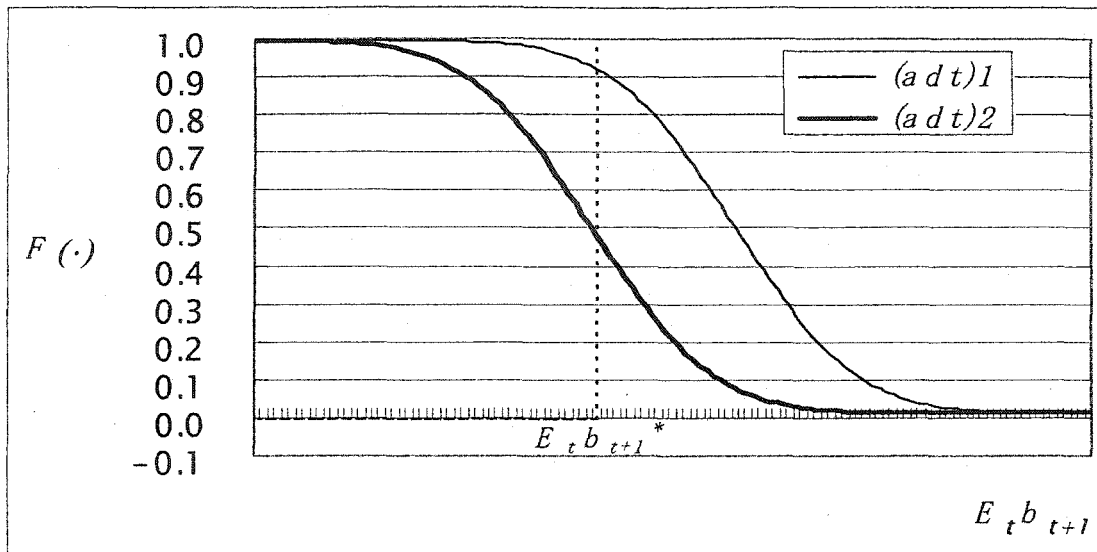
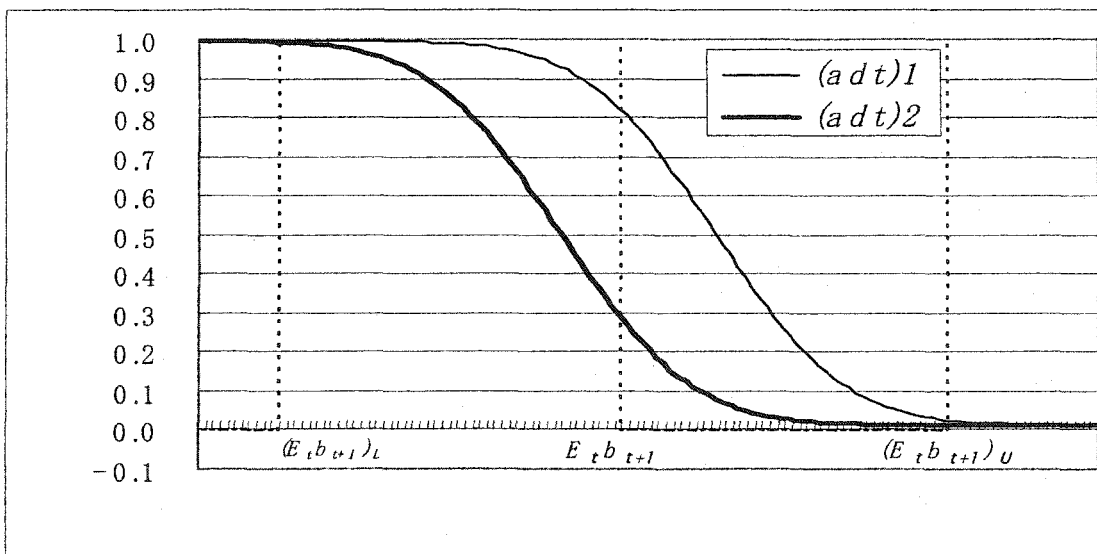


Figure 15. Multiplicity of the solution for $F(\cdot)$ with respect to a given fundamental 2



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Essay II

FIXED, FLOAT, OR INTERMEDIATE?

A CROSS-COUNTRY PANEL ANALYSIS OF EXCHANGE-RATE REGIMES

1. Introduction

Due to the dollar crisis and the collapse of the Bretton Woods system in the early 1970s, several industrial countries abandoned their fixed exchange rate regimes and shifted to floating exchange rates. Since then, the choice of exchange rate regimes has been one of the most discussed issues in international finance. This paper investigates the determinants of three exchange rate regimes (fixed, flexible and intermediate), using a multiple choice model and applying it to three different currency zones: the US dollar, the ECU/German mark, and the CFA franc currency blocks.

A large volume of literature has investigated the choice of exchange rate regimes for the last thirty years, and we can divide it into two main groups: early discussions and currency crises theories. The early discussions of the choice of exchange regimes examine systematic differences between float and peg countries. These studies are closely related to the literature on optimal currency area (Mundell, 1961). The currency crises that occurred in the international financial market in the 1980s and 1990s led to another trend in the literature. These currency crisis models analyze how a fixed exchange rate regime collapses and cause a country to shift to a floating exchange rate regime. This group of literature has a close relation with the three different generations of currency crises theories initiated by Krugman (1979).

By using the explanatory variables from these previous studies, this paper

analyzes the determinants of the choice of currency regimes with the updated data of 138 countries, and answers various questions debated in the literature. The contribution of this study to the literature is twofold. First, unlike previous studies, which analyzed the choice between two exchange rate regimes, the paper uses the multinomial logit model, which allows a choice between three exchange rate regimes. To my knowledge, no other recent paper has applied this methodology to the exchange rate analyses. Second, the paper covers three different currency zones to explore differences in international monetary arrangements.

The results confirm the previous findings in the literature that an increase in inflation differential is likely to shift a country to an intermediate regime, while a decrease in this variable tends to move it to a fixed regime. Unlike the previous literature, however, this study finds that bank domestic credit and the current account balance have a significant effect on the regime changes from a fixed to an intermediate regime, and from an intermediate to a floating regime. This is a striking result because explanatory variables, in most of the existing studies using the logit estimation, cannot account for the regime change to an intermediate regime.

2. Literature review and discussion of variables

2-1. A brief review of exchange regimes literature

The early discussions of the choice of exchange regimes examine systematic differences between float and peg countries. These studies are closely related to the literature on optimal currency area (Mundell, 1961). Country size, openness, inflation, and trade patterns are suggested as key factors that determine the choice of currency regimes (Heller, 1978, Dreyer, 1978, Holden and Suss, 1979, and Bosco, 1987). Some other studies explore monetary and inflationary effects on the choice of regimes with a standard type open-macro model (Melvin, 1985) and introduce the real exchange rate variability into the analysis (Savvides, 1990). The main issues that these studies analyze are monetary independence, anti-inflation effects, and volatility of exchange rates. Flood, Bhandari, and Horne (1989) expand a theoretical aspect of transition between exchange regimes further. Edison and Melvin (1990), LeBaron and McCulloch (2000) provide reviews of these discussions.

The currency crises that occurred in the international financial market in the 1980s and 1990s led to another trend in the literature. These currency-crisis models analyze how a fixed exchange rate regime collapses and shifts to a floating exchange rate regime. The first generation model originated by Krugman (1979) assumes that expansion of domestic credit eventually causes the collapse of fixed exchange rates. The second-generation model introduced by Obstfeld (1994) employs macroeconomic variables, while the third generation model (e.g., Chang and Velasco, 1998) focuses on

financial variables such as weakness of the banking sector for the theoretical interpretation of the structure of currency collapses.

On the other hand, the empirical analysis of currency crises explores changes in exchange regimes with cross-country data. Frankel and Rose (1996) use the probit model to estimate the probability of currency crises with data of more than 100 developing countries. Sachs, Tornell and Velasco (1996) investigate effects of the Mexican peso crisis of 1994 on other countries using cross-country regression. Kaminsky, Lizondo, and Reinhart (1998) study currency crises with panel data of 20 countries. They aim to construct early-warning indicators of a currency crisis and find that some traditional fundamental variables, such as exports and real exchange rates help to predict a crisis. Berg and Pattillo (1999) compare these three approaches and discuss how they could have predicted the Asian crises.

More recent studies expand this strand of literature in various ways. Ghosh, Gulde, Ostry, and Wolf (1997) investigate how exchange regimes influence macroeconomic variables, such as inflation, money, output and interest rates. While most researchers use the IMF classification that is based on claims from governments, Yeyati and Sturzenegger (1999) use three key variables: monthly changes of exchange rates, standard deviations of exchange rates, and volatility of foreign reserves to classify exchange regimes. Masson (2000) discusses the transition probability of exchange rate

regimes. He uses three categories of exchange regimes: floating, intermediate, and fixed, and estimates the transition probability of regime changes using the Markov chains.

2-2. Discussion of variables 1: Dependent variables

Heller's work (1978) is one of the seminal papers that analyze the choice of exchange regimes using cross-country data. It introduces a discriminant score as a dependent variable (a fixer or floater). Dreyer (1978) is the first to use a discrete dependent variable for this kind of analysis. He uses the ordered probit model to estimate three different exchange rate regimes: float, intermediate, and pegged. Holden, Holden, and Suss (1979) generate a flexibility index of exchange rates and analyze the variation of the index using the OLS estimation.

In order to investigate effects of monetary and inflationary shocks on the choice of exchange regimes, Melvin (1985) divides regimes into four different categories: single-currency peg, basket peg, crawling-peg, and floating. He analyzes the changes in these regimes using the ordered logit model. Savvides (1990) extends Melvin's research by employing the two-stage limited-dependent variable model. His classification of regimes is binary, i.e. fixed and floating. The fixed regime includes both single and basket pegs, and the floating regime consists of the crawling peg and floating regimes.

Bosco (1987) offers an empirical study that uses one of the most statistically

advanced techniques in these two groups of literature. He examines both two-(fixed and float) and three-(fixed, intermediate, and float) choice classifications using the binomial and multinomial logit models. He is also the first to introduce the unordered multinomial choice analysis.

The studies in the 1990s focus on the collapse of fixed exchange regimes. Frankel and Rose (1996) use a binary dependent variable, either the currency “crash” or “non-crash”, in their probit model.

2-3. Discussion of variable 2: Explanatory variables

Early studies (Heller, 1978, Dreyer, 1978, Holden, Holden, and Suss, 1979, Bosco, 1987), which are closely related to the theory of optimal currency area (Mundell, 1961), investigate how the different economic structures could determine the choice of exchange rate regimes. These studies include the following explanatory variables belonging to the literature on optimal currency area: openness of country, size of capital transaction, economic size, patterns of international trade, and inflation differential.

The studies of the 1980s are highly influenced by the development of the open-economy macroeconomic theory. Melvin (1985) and Savvides (1990) investigate effects of monetary and inflationary shocks on the choice of exchange regimes. In addition to the variables from the 1970s work, monetary and price shocks are included in their analyses.

In the 1990s, the evolution of the theory of currency collapses provides another perspective to this type of analysis. The theory of currency collapses investigates the structure of regime changes in exchange rates; in particular, from a fixed to a floating regime. It also addresses various new factors regarding this economic phenomenon. Frankel and Rose (1996), Sachs Tornell and Velasco (1996), Kaminsky, Lizondo, and Reinhart (1998) empirically investigate currency collapses employing the following new explanatory variables for the justification of the theory: overvalued exchange rates, current account balance, level of foreign reserves, domestic credit, external debt, and private bank liability. Using a continuous crisis indicator as an explained variable, Eliasson and Kreuter (2001) test the effects of new types of financial variables, such as return on equity market and the ratio of M2 money supply to banking reserves, contagion, with an ordered logit model and country specific effects.

This paper investigates the performances of two different groups of explanatory variables. The first group of variables, which are mainly chosen from the optimal currency area discussion, are called "OCA" variables, and the second group, which are employed in the theory of currency collapse, are called "CC" variables in this paper.

2-4. Are exchange rate regimes ordered?

Much of the previous literature implicitly assumes that exchange rate regimes are

ordered. This assumption indicates that a country is likely to increase or decrease the degree of flexibility of exchange rate regimes sequentially (e.g., change from a fixed to an intermediate regime, from an intermediate to a floating regime). However, actual events, especially in the second half of the 1990s, hardly support this principle. Many countries change exchange regime without any apparent order.

Bosco (1987) is the first to investigate the possibility of unordered choices of exchange rate regimes. He examines both ordered and unordered multinomial choice models to investigate country's exchange regime choices.

Masson's work (2000) also offers some material for this discussion. He estimates the transition probabilities among three exchange rate regimes using the Markov chains. The estimated transition probability does not support the two-pole hypothesis, which assumes that exchange rate regimes tend towards either a fixed or a floating regime.

3. Methodology

3-1. Multinomial logit model

The multiple-regime approach with the ordered assumption frequently fails to explain the reality of the international financial world. The unordered multiple-choice models, which deal with polychotomous dependent variables, are more appropriate for

this analysis.¹

The unordered multinomial logit is originally introduced by Nerlove and Press (1973) and its formula is as follows:

$$\text{Prob}(Y_i = k) = \frac{e^{\beta_k X_i}}{\sum_{j=0}^J e^{\beta_j X_i}} \text{ for } j = 0, 1, 2, \dots, J.$$

and

$$\sum_{j=1}^J \text{Prob}(Y_i = j) = 1$$

If we impose an assumption of $\beta_0 = 0$:

$$\text{Prob}(Y_i = k) = \frac{e^{\beta_k X_i}}{1 + \sum_{j=1}^J e^{\beta_j X_i}} \text{ for } j = 1, 2, \dots, J,$$

$$\text{Prob}(Y_i = 0) = \frac{1}{1 + \sum_{j=1}^J e^{\beta_j X_i}} \text{ for } j = 0.$$

When $j=1$, this model is equivalent to the binomial logit. In the analysis of three choices of exchange rate regimes, $j=2$ and i stands for the i th observation. X_i is a vector of independent variables.

¹ To test this point more directly, I compare the ordered and unordered multinomial logit approaches for the OCA and CC variables. I find that in both cases, the Akaike Information Criterion (AIC) and the pseudo- R^2 support the unordered multinomial logit model over the ordered logit model (Table 1).

The multinomial logit model requires one base category. If we choose a fixed exchange regime as a base regime and the intermediate and floating regimes as the first and second categories:

$Y_i=0$ (Fixed exchange regime)

$Y_i=1$ (Intermediate regime)

$Y_i=2$ (Floating regime).

Accordingly:

$$\begin{aligned} \text{Pr ob}(Y_i = 0) &= \frac{1}{1 + e^{\beta_1 X_i} + e^{\beta_2 X_i}} \\ \text{Pr ob}(Y_i = 1) &= \frac{e^{\beta_1 X_i}}{1 + e^{\beta_1 X_i} + e^{\beta_2 X_i}} \\ \text{Pr ob}(Y_i = 2) &= \frac{e^{\beta_2 X_i}}{1 + e^{\beta_1 X_i} + e^{\beta_2 X_i}} \end{aligned}$$

where $\beta_0 = 0$ is assumed in the model. The second and third formulas indicate the probability of regime changes from a fixed to an intermediate regime, and a fixed to a floating regime respectively. The first formula is the probability of an exchange rate regime remaining fixed. Appendix 1 shows the derivation of the multinomial logit model.

3-2. IIA property

The multinomial logit model is frequently interpreted as an odds-ratio model of two probabilities:

$$\text{Pr ob}(Y = m) = \frac{e^{\beta_m' X_i}}{\sum_{j=1}^J e^{\beta_j' X_i}}$$

$$\text{Pr ob}(Y = n) = \frac{e^{\beta_n' X_i}}{\sum_{j=1}^J e^{\beta_j' X_i}}$$

$$\frac{\text{Pr ob}(Y = m)}{\text{Pr ob}(Y = n)} = \frac{e^{\beta_m' X_i}}{e^{\beta_n' X_i}} = e^{X_i'(\beta_m - \beta_n)}$$

The formula of odds-ratio indicates that the ratio of two probabilities is not affected by the other choices. A choice of any two alternatives is independent from the others. This property is called independent of irrelevant alternatives (IIA). Independent and identically distributed stochastic terms in the random utility formula provide this IIA property to the multinomial logit model. Accordingly, the multinomial logit is an IIA-assuming model, and if the IIA assumption is violated, there may be biased estimates.

The most common IIA-test methodology is the Hausman-McFadden test. However, because my data set does not satisfy the statistical conditions for this test, I employ the Small-Hsiao IIA test procedure as an alternative test.² Table 2 shows the results of the Small-Hsiao IIA test. In the table, test chi-squared values for the OCA and CC are smaller than their critical values at a 95% confidential level. The null hypothesis

² Appendix 2 presents a statistical discussion of the Hausman-McFadden and Small-Hsiao IIA tests.

can not be rejected, and we can assume that the data have the IIA property.

4. Conceptual framework

4-1. Dependent variables

The IMF exchange rate classification (1983-1998) broadly divides exchange rate regimes into four categories: fixed, flexibility-limited, managed-float, and independent-float.³

The flexibility-limited category corresponds to a crawling-peg regime, and the managed-float category is applicable to a dirty-float regime. This paper adopts Masson's (2000) categorization, which defines both flexibility-limited and managed-float as intermediate regimes. Accordingly, the following three regimes are employed in the analysis: fixed, intermediate, and (independent) floating regimes.

This categorization has various advantages. If we analyze only two choices of regimes, float or fixed, we must omit the data of intermediate regimes. Otherwise, these intermediate regimes have to be categorized as either floating or fixed regimes. In both cases, statistical significance of analyses may decline. On the other hand, using more than three regimes can create complications in the data handling process.

³ The latest IMF classification (1999-) uses the more particularized categories of regimes: 1) Exchange arrangement with no separate legal tender, 2) Currency board arrangement, 3) Conventional pegged arrangement, 4) Pegged exchange rate within horizontal bands, 5) Crawling peg, 6) Crawling band, 7) Managed floating with no pre-announced path for the exchange rate, 8) Independently floating. Among them, regimes 1, 2, and 3 are categorized as a fixed, 4,5,6, and 7 are an intermediate, and 8 is classified as a floating regime in the analysis.

4-2. Explanatory variables from the OCA literature

As the former section discusses, researchers employ various kinds of explanatory variables to analyze the choice of exchange rate regimes. Among them, this paper focuses on two groups of variables. The first group of variables is mainly chosen from the optimal currency area discussion (OCA discussion), and the second group is from the theory of currency collapses (CC discussion). These two groups of variables have never been discussed simultaneously in the previous literature, and this paper compares the performances of both groups of variables.

I select the following variables from the first group of variables: economic size, openness of country, inflation differential, size of capital mobility, variability of real exchange rate.

The economic size is measured by the level of real GDP (PPP base). Heller (1978) suggests that a smaller country should have less variety of traded goods as well as industries. The country also has goods-markets with low efficiency. The direct impact of a fluctuation of a foreign price should be more undesirable for the country. Therefore, to limit the impact of the foreign price effect, the smaller country is more likely to reduce the flexibility of the exchange rate and adopt a fixed exchange regime. Thus, the size of an economy should be positively related to the degree of flexibility of regimes.

Openness of country is defined as: $(Export + Import) / GDP$. The classical literature (Heller, 1978, Holden, Holden, and Suss, 1979) assumes that the flexibility of exchange rate regimes negatively correlates with the degree of openness. For a closed economy, it is more difficult to adjust its trade in-balance than for an open economy. Consequently, a closed country is more likely to increase the flexibility of exchange rate regimes. On the other hand, the impact of the fluctuation of an exchange rate on a domestic price of an open economy is greater than that of a closed economy. Therefore, it tends to reduce the flexibility of exchange rate regimes.

Inflation differential is defined as: $Domestic\ inflation - Foreign\ inflation$, measured by the GDP deflators. It should be positively correlated with the flexibility of exchange rate regimes. The relatively higher inflation rate generates overvalued exchange rates that expand a trade deficit, and a country has to adjust its exchange regime more frequently. It consequently leads a fixed exchange rate country to abandon its regime. The level of inflation should positively correlate with the flexibility of exchange rate regimes.

Capital mobility in this paper is: $Gross\ capital\ flow / GDP$.⁴ Holden, Holden, and Suss (1979) and Savvides (1990) claim that the effect of this factor is not clear. Under a fixed exchange regime, a high degree of capital mobility ruins monetary policy

⁴ Gross capital flow in this paper is the sum of 1). FDI flows (assets and liabilities sides), 2). Portfolio investment flows (assets and liabilities sides), 3). Other investment flows (assets and liabilities sides) recorded in the financial account of the IMF Balance of Payment Statistics (regardless of sign).

independence. In the face of an adverse shock, a country is likely to shift to a higher flexibility of exchange regime. However, some analysts also argue that low capital mobility requires the trade account to adjust for international imbalances, supporting the case for a flexible regime (Bosco, 1987). If this argument holds, we find a negative relation between capital mobility and the probability of a country opting for a flexible regime. The negative relation between high capital mobility and the flexibility of exchange rate regimes also returns to the OCA discussion (Mundell, 1961). The empirical results of Holden, Holden, and Suss (1979) and Savvides (1990) show the negative relation between flexibility of exchange regimes and capital mobility, thus, supporting the second discussion.

The Variability of the real exchange rate is measured by the standard deviation of real exchange rates for the previous five years, as opposed to the fixed standard deviation of the experimental period. The real exchange rate (RER) in this paper is: $(\text{nominal exchange rate} \times \text{foreign price level}) / \text{domestic price level}$. Melvin (1985) and Savvides (1990) argue that the higher variability of the real exchange rate is more likely to shift a country to a floating exchange regime. They point out that a floating exchange rate is expected to offset the variability of the RER.

4-3. Explanatory variables from the CC literature

Among the second group of variables, this paper focuses on the following variables: government spending, bank domestic credit, economic growth, foreign reserves, current account balance, foreign liability, FDI, and overvalued exchange rates. Researchers in the 1990s broadly used these variables to investigate causes of changes in regimes from a fixed rate to more flexible ones.

Government spending in this paper is defined as: *General government final consumption expenditure / GDP*. There are two different discussions regarding the effect of this variable on regimes. The first discussion leads to a positive relation. More government spending should increase the vulnerability of the financial sector because of a crowding out effect. Consequently, there is more selling pressure on the exchange rate and countries tend to opt out of the fixed regime. Eichengreen, Rose and Wyplosz (1995) empirically support this view. The second discussion is based on the simple Mundell-Fleming type model. Given perfect capital mobility, fiscal policy is effective only if the exchange rate is fixed. Therefore, governments that frequently rely on fiscal policy for economic stabilization will opt for a fixed exchange regime, suggesting a negative correlation between public spending and the degree of flexibility.

Bank domestic credit is: *Domestic credit provided by banking sector / GDP*. The first generation currency crisis model focuses on this variable as a key to currency collapses. Domestic expansion policy raises the value of the indicator and often causes

capital outflow from a country. Eventually, a country has to abandon its fixed exchange regime and switch to an intermediate or a floating exchange regime. The previous literature uses the ratio of aggregate domestic credit to GDP. This banking domestic credit has a higher degree of statistical significance and it is also an indicator for bank related liquidity crises.

Economic growth is measured by the *percentage change in per capita GDP*.

Frankel and Rose (1996) argue that economic recession should increase the probability of currency crises.

Current account balance and *Foreign reserves* are measured by *Current account balance / GDP*, and *Gross international reserve / Monthly import*, respectively. Most currency crisis models commonly assume that a decline in these variables increases the vulnerability of a fixed exchange regime. Consequently, they should negatively correlate with the flexibility of exchange regimes.

Foreign liability is: $[Flow\ of\ Portfolio\ investment\ (Liabilities) + Flow\ of\ other\ investment\ (Liabilities)] / Export$, and *FDI* is: $Flow\ of\ direct\ investment\ (Liability) / Export$. The third generation currency crisis model assumes that moral hazard lending to the financial sector is a cause of currency crises. A high level of borrowing from abroad eventually causes liquidity crises in the banking sector, and massive capital outflow occurs consequently. Therefore, an increase in these variables should raise the probability

of abandonment of a fixed exchange regime.

The degree of overvaluation of the exchange rate is measured by the deviation of the real exchange rate from the average of the previous five years.⁵ The real exchange rate in this paper is: $(\text{nominal exchange rate} \times \text{foreign price level}) / \text{domestic price level}$. Many researchers suggest that appreciation of the real exchange rate is more likely to lead a country to opt for a floating exchange regime. Overvalued exchange rates should generate a high maintenance cost of a fixed exchange rate in many ways.

4-4. Foreign variables and currency zones

Some of the literature in the second-generation currency crisis model, such as Bensaïd and Jeanne (1997), Ozkan and Sutherland (1998), discuss important roles of foreign factors in the process of currency collapses. Real world events in the 1990s, such as the ERM crisis of 1992 or the Asian crises of 1998, support this idea, and to investigate it, this paper uses the following foreign variables: *Foreign interest rates* and *foreign economic growth rates*. Rises in foreign interest rates should increase the probability of a collapse of a fixed exchange regime, likewise the foreign economic contraction may have the same effect.

⁵ Several measures of overvaluation are employed in the exchange rate analyses; deviation from absolute PPP, deviation from average (Frankel and Rose, 1996), deviation from trend (Kaminsky, Lizondo, Reinhart, 1998), etc. I examined different measures of overvaluation; however, the differences in results were not significant.

Another contribution of this paper is to cover the three different currency zones: the US dollar currency zone, the ECU currency zone, and the CFA franc currency zone. Covering more currency zones provides more accuracy to this type of cross-country analysis.

Most of the previous research, which employs foreign variables, uses a variety of world variables, such as a world interest rate or world inflation rate, as foreign factors.⁶ In many cases, US macroeconomic variables or OECD country averages are employed for these world variables. This methodology implicitly assumes the US economy is the key external factor for most currencies. However, there are a number of currency zones, and many currencies are adjusted to others besides the US dollar. In those cases, a country holding an anchor currency is likely to have a greater economic impact on member countries of the currency zone than the United States does.

Consequently, in my analysis, for countries from the US dollar zone, the ECU zone, and the CFA franc zone, the foreign variables are based on, respectively, the US, German, and French variables. Variables involving foreign factors, such as inflation differential, real exchange rate, foreign interest, and foreign economic growth, are computed using data from those three anchor countries.

⁶ Frankel and Rose (1996).

5. Data and treatment

5-1. Data

Most data for explanatory variables in this paper are from *the World Development Indicators*.⁷ Data for foreign liabilities and FDI are obtained from the IMF's *Balance of Payment Statistics*. The choice of exchange regimes, which is a dependent variable of this analysis, are collected from the IMF's *Exchange Arrangements and Exchange Restrictions Annual Reports*. These sources include data of more than 200 countries. Among them, countries that belong or used to belong to one of the three currency zones are chosen for this analysis. Some of them must be excluded due to missing data. Accordingly, the number of countries used for this analysis declines to 138 (US-dollar zone 92, ECU zone 28, and CFA franc zone 18). The categorization of currency zones is based on Yeyati and Sturzenegger (1999), and the regional classifications of countries follow the World Bank development report. Appendix 6 shows the list of countries in the analysis. The experimental period covers from 1982 to 1999, and the sample size is 1749. Appendix 7 shows symbols and definitions of explanatory variables.

5-2. Ratios of foreign-liability variables

Foreign-liability variables are commonly used in ratios of other macro variables,

⁷ GDP and PPP related data of Germany are from the OECD web site.

such as GDP, external debts, or exports, in this type of analysis. My research employs ratios to exports, and they have various advantages such as improving the efficiency of analysis when compared with the GDP ratios of foreign variables. The correlation matrix of Table 3 shows that the correlations of foreign-liability inflow and FDI with the other variables become lower when we use the export ratios.

5-3. Multicollinearity and principal component analysis

Because we deal with a number of macro variables simultaneously, the multicollinearity problem is likely to arise among them. In Table 3 that is the correlation matrix of variables, some of these variables—*rsv*, *cab*, *fliab*, and *fdi*—show some degree of multicollinearity with other variables.

The principal component analysis is commonly used for detection of multicollinearity problems.⁸ The test results indicate that multicollinearity of the four variables, *rsv*, *cab*, *fliab*, and *fdi*, does not cause a serious problem to my estimation results. Therefore, I continue to employ the original specification that simply estimates effects of macro variables, not including them in the principal components, since it offers the advantage of analyzing their effects separately.

There is a great possibility that the choice of exchange rate regimes may also

⁸ Appendix 3 presents a procedure of the principal component analysis.

influence these macro variables. In order to avoid any possibilities regarding endogenous problems, explanatory variables in this analysis have a year lag behind the dependent variable.

6. Empirical results

6-1. Result 1: OCA model

The first section investigates the explanatory powers of the traditional type variables on the choice of exchange regimes. The first panel of Table 4 shows the results of the multinomial logit estimation covering the whole experimental period from 1982 to 1999. A *LRT* (likelihood ratio test) statistic, which is denoted as $\chi^2(k)$ in the panel, and a pseudo- R^2 are commonly used as a measure of the goodness-of-fit for this type of logit estimation (see Appendix 3).

The first two columns of the panel, which are estimated results for regime changes from a fixed to a floating regime, and from a fixed to an intermediate regime, use the fixed exchange regime as its base category. The third column, which is for the regime change from an intermediate to a floating regime, uses the intermediate regime as a base category. Double asterisks (**) indicate that an estimated coefficient has a 95% level of statistical significance and single asterisks (*) indicate a 90% level.⁹

⁹ I display the estimated coefficients of multinomial logit in the panel. Some researchers use the relative risk ratio to interpret effects of variables. Appendix 5 presents a statistical discussion about

In the first column, which explains how each explanatory variable affects the change in exchange regimes from a fixed to a floating regime, all the five variables have a statistical significance of a 95% confidential level. The positive effect of economic size (gdp) is consistent with the theory. The result indicates that a larger economy is more likely to adopt a floating exchange regime. As discussed in the previous section, openness has a negative effect on the flexibility of exchange regimes. Accordingly, a country, which opens its economy more, is more likely to choose a fixed exchange regime. Inflation differential also has an expected sign, which indicates that inflation leads a country to opt for a flexible regime. The positive effect of the real exchange rate variability is also consistent with the theoretical discussion above. Regarding capital mobility, there are two discussions of its effect on regimes. My empirical results support the second discussion that assumes a high degree of capital mobility shifts a country to a floating regime because of the ineffectiveness of monetary policy caused by a fixed regime.

In the second column, which shows effects of the variables on the regime change from a fixed to an intermediate regime, the variability of the real exchange rate loses statistical significance and the rest of the explanatory variables have a 95% confidential level. Except for openness, most of the variables have the same signs for their

the relative risk ratio.

coefficients as the former regime change. The result indicates that openness leads a country to increase its flexibility of exchange regimes. It is not consistent with the previous discussion. We need to further investigate this result.

In the third column, which shows effects of the variables on the regime change from an intermediate to a floating regime, the estimated results are very different from the previous two regime changes. Except for openness, the absolute size of effects of most of the variables becomes much smaller than those of the previous two cases, and capital mobility does not have statistical significance. In this regime change, an increase in openness has a negative effect on the flexibility of exchange regimes, and it is consistent with the theoretical discussion. However, the negative sign of the economic size indicates that a bigger economy tends to adopt an intermediate regime rather than a floating regime. The following chapter discusses this result.

In summary, four explanatory variables keep the statistical significance of a 95% confidential level in the first two regime changes, from a fixed to a floating regime, and from a fixed to an intermediate regime. Very similar factors should determine these two regime changes. However, only three of the variables, economic size, openness, and inflation differential, have statistical significance for the regime change from an intermediate to a floating regime. Thus we can assume that these three variables are essential factors for the choice of exchange regimes.

Stability of parameters

In order to analyze the stability of effects of the OCA variables, I divide the experimental period into two sub-periods and estimate the model for each period. The second and third panels of Table 4 show the results of the estimations for the first half (1982-1990) and second half (1991-1999) period respectively.

If we compare the regime change from a fixed to a floating regime in both panels, all the variables hold the same sign for their coefficients across the two sub periods. However, only three variables—economic size, inflation differential, and variability of real exchange rate—remain statistically significant during both half periods.

Regarding the change from a fixed to an intermediate regime, all the variables except for real exchange rate variability retain the same sign and statistical significance in both experimental periods. The real exchange rate variability has a negative sign in the 1990s. However, the magnitude of the effect and statistical significance are very low.

The estimated results for the regime change from an intermediate to a floating regime show that all the variables hold the same sign for their coefficients across the periods. In this regime change, openness, inflation differential, and variability of real exchange rate remain 90% statistically significant during both periods. Compared with the previous two cases, this regime change is not effectively explained by those variables,

and their performances were relatively poor, especially during the 1980s.

Over all, the inflation differential is the most robust variable and performs well across the periods and different regime changes. We can assume that it is the most stable factor that determines the choice of exchange regimes. Bosco (1987) has a similar result to my analysis, in which openness has a positive effect on the regime change from a fixed to a floating regime, and the inflation differential most effectively explains the three different regime changes. His model also performs well in the fixed to float regime change.

6-2. Result 2: CC model

The second section investigates the explanatory powers of variables from the currency-crises literature. The first panel of Table 5 shows the results of the multinomial logit estimation covering the whole experimental period from 1982 to 1999.

The first column, which displays the estimated results for the regime change from a fixed to a floating regime, shows that seven out of ten explanatory variables have a 95% statistically significant level. Government spending has a negative effect on the flexibility of exchange regimes, and the result supports the first discussion, which argues that a large government tends to adopt a fixed exchange rate. Regarding the signs of the other variables, bank domestic credit, economic growth, foreign reserves, foreign liability,

FDI, and foreign economic growth have the expected signs that the previous discussion predicts. However, a positive sign of the current account balance and a negative sign of foreign interest rates are not consistent with the theoretical assumptions.

The estimated results for the regime change from a fixed to an intermediate regime show that six variables have a 95% confidential level of statistical significance, and two have a 90% confidential level. Economic growth and foreign reserves have different signs for their coefficients from the previous regime change and their signs are not consistent with the theoretical discussion nor the current account balance and foreign interest rates.

The third column, which displays the regime change from an intermediate to a floating regime, shows that seven variables have a 95% confidential level. The signs of the variables are the same as those of the regime change between a fixed and a floating regime except for FDI and overvalued exchange rates. The results indicate that an increase in FDI and the overvalue exchange rate tend to lead a country to an intermediate regime from a floating one, and they are not consistent with the previous discussion.

If we compare the three different regime changes, five of the explanatory variables— bank domestic credit, economy growth, current account balance, foreign liability and foreign interest rates—maintain statistical significance of a 90% confidential level in all three regime changes. These variables should be essential factors for the

choice of exchange regimes.

Stability of parameters

In order to analyze the stability of effects of these variables, we divide the experimental period into two sub-periods and estimate the model for each period. The second and third panels of Table 5 are the results of the estimations for the first half (1982-1990) and the second half (1991-1999) period respectively.

If we compare the estimated results for the regime change from a fixed to a floating regime, government spending, bank domestic credit, economic growth, current account balance, foreign liability, and foreign interest rates hold the same sign for their coefficients in both periods. Among them, government spending, bank domestic credit, and the current account balance maintain a 95% level of statistical significance and hold the same signs during both half periods.

Regarding the regime change between a fixed and an intermediate regime, bank domestic credit, foreign reserves, current account balance, foreign liability, FDI, and foreign interest rates maintain the same signs in both experimental periods. However, only the current account balance has statistical significance in its coefficient across the two periods.

In the result panels for the regime change from an intermediate to a floating

regime, all the variables except for FDI hold the same sign for their coefficients. However, only one variable, bank domestic credit, maintains the statistical significance in its coefficient across the periods.

Overall, bank domestic credit and the current account balance are the most robust variables that perform well across the periods and different regime changes. We can assume that they are the most stable factor that determines exchange regimes of countries. We can also conclude that these variables from the CC literature do not perform well in the 1990s for the regime change between a fixed and an intermediate regime, and in the 1980s for the change from an intermediate to a floating regime.

6-3. Result 3: Regional models and comparison of OCA and CC

The third investigation of this chapter is a comparison of models dividing into different groups of countries.

As the previous chapter discusses, my analysis chooses focuses on three different currency zones: the US dollar, the ECU and German mark, and the CFA franc. Because the US dollar zone includes countries from many different geographic regions, we choose countries from Latin America and the Caribbean zone, and East Asia and the Pacific zone. Accordingly, we estimate models with respect to four different groups of countries, the ECU and German mark (EUR group), and the CFA franc (FRN group), Latin America

and the Caribbean (LAT group), East Asia and the Pacific (EAP group). Table 6 shows estimated results for the OCA variables with four different regional groups and Table 7 shows those of the CC variables.

OCA model

The estimated results of the OCA model for the EUR group countries show that economic size and variability of real exchange rate have a strong effect on the change in exchange regimes. The sign of the real exchange rate variability indicates that higher variability is more likely to shift a country to a floating regime, while lower variability makes the country stay in an intermediate regime.

With respect to the FRN countries, due to the lack of floating regime samples, the OCA model only analyzes the regime change from a fixed to an intermediate regime. The estimated results for this regime change demonstrate that economic size and inflation differential have statistical significance, and the signs indicate that a larger economy and higher inflation differential are more likely to lead a country to an intermediate regime from a fixed regime. Another remarkable result is that the absolute sizes of these variable effects are greater than those of other groups of countries.

The results of the OCA for the Latin American countries indicate that only economic size performs well across the three different regime changes. The OCA model

does not effectively explain the regime change between an intermediate and a floating regime

Regarding the EAP group of countries, economic size and openness maintain 95% statistical significance for all three-regime changes, and inflation differential and capital mobility also perform relatively well. However, variability of the real exchange rate does not effectively work in this regional group.

CC model

The estimated results of the CC model for the EUR group show that bank domestic credit and economic growth maintain statistical significance across two different regime changes, from a fixed to a floating regime, and from an intermediate to a floating regime. On the other hand, FDI has a 90% confidential level for the regime changes from a fixed to a floating, and from a fixed to an intermediate regime. However, none of them performs well across all three-regime changes.

Similar to the OCA model, because of the lack of floating regime samples, the CC model for the FRN countries only provides the estimated result for the regime change from a fixed to an intermediate regime. The estimated results show that government spending, bank domestic credit, foreign reserves, foreign liability, overvalued exchange rates, and foreign interest rates have a 90% level of statistical significance. However, two

of them, overvalued exchange rates and foreign interest rates do not have the predicted signs. The results indicate that countries with overvalued exchange rates tend to stay in a fixed exchange rate regime, and decreases in foreign interest rates are more likely to lead a country to an intermediate regime.

Regarding the CC model for the Latin American countries, government spending and foreign interest rates have statistical significance for all three regime changes. However, the effect of foreign interest rates is not the same as the predicted one. Foreign reserves, foreign liability, overvalued exchange rates, and foreign economic growth perform well for the first two regime changes.

The estimated results of the CC model for the EAP group countries show that economic growth and foreign reserves work for all three-regime changes. Government spending and bank domestic credit only work for the regime changes from a fixed to an intermediate regime, and from an intermediate to a floating regime. On the other hand, foreign liability, FDI, and foreign interest rates only perform well for the regime changes from a fixed to a floating regime and from an intermediate to a floating regime.

Comparison of OCA and CC

Eventually, we compare performances of the two models, the OCA and the CC, with respect to different regional groups of countries. Table 8 compares the log-

likelihood of the OCA and the CC for each regional model.

First of all, regarding the pooling type data, which includes all countries from different regional groups, the OCA model performs well as compared with the CC model, and it outperforms the CC for both the 1980s and the 1990s. Regarding the regional models, the OCA works better for the EUR and the LAT groups, while the CC performs better for the FRN and the EAP groups. The results of the in-sample prediction test in Tables 9-11 are also consistent with all of these outcomes.

The OCA model mainly focuses on variables representing fundamental economic structures, while the CC covers variables of country's financial conditions. Many researchers argue that currency-regime changes in Europe and Latin America are likely to be caused by the fundamental economic deterioration. On the other hand, Asian currencies are influenced by changes in financial related sectors. Consequently, my result may support the standard discussion of currency regime changes with respect to regional levels.

7. Conclusion

Much of the literature on the choice of exchange regimes uses the two-regime approach, which employs only two categories of exchange regimes: fixed and floating rates. Few studies apply the three regime approach which includes an intermediate

exchange regime but most of them explicitly or implicitly assume that three regimes (fixed, intermediate, and floating) are ordered. In this paper, I use these three regimes of exchange rates assuming that they are not necessarily ordered.

To conduct my analysis, I consider the three different currency blocks: the US dollar, the ECU, and the CFA franc; and use the multinomial-choice variable analysis, which is likely to increase the accuracy of my results. This specification of the model is an original contribution to the literature.

My results show that inflation differential, which is a popular explanatory variable in exchange rate research, has the most stable effect on the change of exchange regimes. Among the variables used in the literature in the 1990s, bank domestic credit and the current account balance effectively explain all three regime changes. This is another remarkable result of my analysis, because most of the previous studies using the multinomial logit do not find any variable which efficiently explains the regime change to an intermediate regime. If we compare two different models, the OCA model generally performs better than the CC model for the data including all the groups of countries; however, regarding the CFA franc block, and East Asian and the Pacific countries, the CC model has higher explanatory powers than the OCA.

My analysis does not find a consistent linear relationship between the flexibility of exchange regimes and changes in macroeconomic variables. Some of the explanatory

variables do not have high levels of statistical significance. This inconclusive result requires further investigation into the models and methodology of exchange rate research.

Appendix 1. Derivation of Multinomial logit model

The following discussion mostly refers to Ben-Akiva and Lerman (1985).

1-1. Random utility model

The random utility model is the key concept in deriving the unordered multinomial logit model. We suppose that the i th person makes his decision regarding choice j based on the following utility function:

$$U_{ij} = \beta_j' X_i + \varepsilon_{ij}.$$

$\beta_j' X_i$ is a systematic part of the decision, and ε_{ij} is a stochastic part. If he makes choice k ($k=j$), the utility of the choice k has to be the maximum among all the choices.

Accordingly, the probability of choice k is:

$$\text{Prob}(k) = \text{Prob}[U_{ik} \geq \max_{j=1, \dots, J} (U_{ij})], j \neq k$$

Let $U_i^{\max} = \max_{j=1, \dots, J} (U_{ij})$ and $U_i^{\max} = \beta^{\max}' X_i + \varepsilon_i^{\max}$:

$$\text{Prob}(k) = \text{Prob}(U_{ik} \geq U_i^{\max}), j \neq k$$

$$\text{Prob}(k) = \text{Prob}(\beta_k' X_i + \varepsilon_{ik} \geq \beta^{\max}' X_i + \varepsilon_i^{\max}), j \neq k$$

$$\text{Prob}(k) = \text{Prob}[-(\beta^{\max}' X_i - \beta_k' X_i) \geq \varepsilon_i^{\max} - \varepsilon_{ik}], j \neq k$$

1-2. Weibull distribution

i). Now we assume that the stochastic term ε_{ij} is independent and identically distributed with the Weibull distribution (or Type I extreme-value distribution) of parameters (η_{ij}, μ) , where η and μ are location and scale parameters respectively. μ should be constant across choices. The distribution and the density functions of ε_{ij} are:

$$F(\varepsilon_{ij}) = \exp[-e^{-\mu(\varepsilon_{ij}-\eta_{ij})}],$$

$$f(\varepsilon_{ij}) = \mu e^{-\mu(\varepsilon_{ij}-\eta_{ij})} \exp[-e^{-\mu(\varepsilon_{ij}-\eta_{ij})}].$$

The mode of distribution is η_{ij} , and the mean is $\eta_{ij} + 0.577 / \mu$. If we suppose $\eta_{ij}=0$ and $\mu=1$:

$$F(\varepsilon_{ij}) = \exp[-e^{-\varepsilon_{ij}}]$$

$$f(\varepsilon_{ij}) = e^{-\varepsilon_{ij}} \exp[-e^{-\varepsilon_{ij}}]$$

$$f(\varepsilon_{ij}) = \exp[-\varepsilon_{ij} - e^{-\varepsilon_{ij}}],$$

where the mode of distribution is zero, and the mean is 0.577. We can also assume the

following probability function:

$$\text{Prob}(x \geq \varepsilon_j) = F(x) = \exp[-e^{-x}].$$

ii). The Weibull distribution also has the following logistic-formula property regarding the difference of two independent stochastic terms of ε_{i1} and ε_{i2} with parameters of (η_{i1}, μ) and (η_{i2}, μ) :

$$F(\varepsilon_{i1} - \varepsilon_{i2}) = \frac{1}{1 + e^{\mu[(\eta_{i2} - \eta_{i1}) - (\varepsilon_{i1} - \varepsilon_{i2})]}}$$

If we suppose $\eta_j = 0$ and $\mu = 1$:

$$F(\varepsilon_{i1} - \varepsilon_{i2}) = \frac{1}{1 + e^{-(\varepsilon_{i1} - \varepsilon_{i2})}}.$$

Following property (i):

$$\text{Prob}(x \geq \varepsilon_{i1} - \varepsilon_{i2}) = F(x) = \frac{1}{1 + e^{-x}}$$

iii). Another important property of the Weibull distribution of ε_j , which has parameters

(η_j, μ) , is:

$$E[\max(\varepsilon_{i1}, \varepsilon_{i2})] = \frac{1}{\mu} \ln(e^{\mu\eta_1} + e^{\mu\eta_2}) + 0.577 / \mu$$

Consequently,

$$E[\max(\varepsilon_{i1}, \varepsilon_{i2}, \dots, \varepsilon_{iJ})] = \frac{1}{\mu} \ln \sum_{j=1}^J e^{\mu\eta_j} + 0.577 / \mu.$$

Letting:

$$U_{ij} = V_{ij} + \varepsilon_{ij},$$

where V_{ij} is a systematic component (non-stochastic), U_{ij} is also Weibull distributed with parameters $(\eta_j + V_{ij}, \mu)$. We can also suppose the following property of U_{ij} :

$$E[\max(U_{i1}, U_{i2}, \dots, U_{iJ})] = \frac{1}{\mu} \ln \sum_{j=1}^J e^{\mu(\eta_j + V_{ij})} + 0.577 / \mu.$$

Now we assume $\eta_j = 0$ and $\mu = 1$, and $U_i^* = \max_{j=1, \dots, J} (U_{ij}) = V_i^* + \varepsilon_i^*$. Accordingly:

$$E(U_i^*) = E[\max(U_{i1}, U_{i2}, \dots, U_{iJ})] = \ln \sum_{j=1}^J e^{V_{ij}} + 0.577$$

$$E(\varepsilon_i^*) = \eta_i^* + 0.577 / \mu = 0.577.$$

In consequence:

$$E(V_i^*) = \ln \sum_{j=1}^J e^{V_j}.$$

1-3. Multinomial logit model

Now we return to the choice model with a random utility. Supposing:

$$x = -(\beta^{\max} X_i - \beta_k X_i)$$

$$\varepsilon_{i1} = \varepsilon_i^{\max}$$

$$\varepsilon_{i2} = \varepsilon_{ik}$$

Using property (ii), our choice model is:

$$\text{Prob}(k) = \text{Prob}[-(\beta^{\max} X_i - \beta_k X_i) \geq \varepsilon_i^{\max} - \varepsilon_{ik}]$$

$$\text{Prob}(k) = F[-(\beta^{\max} X_i - \beta_k X_i)]$$

$$\text{Prob}(k) = \frac{1}{1 + e^{-[-(\beta^{\max} X_i - \beta_k X_i)]}} = \frac{1}{1 + e^{(\beta^{\max} X_i - \beta_k X_i)}}$$

$$\text{Prob}(k) = \frac{e^{\beta_k X_i}}{e^{\beta_k X_i} + e^{\beta^{\max} X_i}}$$

Letting $V_i^* = \beta^{\max'} X_i$, property (iii) provides:

$$E(\beta^{\max'} X_i) = \ln \sum_{j=1}^J e^{\beta_j' X_i}, (j \neq k)$$

Assuming $\beta^{\max'} X_i = E(\beta^{\max'} X_i)$

$$\text{Prob}(k) = \frac{e^{\beta_k' X_i}}{e^{\beta_k' X_i} + \exp(\ln \sum_{j=1}^J e^{\beta_j' X_i})}, (j \neq k)$$

Because:

$$\exp(\ln \sum_{j=1}^J e^{\beta_j' X_i}) = \sum_{j=1}^J e^{\beta_j' X_i}, (j \neq k)$$

therefore:

$$\text{Prob}(k) = \frac{e^{\beta_k' X_i}}{e^{\beta_k' X_i} + \sum_{j=1}^J e^{\beta_j' X_i}}, (j \neq k)$$

$$\text{Prob}(k) = \frac{e^{\beta_k' X_i}}{\sum_{j=1}^J e^{\beta_j' X_i}}.$$

We eventually have the multinomial logit formula.

Appendix 2. IIA test methodologies

The most common IIA-test methodology is the Hausman-McFadden test. If the choice of any two alternatives is independent from the others (IIA holds), omitting a subset of the alternatives should not change the estimated coefficients. However, if it is not independent, the estimated coefficient will not be consistent. The following Hausman-statistic examines this inconsistency:

$$\chi^2 = (\hat{\beta}_r - \hat{\beta}_f)' [\hat{V}_r - \hat{V}_f]^{-1} (\hat{\beta}_r - \hat{\beta}_f)$$

where $\hat{\beta}_f$ is the vector of estimators of the full set of choices, and $\hat{\beta}_r$ is that of the restricted set which omits a subset of choice. \hat{V}_r and \hat{V}_f are the asymptotic covariance matrices.

The statistic is asymptotically distributed as chi-squared with K (the number of elements in the vector of coefficients). This Hausman statistic requires:

- i). $[\hat{V}_r - \hat{V}_f]$ is invertible.
- ii). \hat{V}_r is great than \hat{V}_f .

The Small-Hsiao test is another methodology to test the IIA property. The test procedure randomly divides the full data set into two groups, denoted A and B. Using sample A, we get $\hat{\beta}_f^A$, which is the vector of estimators of the full set of choices, and we also get the vector of estimators $\hat{\beta}_f^B$ from sample B; and we compute the weighted average of two sets of coefficients:

$$\hat{\beta}_f^{AB} = (1/\sqrt{2})\hat{\beta}_f^A + (1-1/\sqrt{2})\hat{\beta}_f^B.$$

Next, we obtain $\hat{\beta}_r^B$ that is a vector of estimators of the restricted set omitting a subset of choice based on sample B.

Finally, we compute the log likelihood of the sample B using $\hat{\beta}_f^{AB}$ and $\hat{\beta}_r^B$, and get $\ln L_{\hat{\beta}_f^{AB}}^B$ and $\ln L_{\hat{\beta}_r^B}^B$ respectively and obtain the following statistic:

$$\chi^2 = -2[\ln L_{\hat{\beta}_f^{AB}}^B - \ln L_{\hat{\beta}_r^B}^B].$$

The statistic is asymptotically distributed as chi-squared with K (the number of elements in the vector of coefficients) degrees of freedom.

Because my data set does not satisfy the condition of i) and ii) for the Hausman-McFadden test, I employ this Small-Hsiao IIA test procedure. Table 2 shows the results

of the IIA test. The test chi-squared values are 2.803, 7.454, and 2.036. The critical chi-square value with 6 degrees of freedom and a 95% confidence level is 12.59. We cannot reject the null hypothesis, and the estimators of the restricted and unrestricted sets do not differ too much. Accordingly, we can assume that the data has the IIA property.

Appendix 3. Principal component analysis

The principal component analysis is commonly used for detection of multicollinearity problems. For the first step of this procedure, we regroup these variables, rsv, cab, fliab, and fdi, which are correlated and believed to exert an influence on the choice of exchange rate regimes, and compute a set of principal components.

Next we choose the first three principal components, which explain 89 percent of the variation of variables (Table 12), and include them into estimated regression equations, excluding rsv, cab, fliab, and fdi. The estimated results (Table 13) show that each component is statistically significant in at least one of the regime changes. However, they do not affect the significance or the sign of estimates of the other estimates in either regime choice.

I also ran the regressions using current account and reserves, including one and not the other. None of these cases affects the significance of the coefficient of FDI. These results indicate that multicollinearity of the four variables, rsv, cab, fliab, and fdi, does not

cause a serious problem to my estimation results.

Appendix 4. Measure of goodness-of-fit

i). LRT (Likelihood ratio test)

The *LRT*-statistic tests whether or not all coefficients in a model are zero ($\beta_1 = \beta_2 = \dots = \beta_k = 0$), which is the null hypothesis of the test. The test statistic is:

$$\chi^2 = -2[\ln \hat{L}_r - \ln \hat{L}],$$

where \hat{L}_r is the maximum value of the likelihood function assuming ($\beta_1 = \beta_2 = \dots = \beta_k = 0$), and \hat{L} is that of the unrestricted model. It is distributed as chi-squared with k degrees of freedom. The problem with this test is that the statistic tends to be a large number, and as a result, we can easily reject the null hypothesis with very low significance.

ii). Pseudo- R^2 .

Another measure of goodness-of-fit in my analysis is Pseudo- R^2 :

$$\text{Pseudo-} R^2 = 1 - \frac{\ln \hat{L}}{\ln \hat{L}_r}$$

This statistic is similar in character to the likelihood ratio. Unlike R^2 for linear models, the upper bound of this R^2 is much less than 1 because the term $\frac{\ln \hat{L}}{\ln \hat{L}_r}$ cannot be close to zero. In Frankel and Rose (1996), which uses similar kinds of data to that of my analysis, the Pseudo- R^2 for their probit model is 0.20.

iii). AIC

AIC (Akaike's information criterion) on this paper is defined as:

$$AIC = \frac{-2 \ln \hat{L}}{T} + \frac{2q}{T}$$

where, T and q are the number of observation and parameters respectively.

Appendix 5. Odds ratio and relative risk ratio

Coefficients of the multinomial logit model are not easily explained. The marginal effects of independent variables on probabilities are:

$$\frac{\partial \text{Prob}(Y = k)}{\partial X_i} = \text{Prob}(k)[\beta_k - \sum_{j=0}^J \text{Prob}(Y = j)\beta_j] = \text{Prob}(k)[\beta_k - \bar{\beta}].$$

The formula shows that the marginal effect can be influenced by coefficients of other variables due to the inclusion of a weighted average of $\bar{\beta}$. A problematic condition here is that the sign of the marginal effect would not be the same as that of the estimated coefficient.

Because of these inconveniences, many researchers use the odds-ratio, which is the relative probability of one choice against another, to interpret the effects of explanatory variables in the multinomial logit model:

$$\frac{\text{Prob}(Y = m)}{\text{Prob}(Y = n)} = \frac{e^{\beta_m x_i}}{e^{\beta_n x_i}} = e^{x_i(\beta_m - \beta_n)}.$$

In general, $Y = n$ is chosen as a base category and set $\beta_n = 0$. Consequently:

$$\frac{\text{Prob}(Y = m)}{\text{Prob}(Y = n)} = e^{\beta_m x_i}$$

The odds-ratio is the exponentiated value of estimators. Taking the natural log:

$$\ln \left[\frac{\text{Prob}(Y = m)}{\text{Prob}(Y = n)} \right] = \beta_m x_i,$$

the estimator will be linear in the explanatory variables.

In order to discuss the effects of changes in explanatory variables on the relative probability (odds-ratio), relative risk ratios are commonly used. Now we assume $x_i = a$ changes to $x_i = a + 1$. Accordingly, the ratio of the relative probability for this unit change is:

$$\frac{\left[\frac{\text{Pr } ob(Y = m)}{\text{Pr } ob(Y = n)} \right]_{x_i = a+1}}{\left[\frac{\text{Pr } ob(Y = m)}{\text{Pr } ob(Y = n)} \right]_{x_i = a}} = \frac{e^{\beta_m(a+1)}}{e^{\beta_m a}} = e^{\beta_m}.$$

This is the exponentiated value of the coefficient and indicates the ratio of the relative probabilities corresponding to one unit change in the explanatory variable. *Stata* denotes this relative risk ratio as RRR. One benefit of this measure is that it is not influenced by the coefficients of other variables. Table 14 shows the estimated coefficients and the relative risk ratios of the OCA model, comparing with the plain coefficients.

Appendix 6. List of Countries

USD Zone

(Latin America and the Caribbean)

Antigua and Barbuda, Argentina, Bahamas The, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay, Venezuela RB,

(East Asia and the Pacific)

Australia, China, Hong Kong, Indonesia, Japan, Korea Rep., Lao PDR, Malaysia, Mongolia, New Zealand, Papua New Guinea, Singapore, Solomon Islands, Thailand,

(Other regions)

Algeria, Armenia, Azerbaijan, Bahrain, Bangladesh, Belarus, Burundi, Canada, Egypt Arab Rep., Ethiopia, Gambia The, Georgia, Germany, Ghana, Guinea, Hungary, India, Iran Islamic Rep., Israel, Jordan, Kenya, Kyrgyz Republic, Lithuania, Malawi, Maldives, Mauritania, Mauritius, Mozambique, Nepal, Nigeria, Pakistan, Romania, Russian Federation, Rwanda, Saudi Arabia, Sierra Leone, South Africa, Sri Lanka, Syrian Arab Republic, Tanzania, Turkey, Turkmenistan, Uganda, Ukraine, Zambia, Zimbabwe,

CFA Franc Zone

Benin, Burkina Faso, Cameroon, Cape Verde, Chad, Comoros, Congo Rep., Cote d'Ivoire, Equatorial Guinea, Gabon, Guinea-Bissau, Madagascar, Mali, Morocco, Niger, Senegal, Togo, Tunisia

ECU & German Mark Zone

Albania, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Greece, Iceland, Ireland, Italy, Macedonia FYR, Malta, Moldova, Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom

Appendix 7. Definitions of explanatory variables

OCA model

gdp: Economic size = $\text{LN}(\text{GDP} / \text{PPP})$

open: Openness of country = $(\text{Export} + \text{Import}) / \text{GDP}$

inf: Inflation differential = $\text{LN}(1 + \text{Domestic inflation}) - \text{LN}(1 + \text{Foreign inflation})$

gcf: Size of capital mobility = $\text{Gross capital flow} / \text{GDP}$

rerv: variability of real exchange rates = standard deviation of real exchange rates. (latest five years) [$\text{Real exchange rate} = (\text{Nominal exchange rate} \times \text{Foreign price}) / \text{Domestic price}$]

CC Model

gov: Government spending = $\text{Government final consumption expenditure} / \text{GDP}$

bankc: Bank domestic credit = $\text{Domestic credit provided by banking sector} / \text{GDP}$

dgdg: Economic growth = $\text{Percentage change in per capita GDP}$

rsv: Foreign reserve = $\text{Gross international reserve} / \text{Import}(\text{month})$

cab: Current account balance = $\text{Current account balance} / \text{GDP}$

fliab: Foreign liability = $\text{Flow of portfolio and other investments (liability)} / \text{Export}$

fdi: FDI = $\text{Flow of direct investment (liability)} / \text{Export}$

dev : Overvalued exchange rates = deviation from latest five years average of real exchange rates.

intf: Foreign interest rate

dgdgpf: Foreign economic growth = $\text{Percentage change in foreign per capita real GDP}$.

Table 1. Comparison of Unordered and Ordered logit models

Mlogit: Unordered Multinomial Logit

Ologit: Ordered Multinomial Logit

Comparison of models: 1982-1999

		Mlogit	Ologit
Sample Size		1749	1749
OCA	AIC	1.682	1.787
	Pseudo R2	0.192	0.137
CC	AIC	1.943	1.962
	Pseudo R2	0.071	0.055

Comparison of models: 1982-1990

		Mlogit	Ologit
Sample Size		841	841
OCA	AIC	1.324	1.372
	Pseudo R2	0.269	0.233
CC	AIC	1.708	1.687
	Pseudo R2	0.065	0.062

Comparison of models: 1991-1999

		Mlogit	Ologit
Sample Size		908	908
OCA	AIC	1.889	2.020
	Pseudo R2	0.145	0.079
CC	AIC	2.077	2.120
	Pseudo R2	0.069	0.038

Table 2. Small-Hsiao Test of IIA**

Small-Hsiao Test of IIA (OCA Model)	
(The base category is "Fixed regime", and "Intermediate regime" will be eliminated.)	
LnL for weighted average of coefficients in two half-samples:	-273.99840
LnL based on restricted model (arrange==2 omitted):	-272.33044
Test chi2(6) =	3.336, Pr = 0.7657
(The base category is "Fixed regime", and "Floating regime" will be eliminated.)	
LnL for weighted average of coefficients in two half-samples:	-348.74733
LnL based on restricted model (arrange==1 omitted):	-346.36598
Test chi2(6) =	4.763, Pr = 0.5746
(The base category is "Intermediate regime", and "Fixed regime" will be eliminated.)	
LnL for weighted average of coefficients in two half-samples:	-272.53839
LnL based on restricted model (arrange==3 omitted):	-272.18655
Test chi2(6) =	0.704, Pr = 0.9944
Small-Hsiao Test of IIA (CC Model)	
(The base category is "Fixed regime", and "Intermediate regime" will be eliminated.)	
LnL for weighted average of coefficients in two half-samples:	-305.88351
LnL based on restricted model (arrange==2 omitted):	-296.76165
Test chi2(11) =	18.244, Pr = 0.0761
(The base category is "Fixed regime", and "Floating regime" will be eliminated.)	
LnL for weighted average of coefficients in two half-samples:	-461.77549
LnL based on restricted model (arrange==1 omitted):	-456.91623
Test chi2(11) =	9.719, Pr = 0.5559
(The base category is "Intermediate regime", and "Fixed regime" will be eliminated.)	
LnL for weighted average of coefficients in two half-samples:	-270.97318
LnL based on restricted model (arrange==3 omitted):	-264.89424
Test chi2(11) =	12.158, Pr = 0.3519

**For the OCA model, the critical chi-squared value (6) at the 95% confidence level is 12.59, and all the test values are smaller than the critical value. Regarding the CC model, the critical chi-squared value (11) at the 95% confidence level is 19.68, and all the test values are also smaller than this critical value.

Table 3. Correlation matrix between regression variables and foreign variables

Correlation matrix using foreign liability variables (fliab and fdi) of ratios to Export

	gov	bankc	dgdp	rsv	cab	fliab2	fdi2	dev	intf	dgdpf
gov	1.000									
bankc	0.233	1.000								
dgdp	-0.019	0.040	1.000							
rsv	-0.165	0.054	0.037	1.000						
cab	-0.081	0.167	-0.095	0.250	1.000					
fliab2	-0.059	-0.059	0.025	-0.067	-0.305	1.000				
fdi2	-0.043	-0.030	0.162	-0.005	-0.407	-0.038	1.000			
dev	0.013	-0.017	0.008	0.010	0.052	0.029	-0.045	1.000		
intf	0.123	0.039	-0.053	-0.065	-0.053	0.075	-0.030	0.001	1.000	
dgdpf	0.055	0.036	0.395	-0.016	0.052	0.002	-0.037	0.066	-0.054	1.000

Correlation matrix using foreign liability variables (fliab and fdi) of ratios to GDP

	gov	bankc	dgdp	rsv	cab	fliab1	fdi1	dev	intf	dgdpf
gov	1.000									
bankc	0.233	1.000								
dgdp	-0.019	0.040	1.000							
rsv	-0.165	0.054	0.037	1.000						
cab	-0.081	0.167	-0.095	0.250	1.000					
fliab1	0.071	0.058	0.010	-0.061	-0.160	1.000				
fdi1	0.016	-0.039	0.177	-0.032	-0.504	0.022	1.000			
dev	0.013	-0.017	0.008	0.010	0.052	-0.020	-0.123	1.000		
intf	0.123	0.039	-0.053	-0.065	-0.053	0.070	-0.079	0.001	1.000	
dgdpf	0.055	0.036	0.395	-0.016	0.052	0.009	-0.088	0.066	-0.054	1.000

Table 4. OCA Model Estimates

Full Sample 1982-1999: obs=1749			
Variables	Fixed-Float	Fixed-Inter	Inter-Float
gdp	0.54 ** (12.5)	0.70 ** (18.1)	-0.16 ** (-3.9)
open	-0.01 ** (-2.9)	0.01 ** (3.9)	-0.01 ** (-5.5)
inf	0.03 ** (5.4)	0.04 ** (7.0)	-0.01 ** (-2.0)
gcf	0.01 ** (2.1)	0.01 ** (2.3)	0.00 (0.2)
rerv	1.05 ** (4.8)	0.33 (1.5)	0.72 ** (3.8)
C	-13.93 (-12.6)	-18.07 (-18.3)	4.14 (3.8)
LRT	691.55		
Pseudo-R ²	0.192		
AIC	1.682		

Sub Sample 1982-1990: obs=841			
Variables	Fixed-Float	Fixed-Inter	Inter-Float
gdp	0.78 ** (8.4)	0.82 ** (13.0)	-0.04 (-0.5)
open	0.00 (-0.7)	0.01 ** (2.2)	-0.01 * (-1.8)
inf	0.02 * (1.8)	0.03 ** (4.2)	-0.02 * (-1.7)
gcf	0.04 ** (2.3)	0.04 ** (2.6)	0.00 (0.1)
rerv	4.67 ** (6.7)	2.07 ** (3.5)	2.60 ** (4.1)
c	-21.85 (-8.8)	-21.74 (-13.4)	-0.11 (-0.1)
LRT	400.44		
Pseudo-R ²	0.269		
AIC	1.324		

Sub Sample 1991-1999: obs=908			
Variables	Fixed-Float	Fixed-Inter	Inter-Float
gdp	0.40 ** (7.7)	0.61 ** (11.9)	-0.21 ** (-4.3)
open	-0.01 ** (-4.1)	0.00 ** (2.1)	-0.02 ** (-5.6)
inf	0.02 ** (3.3)	0.03 ** (4.3)	-0.01 * (-1.7)
gcf	0.00 (1.1)	0.00 * (1.7)	0.00 (-0.1)
rerv	0.45 ** (2.3)	-0.05 (-0.2)	0.50 ** (2.5)
c	-9.30 (-7.0)	-15.33 (-11.7)	6.03 (4.6)
LRT	286.57		
Pseudo-R ²	0.145		
AIC	1.889		

Note

t-statistics in parenthesis. * significant at the 10-percent level; ** significant at the 5-percent level.

LRT (Likelihood ratio test) = $\chi^2 = -2[\ln \hat{L}_r - \ln \hat{L}]$, \hat{L}_r : Maximum value of the likelihood function assuming ($\beta_1 = \beta_2 = \dots = \beta_k = 0$),

\hat{L} : Maximum value of the likelihood function of the unrestricted model

$$Pseudo-R^2 = 1 - \frac{\ln \hat{L}}{\ln \hat{L}_r}$$

$$AIC = -\frac{2 \ln \hat{L}}{T} + \frac{2K}{T}, \text{ T: Number of observations, K: Number of parameters}$$

Table 5. CC Model Estimates

Full Sample 1982-1999: obs=1749			
Variables	Fixed-Float	Fixed-Inter	Inter-Float
gov	-0.05 ** (-4.3)	0.00 (-0.4)	-0.05 ** (-4.0)
bnkc	0.01 ** (5.7)	0.01 ** (3.5)	0.00 ** (2.7)
dgdg	-0.04 ** (-3.0)	0.02 ** (2.0)	-0.06 ** (-4.3)
rsv	-0.04 (-1.1)	0.06 ** (2.5)	-0.10 ** (-3.0)
cab	0.07 ** (6.1)	0.05 ** (5.3)	0.02 ** (2.0)
fliab	0.01 ** (3.8)	0.00 * (1.8)	0.00 ** (2.2)
fdi	0.01 (0.9)	0.03 * (1.7)	-0.01 (-0.8)
dev	-0.07 (-0.6)	-0.13 (-1.4)	0.06 (0.5)
intf	-0.25 ** (-7.5)	-0.06 ** (-2.6)	-0.19 ** (-5.7)
dgdpg	-0.09 ** (-3.8)	-0.06 ** (-3.7)	-0.02 (-1.0)
c	2.52 (6.3)	0.11 (0.4)	2.41 (5.9)
LRT	255.29		
Pseudo-R ²	0.071		
AIC	1.943		

Sub Sample 1982-1990: obs=841			
Variables	Fixed-Float	Fixed-Inter	Inter-Float
gov	-0.05 ** (-2.2)	-0.02 * (-1.8)	-0.02 (-1.1)
bnkc	0.02 ** (5.0)	0.01 ** (3.6)	0.01 ** (2.4)
dgdg	-0.03 (-1.2)	-0.01 (-0.4)	-0.02 (-0.9)
rsv	0.03 (0.5)	0.07 ** (2.3)	-0.05 (-0.9)
cab	0.12 ** (4.6)	0.04 ** (2.5)	0.08 ** (3.1)
fliab	0.01 (1.2)	0.00 (1.4)	0.00 (0.3)
fdi	0.05 ** (2.3)	0.03 (1.3)	0.02 (0.8)
dev	1.59 ** (4.2)	0.89 ** (3.3)	0.70 * (1.8)
intf	-0.03 (-0.4)	-0.01 (-0.2)	-0.02 (-0.3)
dgdpg	0.00 (0.0)	-0.02 (-0.6)	0.01 (0.3)
c	-1.62 (-1.7)	-0.86 (-1.6)	-0.76 (-0.8)
LRT	97.27		
Pseudo-R ²	0.065		
AIC	1.708		

Sub Sample 1991-1999: obs=908			
Variables	Fixed-Float	Fixed-Inter	Inter-Float
gov	-0.06 ** (-3.6)	0.01 (0.8)	-0.07 ** (-4.3)
bnkc	0.01 ** (3.2)	0.00 (1.3)	0.00 ** (2.1)
dgdg	-0.03 * (-1.8)	0.05 ** (3.1)	-0.08 ** (-4.4)
rsv	-0.11 ** (-2.5)	0.04 (1.0)	-0.15 ** (-3.5)
cab	0.08 ** (5.0)	0.06 ** (4.8)	0.01 (0.7)
fliab	0.01 ** (3.5)	0.00 (0.8)	0.01 ** (2.6)
fdi	-0.02 (-0.6)	0.02 (0.6)	-0.03 (-1.4)
dev	-0.25 * (-1.7)	-0.34 ** (-2.5)	0.10 (0.9)
intf	-0.14 ** (-2.5)	-0.01 (-0.1)	-0.13 ** (-2.5)
dgdpg	0.06 (1.3)	0.03 (0.9)	0.02 (0.6)
c	1.84 (3.5)	-0.49 (-1.0)	2.33 (4.5)
LRT	135.93		
Pseudo-R ²	0.069		
AIC	2.077		

Table 6. OCA Model Estimates: Regional Analysis

EUR 1982-1999: obs=339			
Variables	Fixed-Float	Fixed-Inter	Inter-Float
gdp	0.36 * (1.7)	0.73 ** (6.1)	-0.37 * (-1.8)
open	-0.08 ** (-4.6)	0.00 (0.4)	-0.08 ** (-4.7)
inf	-0.29 ** (-4.8)	0.01 (1.3)	-0.30 ** (-4.9)
gcf	0.04 ** (3.4)	-0.01 (-0.9)	0.04 ** (4.1)
rerv	7.20 ** (5.2)	-1.34 * (-2.0)	8.54 ** (5.8)
c	-5.50 (-0.9)	-17.72 (-5.5)	12.22 (2.1)
LRT	173.28		
Pseudo-R ²	0.263		
AIC	1.500		

CFA1982-1999:obs264	
Variables	Fixed-Inter
gdp	1.27 ** (5.3)
open	-0.01 (-0.8)
inf	0.11 ** (4.9)
gcf	0.02 (0.7)
rerv	0.62 (0.7)
c	-31.39 (-5.6)
LRT	92.24
Pseudo-R ²	0.396
AIC	0.617

LAT 1982-1999: obs=415			
Variables	Fixed-Float	Fixed-Inter	Inter-Float
gdp	0.73 ** (5.0)	1.04 ** (6.8)	-0.30 ** (-2.5)
open	0.01 (1.3)	0.02 ** (2.5)	-0.01 (-1.3)
inf	0.08 ** (4.5)	0.09 ** (4.9)	-0.01 (-0.9)
gcf	0.00 (0.1)	0.00 (0.1)	0.00 (-0.1)
rerv	1.55 * (1.9)	1.38 * (1.7)	0.17 (0.3)
c	-19.4 (-5.2)	-26.87 (-6.9)	7.47 (2.3)
LRT	265.97		
Pseudo-R ²	0.315		
AIC	1.450		

EAP 1982-1999: obs=193			
Variables	Fixed-Float	Fixed-Inter	Inter-Float
gdp	0.31 ** (2.1)	0.74 ** (5.2)	-0.43 ** (-3.2)
open	-0.04 ** (-3.7)	0.01 ** (2.3)	-0.05 ** (-4.4)
inf	0.14 ** (3.2)	0.12 ** (2.6)	0.03 (1.1)
gcf	0.04 ** (2.9)	-0.03 (-1.2)	0.06 ** (2.7)
rerv	-0.67 (-0.4)	-0.26 (-0.2)	-0.40 (-0.4)
c	-5.71 (-1.4)	-19.09 (-5.1)	13.38 (3.4)
LRT	100.90		
Pseudo-R ²	0.239		
AIC	1.783		

Note

t-statistics in parenthesis. * significant at the 10-percent level; ** significant at the 5-percent level.

LRT (Likelihood ratio test) = $\chi^2 = -2[\ln \hat{L}_r - \ln \hat{L}]$, \hat{L}_r : Maximum value of the likelihood function assuming ($\beta_1 = \beta_2 = \dots = \beta_k = 0$),

\hat{L} : Maximum value of the likelihood function of the unrestricted model

$$Pseudo-R^2 = 1 - \frac{\ln \hat{L}}{\ln \hat{L}_r}$$

$$AIC = -\frac{2\ln \hat{L}}{T} + \frac{2K}{T}, T: \text{Number of observations, } K: \text{Number of parameters}$$

Table 7. CC Model Estimates: Regional Analysis

EUR 1982-1999: obs=339				CFA1982-1999: obs264		LAT 1982-1999: obs=415				EAP 1982-1999: obs=193			
Variables	Fixed-Float	Fixed-Inter	Inter-Float	Variables	Fixed-Inter	Variables	Fixed-Float	Fixed-Inter	Inter-Float	Variables	Fixed-Float	Fixed-Inter	Inter-Float
gov	0.04 (0.9)	0.00 (0.1)	0.04 (0.9)	gov	-0.71 ** (-4.3)	gov	-0.18 ** (-5.0)	-0.09 ** (-3.4)	-0.10 ** (-2.6)	gov	-0.01 (-0.2)	-0.44 ** (-4.7)	0.43 ** (4.6)
bnkc	0.02 ** (2.7)	0.00 (-0.3)	0.02 ** (3.2)	bnkc	0.26 ** (5.0)	bnkc	-0.01 (-1.2)	0.00 (-0.5)	-0.01 (-0.8)	bnkc	0.01 (1.2)	-0.02 ** (-2.8)	0.03 ** (3.9)
dgdg	-0.20 ** (-3.4)	0.01 (0.3)	-0.21 ** (-3.7)	dgdg	0.05 (0.8)	dgdg	-0.03 (-1.0)	0.02 (0.9)	-0.05 (-1.6)	dgdg	-0.25 ** (-3.2)	0.21 ** (2.9)	-0.46 ** (-5.4)
rsv	-0.10 (-1.0)	-0.11 ** (-2.0)	0.01 (0.1)	rsv	-0.73 ** (-2.0)	rsv	0.15 ** (2.5)	0.13 ** (2.5)	0.02 (0.4)	rsv	-0.97 ** (-3.9)	-0.40 ** (-2.7)	-0.56 ** (-2.3)
cab	0.05 (0.9)	0.05 * (1.7)	-0.01 (-0.2)	cab	0.02 (0.2)	cab	0.03 (1.0)	0.02 (1.0)	0.01 (0.3)	cab	0.25 ** (3.7)	0.16 ** (2.4)	0.10 (1.3)
fliab	0.02 * (1.9)	0.01 (0.9)	0.01 (1.4)	fliab	0.07 ** (3.4)	fliab	0.02 ** (2.3)	0.02 ** (2.8)	0.00 (0.0)	fliab	0.04 * (1.8)	0.00 (-0.2)	0.04 * (1.8)
fdi	-0.42 * (-1.8)	-0.32 ** (-2.6)	-0.10 (-0.4)	fdi	0.09 (0.6)	fdi	-0.02 (-0.6)	-0.02 (-0.7)	-0.01 (-0.2)	fdi	-1.15 ** (-3.3)	-0.02 (-0.4)	-1.13 ** (-3.3)
dev	-0.68 (-0.9)	-0.40 (-1.1)	-0.28 (-0.4)	dev	4.86 ** (3.7)	dev	1.78 ** (3.6)	1.13 ** (2.7)	0.64 (1.5)	dev	-1.01 (-1.0)	0.53 (0.5)	-1.54 * (-1.8)
intf	0.13 (1.2)	0.09 (1.2)	0.04 (0.4)	intf	-0.32 * (-1.7)	intf	-0.32 ** (-4.4)	-0.15 ** (-3.1)	-0.17 ** (-2.4)	intf	-0.37 ** (-3.1)	-0.06 (-0.7)	-0.30 ** (-2.5)
dgdgpf	0.00 (0.0)	-0.03 (-0.7)	0.03 (0.5)	dgdgpf	0.09 (0.7)	dgdgpf	-0.16 ** (-3.0)	-0.12 ** (-2.9)	-0.05 (-0.9)	dgdgpf	-0.03 (-0.3)	-0.18 ** (-2.0)	0.15 (1.4)
c	-3.74 (-2.0)	0.26 (0.2)	-4.00 (-2.3)	c	-2.70 (-1.0)	c	5.11 (5.7)	2.22 (3.3)	2.89 (3.4)	c	9.13 (4.2)	9.51 (4.8)	-0.39 (-0.2)
LRT	64.37			LRT	162.12	LRT	158.56			LRT	237.80		
Pseudo-R ²	0.098			Pseudo-R ²	0.695	Pseudo-R ²	0.188			Pseudo-R ²	0.562		
AIC	1.881			AIC	0.428	AIC	1.757			AIC	1.178		

Table 8. Comparison of Fitting Statistics
Pooling Model

Pseudo-R2

	OCA	CC
1982-1999 (obs=1749)	0.192	0.071
1982-1990 (obs=841)	0.269	0.065
1991-1999 (obs=908)	0.145	0.069

AIC

	OCA	CC
1982-1999 (obs=1749)	1.682	1.943
1982-1990 (obs=841)	1.324	1.708
1991-1999 (obs=908)	1.889	2.077

Regional Models

Pseudo-R2

	OCA	CC
EUR (obs=339)	0.263	0.098
CFA (obs=264)	0.396	0.695
LAT (obs=415)	0.315	0.188
EAP (obs=193)	0.239	0.562

AIC

	OCA	CC
EUR (obs=339)	1.500	1.881
CFA (obs=264)	0.617	0.428
LAT (obs=415)	1.450	1.757
EAP (obs=193)	1.783	1.178

Note

$$Pseudo-R^2 = 1 - \frac{\ln \hat{L}}{\ln \hat{L}_r}$$

\hat{L}_r : Maximum value of the likelihood function assuming ($\beta_1 = \beta_2 = \dots = \beta_k = 0$),

\hat{L} : Maximum value of the likelihood function of the unrestricted model

$$AIC = -\frac{2 \ln \hat{L}}{T} + \frac{2K}{T}$$

T: Number of observations, K: Number of parameters

Table 9. Prediction Test: Pooling Model

Prediction Test: OCA 1982-1999

	Floating	Inter	Fixed	Total
Predicted	43	704	1002	1749
Correct	20	378	669	1067
Incorrect	23	326	333	682
Prob	46.51%	53.69%	66.77%	61.01%

Prediction Test: CC 1982-1999

	Floating	Inter	Fixed	Total
Predicted	144	339	1266	1749
Correct	71	166	684	921
Incorrect	73	173	582	828
Prob	49.31%	48.97%	54.03%	52.66%

The prediction test shows the prediction power of the estimated model. The procedure is the following:

1. Compute the predicted probability of each regime using the multinomial logit model with the estimated coefficients.
2. Choose the regime, which has the highest predicted probability, and make it as a "predicted regime" of the model.
3. Compare the predicted regime with the actual one.
4. "Prob" in the table indicates how much % of the predicted regimes is correct.

$$\text{Prob} = (\# \text{ of correctly predicted}) / (\# \text{ of incorrectly predicted})$$

Two panels show the results of the prediction test. The second column of the upper panel shows the prediction power of the OCA model over the floating regime. The OCA model predicts 43 floating regimes and 20 of them are correctly predicted, which means that actual and predicted regimes coincide.

Comparing the OCA and CC, the OCA predicts intermediate and fixed regimes better than the CC, while the prediction power of the CC over a floating regime is higher than the OCA. In total, the OCA performs better than the CC model.

Table 10. Prediction Test: Regional Models (EUR and FRN)

Prediction Test: OCA 1982-1999: EUR

	Floating	Inter	Fixed	Total
Predicted	24	235	80	339
Correct	15	149	55	219
Incorrect	9	86	25	120
Prob	62.50%	63.40%	68.75%	64.60%

Prediction Test: OCA 1982-1999: FRN

	Floating	Inter	Fixed	Total
Predicted	2	24	238	264
Correct	2	7	209	218
Incorrect	0	17	29	46
Prob	100.00%	29.17%	87.82%	82.58%

Prediction Test: CC 1982-1999: EUR

	Floating	Inter	Fixed	Total
Predicted	19	271	49	339
Correct	13	161	30	204
Incorrect	6	110	19	135
Prob	68.42%	59.41%	61.22%	60.18%

Prediction Test: CC 1982-1999: FRN

	Floating	Inter	Fixed	Total
Predicted	2	33	229	264
Correct	2	27	220	249
Incorrect	0	6	9	15
Prob	100.00%	81.82%	96.07%	94.32%

Table 11. Prediction test: Regional models (LAT and EAP)

Prediction Test: OCA 1982-1999: LAT

	Floating	Inter	Fixed		Total
Predicted	7	158	250		415
Correct	3	86	193		282
Incorrect	4	72	57		133
Prob	42.86%	54.43%	77.20%		67.95%

Prediction Test: OCA 1982-1999: EAP

	Floating	Inter	Fixed		Total
Predicted	79	69	45		193
Correct	43	41	29		113
Incorrect	36	28	16		80
Prob	54.43%	59.42%	64.44%		58.55%

Prediction Test: CC 1982-1999: LAT

	Floating	Inter	Fixed		Total
Predicted	74	76	265		415
Correct	37	37	183		257
Incorrect	37	39	82		158
Prob	50.00%	48.68%	69.06%		61.93%

Prediction Test: CC 1982-1999: EAP

	Floating	inter	Fixed		Total
Predicted	69	64	60		193
Correct	58	51	42		151
Incorrect	11	13	18		42
Prob	84.06%	79.69%	70.00%		78.24%

**Table 12. Principal Component Analysis
(Eigen Vectors)**

Component	Eigenvalue	Difference	Proportion	Cumulative
1	1.57	0.51	0.39	0.39
2	1.06	0.13	0.27	0.66
3	0.93	0.50	0.23	0.89
4	0.43		0.11	1.00
Eigenvectors				
	1	2	3	4
Rsv	0.36	0.39	0.81	-0.26
Cab	0.70	-0.05	-0.06	0.71
Fliab	-0.39	-0.60	0.59	0.39
fdi	-0.48	0.70	0.05	0.53

**Table 13. CC Model Estimates
with Principal Components**

Factor Analysis 1982-1999: obs=1749			
Variables	Fixed-Float	Fixed-Inter	Inter-Float
gov	-0.05 ** (-4.3)	-0.00 (-0.5)	-0.05 ** (-3.9)
bnkc	0.01 ** (5.9)	0.01 ** (3.7)	0.00 ** (2.9)
dgdg	-0.04 ** (-2.9)	0.02 ** (2.1)	-0.06 ** (-4.3)
pc1	0.06 ** (4.7)	0.06 ** (5.9)	0.00 (0.1)
pc2	-0.02 (-1)	0.03 * (1.8)	-0.05 ** (-2.7)
pc3	0.03 (1.3)	0.07 ** (4.0)	-0.04 ** (-2.0)
dev	-0.06 (-0.6)	-0.14 (-1.4)	0.07 (0.6)
intf	-0.25 ** (-7.4)	-0.06 ** (-2.6)	-0.19 ** (-5.6)
dgdgpf	-0.09 ** (-3.7)	-0.06 ** (-3.7)	-0.02 (-0.9)
c	2.17 (5.6)	0.01 (0.0)	2.16 (5.5)
LRT	239.15		
Pseudo-R ²	0.066		
AIC	1.950		

Table 14. Estimated coefficients and Relative risk ratios (RRR)

OCA model

Full Sample 1982-1999: obs=1749

Plain Coefficients				Relative Risk Ratios			
	Coef.	Std. Err	z		RRR	Std. Err	z
Fixed-Float				Fixed-Float			
gdp	0.540	0.043	12.51	gdp	1.716	0.074	12.51
open	-0.007	0.002	-2.93	open	0.993	0.002	-2.93
infdif	0.029	0.005	5.44	infdif	1.029	0.005	5.44
gcf	0.008	0.004	2.07	gcf	1.008	0.004	2.07
rev	1.047	0.218	4.80	rev	2.850	0.622	4.80
C	-13.927	1.110	-12.55				
Fixed-Intermediate				Fixed-Intermediate			
gdp	0.700	0.039	18.10	gdp	2.015	0.078	18.10
open	0.006	0.002	3.94	open	1.006	0.002	3.94
infdif	0.036	0.005	6.96	infdif	1.037	0.005	6.96
gcf	0.007	0.003	2.33	gcf	1.007	0.003	2.33
rev	0.330	0.225	1.46	rev	1.391	0.314	1.46
C	-18.072	0.987	-18.32				
Intermediate-Float				Intermediate-Float			
gdp	-0.161	0.041	-3.92	gdp	0.852	0.035	-3.92
open	-0.013	0.002	-5.51	open	0.987	0.002	-5.51
infdif	-0.007	0.004	-2.03	infdif	0.993	0.004	-2.03
gcf	0.001	0.003	0.22	gcf	1.001	0.003	0.22
rev	0.717	0.187	3.84	rev	2.048	0.382	3.84
C	4.144	1.086	3.82				

Table 14. (Continued)

CC model			
Full Sample 1982-1999: obs=1749			
Plain Coefficients			
	Coef.	Std. Err	z
Fixed-Float			
gov	-0.055	0.013	-4.32
bankc	0.010	0.002	5.65
dgdg	-0.039	0.013	-3.03
rsv	-0.037	0.033	-1.13
cab	0.074	0.012	6.12
fliab	0.008	0.002	3.78
fdi	0.014	0.017	0.85
dev	-0.070	0.119	-0.59
intf	-0.251	0.034	-7.50
dgdpg	-0.087	0.023	-3.79
C	2.521	0.399	6.32
Fixed-Intermediate			
gov	-0.004	0.009	-0.40
bankc	0.005	0.002	3.50
dgdg	0.020	0.010	1.97
rsv	0.061	0.024	2.52
cab	0.049	0.009	5.28
fliab	0.004	0.002	1.83
fdi	0.027	0.017	1.65
dev	-0.133	0.096	-1.38
intf	-0.057	0.022	-2.63
dgdpg	-0.063	0.017	-3.67
C	0.108	0.294	0.37
Intermediate-Float			
gov	-0.051	0.013	-3.95
bankc	0.004	0.002	2.74
dgdg	-0.059	0.014	-4.34
rsv	-0.099	0.033	-3.00
cab	0.025	0.012	2.04
fliab	0.005	0.002	2.15
fdi	-0.013	0.016	-0.83
dev	0.063	0.121	0.52
intf	-0.194	0.034	-5.65
dgdpg	-0.023	0.024	-0.98
C	2.413	0.411	5.88

Relative Risk Ratios			
	RRR	Std. Err	z
Fixed-Float			
gov	0.947	0.012	-4.32
bankc	1.010	0.002	5.65
dgdg	0.962	0.012	-3.03
rsv	0.963	0.032	-1.13
cab	1.076	0.013	6.12
fliab	1.008	0.002	3.78
fdi	1.014	0.017	0.85
dev	0.933	0.111	-0.59
intf	0.778	0.026	-7.50
dgdpg	0.917	0.021	-3.79
Fixed-Intermediate			
gov	0.996	0.009	-0.40
bankc	1.005	0.002	3.50
dgdg	1.020	0.010	1.97
rsv	1.063	0.026	2.52
cab	1.050	0.010	5.28
fliab	1.004	0.002	1.83
fdi	1.028	0.017	1.65
dev	0.876	0.084	-1.38
intf	0.945	0.020	-2.63
dgdpg	0.939	0.016	-3.67
Intermediate-Float			
gov	0.950	0.012	-3.95
bankc	1.004	0.002	2.74
dgdg	0.943	0.013	-4.34
rsv	0.906	0.030	-3.00
cab	1.025	0.012	2.04
fliab	1.005	0.002	2.15
fdi	0.987	0.016	-0.83
dev	1.065	0.129	0.52
intf	0.823	0.028	-5.65
dgdpg	0.977	0.023	-0.98

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Essay III

STRUCTURAL BREAK AND TWO-POLE HYPOTHESIS
IN EXCHANGE RATE REGIMES

1. Introduction

For the last ten years, sustainability of exchange rate regimes has been attracting the attention of many researchers due to the currency crises of the 1990s, such as those in Mexico (1994), East Asia (1997), Russia (1998) and Brazil (1999). Among the discussions of these crises, the viability of intermediate regimes (e.g., adjustable pegs, crawling pegs, managed floats) is one of the most discussed issues, and many researchers (Obstfeld and Rogoff, 1995, Summers, 2000, Calvo, 2001) point out the vulnerability of these intermediate regimes. These authors also argue that all exchange rate regimes finally converge to either of the two ultimate regimes, “peg” or “float”, and this view is called the two-pole, or the hollowing out hypothesis (Frankel, 1999, Mason, 2000, and Williamson, 2000).

The supporters of the two-pole hypothesis state that high capital mobility or pressure from speculators, which could be avoidable with a purely floating regime, makes the maintenance of the intermediate regime difficult due to the lack of its credibility, which a fixed regime provides with low inflation and financial stability.

On the other hand, there are a number of researchers opposing this view (Frankel, 1999, Williamson, 2000, Willett, 2003). Frankel (1999) points out that the two poles are not always an appropriate regime and a country's optimal choice depends on its characteristics and its internal and external constraints. Williamson (2000) suggests

some advantages of an intermediate regime, such as preventing a large fluctuation of an exchange rate and reducing persistent deviation from its equilibrium level. He also discusses the possibility of lowering the risk of currency attack on an intermediate regime by using cooperative sterilized intervention and a modified capital control rule. His discussion implies the sustainability of an intermediate regime. Willett (2003) also discusses importance of combinations of policies regarding exchange rates and money, and states that the balance of these policies can stabilize an intermediate regime.

Masson (2000) analyzes these two-pole discussions from an empirical point of view. He categorizes three regimes of exchange rates, floating, intermediate, and fixed, and estimates the transition probabilities between regimes using the Markov chains. The estimated result shows that the hypothesis, in which there are only transitions towards the two poles, is strongly rejected.

In this paper, by using updated data from 138 countries, I provide an analysis of exchange rate regimes to discuss the sustainability of an intermediate regime and the two-pole hypothesis. The contribution of this paper to the literature is threefold. First, the paper employs two popular groups of variables for exchange rate regime discussions: one relates to the optimal currency area (OCA) literature and the other relates to currency crises (CC) literature, and examines how economic factors affect the selection of each regime. Second, unlike previous studies which analyzed the choice between two

exchange rate regimes, the paper uses the multinomial logit model, which allows an unordered choice between three exchange rate regimes. The application of this model to the two-pole hypothesis is novel. Third, the paper analyzes the consistency of influence of economic factors over regime changes across time. I conduct an endogenous break-point search test and examine whether a structural break exists in terms of influences of economic factors and how the validity of the two-pole hypothesis changes before and after the break.

The estimated results confirm that support for the two-pole hypothesis depends on types of variables, their direction of changes, as well as sample periods of analysis. More recent data provide weak support for the two-pole discussion and it makes more difficult to state that the intermediate regime is a disappearing state.

2. Stylized Facts

This section provides a brief overview of empirical aspects of exchange regimes.

2-1. Changes in exchange regimes

The IMF exchange rate classification (1983-1998) broadly divides exchange rate regimes into four categories: fixed, flexibility-limited, managed-float, and independent-float.

The flexibility-limited category corresponds to a crawling-peg regime, and the managed-float category is applicable to a dirty-float regime. This paper adopts Masson's (2000) categorization, which defines both flexibility-limited and managed-float as intermediate regimes. Accordingly, the following three regimes are employed in the analysis: fixed, intermediate, and (independent) floating regimes.

This categorization has various advantages. If we analyze only two choices of regimes, float or fixed, we must omit the data of intermediate regimes. Otherwise, these intermediate regimes have to be categorized as either floating or fixed regimes. In both cases, statistical significance of analyses may decline. On the other hand, using more than three regimes can create complications in the data handling process.

Figure 1 shows the number of countries adopting each regime from 1982 to 2000 and the trends in the data. The figure shows a downward trend in the number of fixed regime countries from 1988 to 1998. In particular, a significant decline occurred in 1992, which was the year of the ERM crisis. On the other hand, the selection of a floating regime dramatically expanded in the same period. In the case of the intermediate regime, the trend is the most stable among the three regimes; however, the popularity of the regime increased after 1995, and the intermediate regime attracted a number of countries from the floating regime. Many of these countries expected that an intermediate regime would control capital flows more effectively than a floating regime.

After 1998, some of these intermediate regime countries changed to a fixed one. An appreciation of the US dollar and the birth of the Euro shifted the countries to a fixed exchange regime that pegged to these two anchor currencies.

2-2. Are exchange rate regimes ordered?

Much of the previous literature implicitly assumes that exchange rate regimes are ordered. This assumption indicates that a country is likely to increase or decrease the degree of flexibility of exchange rate regimes sequentially (e.g., change from a fixed to an intermediate regime, from an intermediate to a floating regime). However, actual events, especially in the second half of the 1990s, hardly support this principle. Many countries change exchange regime without any apparent order.

Bosco (1987) is the first to investigate the possibility of unordered choices of exchange rate regimes. He examines both ordered and unordered multinomial choice models to investigate country's exchange regime choices.

Masson's work (2000) also offers some material for this discussion. He estimates the transition probabilities among three exchange rate regimes using the Markov chains. The estimated transition probability does not support the two-pole hypothesis, which assumes that exchange rate regimes tend towards either a fixed or a floating regime.

I test the number of categories into which exchange rate regimes fall. Table 1 displays the sample probability of transition between regimes in my data set. If the two-pole hypothesis is valid, the probability of a transition from a float to an intermediate regime, and from a fixed to an intermediate regime should be close to zero. However, the results in the table (8.19% and 3.09%) are not small enough to support this hypothesis.

3. Methodology and Data

As the former section discusses, most of the previous research implicitly assumes the ordered choice in exchange rate regimes and a linear relationship between the flexibility of the choice of exchange regimes and macroeconomic variables. However, the real world examples indicate that this idea does not always hold, and further more the results of my analysis in section 2-2 do not support the validity of the idea. In order to demonstrate the lack of validity of these hypotheses, this paper provides another angle to test them using a multinomial logit model.

3-1. Multinomial logit model

The multiple-regime approach with the ordered assumption frequently fails to explain the reality of the international financial world. The unordered multiple-choice models, which deal with polychotomous dependent variables, is more appropriate for this

analysis.

The unordered multinomial logit is originally introduced by Nerlove and Press (1973) and its formula is as follows:

$$\text{Pr ob}(Y_i = k) = \frac{e^{\beta_k X_i}}{\sum_{j=0}^J e^{\beta_j X_i}} \text{ for } j = 0, 1, 2, \dots, J.$$

and

$$\sum_{j=1}^J \text{Pr ob}(Y_i = j) = 1$$

I also test for the independence of irrelevant alternative (IIA) property, to verify that the ratio of two probabilities is not affected by other choices and that the choice of any two alternatives is independent from others. I use the Small-Hsiao procedure and find that test results cannot reject the null of IIA for both models. Thus, we can assume that the estimators of the restricted and unrestricted sets do not differ significantly, and my data set has the IIA property.

3-2. Marginal effect and three regimes

To discuss effects of explanatory variables on the choice of exchange regimes, researchers focus on estimated coefficients (plain coefficients) or marginal effects of the multinomial logit model. The paper uses the following formula of marginal effects:

$$\frac{\partial P_j}{\partial x_i} = P_j [\beta_j - \sum_{k=0}^J P_k \beta_k]$$

An advantage of this measure is that we can discuss a total effect on the probability of choosing a regime taking into consideration the influences of all the existing alternatives. For instance, a marginal effect shows us by how much the probability of choosing a flexible regime increases when there is a one unit increase in an independent variable x . This property is a significant advantage because estimated plain coefficients in the multinomial logit are excluding influence from the existing alternatives and we cannot simply discuss effects of variables on the choice of regimes by using signs of coefficients. Researchers sometimes suggest this point as a disadvantage of this measure because signs of marginal effects are not necessarily the same as the plain coefficients.¹ However, this problem does not affect my analysis since I intend to investigate the overall direction and magnitude of the effect on each regime.

3-3. Data

The IMF exchange rate classification (1983-1998) broadly divides exchange rate regimes into four categories: fixed, flexibility-limited, managed-float, and

¹ Because marginal effect takes into account the effect of the variable on the alternative regimes but the plain coefficient does not.

independent-float. The flexibility-limited category corresponds to a crawling-peg regime, and the managed-float category is applicable to a dirty-float regime. This paper adopts Masson's (2000) categorization, which defines both flexibility-limited and managed-float as intermediate regimes. Accordingly, the following three regimes are employed in the analysis: fixed, intermediate, and (independent) floating regimes. The explanatory variables in this paper are chosen based on the OCA and CC discussions.²

Most data for explanatory variables in this paper are from *the World Development Indicators*.³ Data for foreign liabilities and FDI are obtained from the IMF's *Balance of Payment Statistics*. The choice of exchange regimes, which is a dependent variable of this analysis, are collected from the IMF's *Exchange Arrangements and Exchange Restrictions Annual Reports*. These sources include data of more than 200 countries. Among them, countries that belong or used to belong to one of the three currency zones are chosen for this analysis. Some of them must be excluded due to missing data. Accordingly, the number of countries used for this analysis declines to 138 (US-dollar zone 92, ECU zone 28, and CFA Franc zone 18). The categorization of currency zones is based on Yeyati and Sturzenegger (1999), and the regional classifications of countries follow the World Bank development report.⁴ The experimental period

² Section 4 in Essay II presents detailed discussion of the variables.

³ GDP and PPP related data of Germany are from the OECD web site.

⁴ Appendix 6 in Essay II shows the list of countries in the analysis.

covers from 1982 to 1999, and the sample size is 1749.⁵

Foreign-liability variables are commonly used in ratios of other macro variables, such as GDP, external debts, or exports, in this type of analysis. My research employs ratios to exports, and they have various advantages such as improving the efficiency of analysis when compared with the GDP ratios of foreign variables.

There is a great possibility that the choice of exchange rate regimes may also influence macro variables. In order to avoid any possibilities regarding endogenous problems, explanatory variables in this analysis have a year lag behind the dependent variable.

4. Empirical Result 1

4-1. OCA model

The left panel of Table 2 shows estimated marginal effects of the explanatory variables on the probability of choosing regimes based on the OCA variables. In the case of GDP, marginal effects of the float, intermediate, and fixed are 3.94, 12.07, and -16.01. The numbers indicate that a one-unit increase in GDP raises the probability of choosing a float and an intermediate regime by 3.94 and 12.07, and reduces the probability of choosing a fixed regime by 16.01. On the other hand, a one-unit decrease

⁵ Appendix 7 in Essay II shows symbols and definitions of explanatory variables.

of GDP reduces the probability of choosing a float and an intermediate regime by 3.94 and 12.07, but increases the probability of choosing a fixed regime by 16.01.

In the panel, an upward pointed bold triangle indicates a regime which has the maximum positive marginal effect. It means that the regime has the highest occurrence if the independent variable increases. On the other hand, a downward pointed bold triangle indicates a regime which has the maximum negative marginal effect, and it suggests that the regime has the highest occurrence if the independent variable decreases. In the case of GDP, an increase is more likely to shift a country to an intermediate regime while a decrease tends to move the country to a fixed regime.

The two pole hypothesis assumes that an exchange regime converges to either a fixed or a floating regime. However, estimates of the OCA model suggest that countries choose an intermediate regime when explanatory variables increase. When variables decrease, they choose one of two poles, in particular, a fixed regime which has a higher probability than a floating regime.

More specifically, an increase in GDP, openness, inflation differential, and capital mobility is more likely to shift a country to an intermediate regime. A decrease in all the OCA variables, except for openness, increases the probability of choosing a fixed regime. The real exchange rate variability is the only factor that shifts a country to either float or fixed in any case.

The OCA model can not provide strong evidence for the two-pole hypothesis. The left panel of Table 3, which displays the frequency of regimes being chosen, demonstrates that two poles have the slightly higher occurrence than the intermediate (six times compared to four times), however it is not high enough to support the explicit tendency towards two poles.

We can also discuss the validity of the two pole hypothesis with respect to the OCA variables using a visual comparison of occurrences of regimes. Figure 2 displays modified absolute marginal effects weighted by sample means of variables with respect to three different regimes.⁶

The result panels plot the absolute marginal effect resulting from a change in the independent variable. If the occurrence of the intermediate regime is low compared to either of the two poles for any direction of change in the variable, a plotted combination of three modified marginal effects of the float, intermediate, and fixed regimes should have a clear v-shape, because the intermediate regime, which should have the lowest occurrence, comes to the bottom of the combination. In this case, the two pole hypothesis is strongly supported by the data. On the other hand, any other line (inverse v-shaped, a decreasing or increasing bent or straight lines) shows that both poles do not

⁶ The modified absolute marginal effect is equivalent to an absolute semi-log elasticity of the probability of regime i with respect to independent variable x , $\left| \frac{dP_i}{dx} \cdot \bar{x} \right|$. This measure rescales the marginal effect and thus allows a visual comparison between the highest occurrences of regimes as a result of a one percent change in the independent variable.

necessarily have a higher occurrence and the two-pole hypothesis is not strongly supported by the data.

Not surprisingly, the figure provides unfavorable evidence for the two-pole hypothesis, and only *rerv*, which stands for the real exchange rate variability, results in the v-shape that strongly supports the two-pole hypothesis.

4-2. CC Model

The right panel of Table 2 shows estimated marginal effects of the explanatory variables on the probability of choosing regimes based on the CC model. Compared with the OCA, the results are more favorable to the two-pole hypothesis.

Expansionary fiscal policy, contractionary bank domestic credit, deteriorating current account, a fall in foreign liabilities, an increase in foreign interest rates and GDP growth tend to lead countries to select a fixed regime. Contractionary fiscal policy, expansionary bank domestic credit, a fall in GDP growth and foreign reserves, improvement in the current account, an increase in foreign liabilities, a decrease in foreign interest rates, move countries to a floating regime. Only four variable movements, an increase in GDP growth, a rise in foreign reserves and FDI, and a fall in foreign GDP growth, shift countries to an intermediate regime. The right panel of Table 3 also shows that the occurrence of the two poles is about four times as that of the

intermediate regime (thirteen times compared to three times).

Figure 3 also shows that many CC variables support the two-pole hypothesis. Government spending, bank credit, foreign liabilities and foreign interest rates have a v-shape for their plotted combinations of absolute marginal effects.

These estimated results lead to a conclusion that the validity of the two-pole hypothesis is highly dependent on the types of economic variables. The next section discusses influences of structural breaks on the choice of exchange rate regimes.

5. Empirical Result 2

5-1. Simple Chow test for structural break

In this section, we investigate the possibility of a structural change in effects of the explanatory variables during the experimental period. A Chow test is one of the most commonly-used methodologies for structural break tests, and it employs the statistics of a log-likelihood ratio test (LRT).⁷ A simple likelihood ratio test examines whether there is a structural change regarding slope coefficients. If there is no structural change, the log-likelihood of the pooling data should be close to the sum of the

⁷ A popular methodology for the Chow test is to compare SSE (sum of squared error) of the full and sub data sets. Since the discrete dependent variable models do not provide SSE, we use the log-likelihood statistics of the estimated models and compare them applying the LRT (log-likelihood ratio test) methodology:

$$LRT = -2(\ln L_{Full} - \ln L_{Sub1} - \ln L_{Sub2})$$

In the case of the multinomial logit, the degree of freedom for the chi-squared value is:

$$DF = \text{the number of explanatory variables including a constant term} \times 2$$

log-likelihoods of two sub samples. The first test simply divides the experimental period into the 1980s (1982-1990) and the 1990's (1991-1999). Table 4 presents the result of the test for the OCA model.

The estimated LRT (135.29) for my data set easily exceeds its critical chi-square value (21.03), leading us to reject the null hypothesis. The estimators of the restricted (full-sample) and unrestricted (sub-sample) sets may have a significant difference and we can assume that there is a structural change in the experimental period regarding effects of the OCA variables on the choice of exchange regimes.

Next, we investigate the possibility of a structural change regarding effects of the CC variables between the 1980s and the 1990s. Table 4 presents the result of the test. The estimated LRT (117.74) for my data set easily exceeds its critical chi-square value (33.93). We can also reject the null hypothesis and assume that there is a structural change in the experimental period regarding effects of the CC variables.

5-2. Break point search

In the previous section, we arbitrarily chose the year 1990 as a break point of structural change. This section attempts to investigate the possibility of another appropriate break point.

In addition to the original sub-data sets, which cover 1982-1990 and 1991-1999,

we now employ all the years in the experimental period as possible break points and generate 17 different sub-data sets successively using each year as a break point. The next step computes the log-likelihood for the multinomial logit regarding each sub-data set and sequentially obtains the LRT statistics for the structural break test for each break point. Table 5 presents the results of the break point search tests for the OCA model.

The result table shows that the LRT has the greatest value for the data sets with the break point of 1991. More specifically, the structural break point is most likely to exist at the end of 1991. The year 1991 was just before the ERM crisis of 1992, and several currency crises occurred in the following years. Due to the influences of these financial events, the OCA variables, which mostly relate to economic fundamentals of countries, had different effects on exchange regimes.

Table 6 also presents the results of the break point search tests regarding effects of the CC variables. The result table shows that the log-likelihood ratio test (LRT) has the greatest value for the data sets with the break point of 1994, and it indicates that the structural break point is most likely to exist in this year. The CC variables are based on financial conditions of countries. Many researchers suggest that these variables were causes of the currency crises in Mexico and East Asia in the late 1990s. The result of the test indicates that these events strongly influenced the effects of the financial variables during the late 1990s.

5-3. Sub-sample analysis

The result of the sequential Chow test endogenously gives us a more appropriate break point in 1991 for the OCA model and in 1994 for the CC model. We then divide the sample size at these dates and estimate the multinomial logit for the two sub-periods using each group of variables (Tables 7 and 8).

Regarding the first subsample period for the OCA model (Table 7, left panel, first three columns), the estimated result is similar to the full sample estimates for the OCA model. An increase in the independent variables raises the probability of countries choosing an intermediate regime. In contrast, a decrease in the OCA variables increases the probability of countries moving towards a fixed exchange rate regime. The left panel of Table 8 shows that the occurrence of these two possibilities is equal. This result does not support the two-pole hypothesis during the 1980s for the OCA variables.

In the 1990s, the indication of the OCA model is less clear (Table 7, left panel, columns 4 to 6). A rise in three out of five OCA variables and a decrease in real exchange rate variability both increase the probability of countries moving towards an intermediate regime. On the other hand, a decrease in openness, GDP, and inflation differential, and an increase in real exchange rate variability raise the probability of countries choosing one of the two poles. The right panels of Table 8 show that the

probability of either poles being chosen is equal and it is difficult to observe a dominant regime. Moreover, the left and right panels of Figure 4 display that none of the variables has a clear v-shape to support the two-pole hypothesis.

In terms of the CC variables, in which the break occurs later in 1994, the estimates for the first subsample strongly support the two pole hypothesis (Table 9, right panel, columns 1 to 3). A decrease in all CC variables raises the probability of either of the two poles being chosen instead of an intermediate regime, and the result supports the two pole hypothesis. An increase in government spending and overvaluation measure of exchange rate, and improvement in the current account also raise the probability of one of the two poles being chosen. An increase in only three variables, bank domestic credits, economic growth, and reserves, raises the probability of countries moving towards an intermediate regime. The left panel of Table 8 shows that the two poles occur about three times as frequently as the intermediate regime (fourteen times compared to five times). The left panels of Figure 5 show that government spending, current account, foreign interest rates, overvaluation measure, and foreign economic growth have clear v-shaped curves that strongly support the two pole hypothesis.

The estimations using the second subsample starting in 1995 do not show an explicit support for the two pole hypothesis. The result suggests a higher frequency of countries choosing an intermediate regime compared to the first subsample. The

probability of one of the two poles being selected increases when government spending, economic growth rate, reserves, current account, fdi, and foreign interest rates decline. On the other hand, decreases in bank domestic credit, foreign liabilities, and overvalued exchange rate measures cause a rise in the probability of choosing an intermediate regime. The right panel of Table 8 shows that the frequency of the two poles is slightly higher than that of the intermediate regime (ten times compared to eight times) in terms of the total movements; however, regarding an increase in the dependent variables, the frequency of the intermediate is higher than selection of either of the two poles. The left panels of Figure 5 show that only FDI and foreign economic growth have clear v-shaped curves.

In summary, the frequency of two poles being chosen over an intermediate regime is still higher, but less than in the first subsample. The evidence makes it more difficult to argue that the intermediate regime is a transitional or absorbed state.

6. Conclusion

The paper examines how economic factors affect the selection of currency regimes and discusses the viability of the intermediate regime, as well as the validity of the two pole hypothesis. The analysis employs two popular groups of variables, one is from the optimal

currency area discussions and the other relates to the currency crises literature, and examines updated data of 138 countries.

The estimated results confirm that the two-pole hypothesis depends on the type of variables, their direction of change, as well as the time period of analysis. Regarding the full sample analysis using OCA variables, a limited number of variables explicitly support the two-pole hypothesis and the intermediate has a relatively high occurrence. In terms of CC models, more variables support the tendency towards the two poles.

Conducting the endogenous break point search test and dividing the date into two subsample periods, the paper examines the consistency of influences of independent variables over the regime change, and the validity of the two-pole hypothesis across time. The results indicate that there are similar patterns existing in both subsamples regarding OCA variables. An increase in the economic variables is likely to shift a country towards an intermediate regime, while a decrease of these variables tends to cause movement towards two poles, in particular, a fixed regime.

In terms of the CC variables, the estimated results for the first subsample show that many variables explicitly support the two-pole hypothesis. A fall in almost all the explanatory variables increases the occurrence of either of two poles. However, the results for the second subsample do not clearly show the movement towards either of two poles, and the intermediate regime has only a slightly higher occurrence.

The paper concludes that convergent movements towards either of the two poles are not always consistent across time, and the hypothesis of the intermediate regime as a disappearing state does not sufficiently explain the experiences of many countries.

Table 1. Sample probability of transition between regimes

Regime in period T	Obs	Regime in period T+1	Obs	Prob
Float	586	Float	526	89.76%
		Intermediate	48	8.19%
		Fixed	12	2.05%
Intermediate	858	Float	42	4.90%
		Intermediate	763	88.93%
		Fixed	53	6.18%
Fixed	1522	Float	48	3.15%
		Intermediate	47	3.09%
		Fixed	1427	93.76%

Table 2. Full Sample OCA and CC Model Estimates (1982-1999)

OCA Model				CC Model			
	dP/dX				dP/dX		
	Float	Inter	Fixed		Float	Inter	Fixed
gdp	3.94 (7.0)	12.07 ▲ (16.8)	-16.01 ▼ (18.3)	gov	-0.71 ▼ (4.5)	0.22 (1.1)	0.49 ▲ (2.3)
open	-0.15 ▼ (4.4)	0.18 ▲ (5.6)	-0.03 (0.8)	bnkc	0.10 ▲ (5.0)	0.07 (2.2)	-0.17 ▼ (4.8)
infdif	0.22 (3.6)	0.61 ▲ (6.7)	-0.83 ▼ (6.8)	dgdp	-0.63 ▼ (3.9)	0.67 ▲ (3.1)	-0.04 (0.2)
gcf	0.08 (1.6)	0.11 ▲ (2.0)	-0.19 ▼ (2.4)	rsv	-0.84 ▼ (2.1)	1.60 ▲ (3.1)	-0.76 (1.3)
rerv	14.11 ▲ (5.2)	0.70 (0.2)	-14.82 ▼ (2.9)	cab	0.72 ▲ (4.9)	0.70 (3.6)	-1.41 ▼ (6.7)
				fliab	0.09 ▲ (3.5)	0.04 (0.9)	-0.13 ▼ (2.8)
				fdi	0.04 (0.2)	0.54 ▲ (1.6)	-0.58 (1.6)
				dev	-0.20 (0.1)	-0.62 (1.3)	2.82 (1.3)
				nintf	-3.05 ▼ (7.5)	0.10 (0.2)	2.95 ▲ (5.8)
				dgdpf	-0.81 (2.8)	-0.96 ▼ (2.6)	1.77 ▲ (4.5)
LRT		691.55		LRT		255.29	
Pseudo-R²		0.192		Pseudo-R²		0.071	
AIC		1.682		AIC		1.943	

Table 3. Frequency of regimes

Frequency of regimes: OCA Model
(1982-1999)

	Two poles		Intermediate
Increase	1 (0.20)		4 (0.80)
in	Fixed	Float	
Variables	0 (0.00)	1 (0.20)	
	Two poles		Intermediate
Decrease	5 (1.00)		0 (0.00)
in	Fixed	Float	
Variables	4 (0.80)	1 (0.20)	
	Two poles		Intermediate
Total	6 (0.60)		4 (0.40)
	Fixed	Float	
	4 (0.40)	2 (0.20)	

Frequency of regimes: CC Model
(1982-1999)

	Two poles		Intermediate
Increase	6 (0.75)		2 (0.25)
in	Fixed	Float	
Variables	3 (0.38)	3 (0.38)	
	Two poles		Intermediate
Decrease	7 (0.88)		1 (0.13)
in	Fixed	Float	
Variables	3 (0.38)	4 (0.50)	
	Two poles		Intermediate
Total	13 (0.81)		3 (0.19)
	Fixed	Float	
	6 (0.38)	7 (0.44)	

Note

1. The numbers in the table indicate how many times the regime has the highest marginal effect with respect to changes (increase or decrease) in the independent variable.
2. Parentheses indicate the percentage of total.

Table 4. Structural Change Test

	Log-likelihood			LRT	Chi2(95%)	DF
	1982-1999	1982-1990	1991-1999			
OCA	-1459.77	-545.54	-846.58	135.29	21.03	12
CC	-1677.90	-697.13	-921.90	117.74	33.93	22

Note

1. $LRT = -2(\ln L_{Full} - \ln L_{Sub1} - \ln L_{Sub2})$

2. A simple likelihood ratio test indicates that there is a structural change regarding the slope coefficients. If there is no structural change, the log-likelihood of the pooling data should be close to the sum of the log-likelihood of two sub samples. However, our LRT indicates that the differences are large ($LRT > \text{Critical Chi}^2$), and there should be a structural change in the experimental period.

Table 5. Break point test (OCA)

Break Point	Pool (1982-1999)	Sub1 (1982-B Point)	Sub2 (B Point-1998)	LRT	Chi2(95%)	DF
1982	-1459.77	-35.22	-1406.70	35.69	21.03	12
1983	-1459.77	-82.58	-1347.70	58.97	21.03	12
1984	-1459.77	-129.59	-1289.73	80.89	21.03	12
1985	-1459.77	-189.38	-1224.52	91.74	21.03	12
1986	-1459.77	-263.90	-1154.07	83.60	21.03	12
1987	-1459.77	-327.17	-1084.16	96.87	21.03	12
1988	-1459.77	-397.93	-1006.47	110.73	21.03	12
1989	-1459.77	-472.23	-927.03	121.02	21.03	12
1990	-1459.77	-545.54	-846.58	135.28	21.03	12
1991	-1459.77	-620.88	-762.82	152.15	21.03	12
1992	-1459.77	-718.94	-675.68	130.28	21.03	12
1993	-1459.77	-818.99	-581.53	118.50	21.03	12
1994	-1459.77	-919.25	-486.36	108.33	21.03	12
1995	-1459.77	-1024.75	-386.18	97.68	21.03	12
1996	-1459.77	-1123.13	-289.62	94.03	21.03	12
1997	-1459.77	-1217.61	-191.87	100.58	21.03	12
1998	-1459.77	-1346.45	-78.69	69.26	21.03	12

Table 6. Break point test (CC)

Break Point	Pool (1982-1999)	Sub1 (1982-B Point)	Sub2 (B Point-1998)		LRT	Chi2(95%)	DF
1982	-1677.90	-37.52	-1608.96		62.83	33.93	22
1983	-1677.90	-104.60	-1539.88		66.84	33.93	22
1984	-1677.90	-180.25	-1461.47		72.37	33.93	22
1985	-1677.90	-262.11	-1380.09		71.39	33.93	22
1986	-1677.90	-339.64	-1293.26		89.99	33.93	22
1987	-1677.90	-415.67	-1209.63		105.19	33.93	22
1988	-1677.90	-503.92	-1119.75		108.44	33.93	22
1989	-1677.90	-598.21	-1022.71		113.96	33.93	22
1990	-1677.90	-697.13	-921.90		117.74	33.93	22
1991	-1677.90	-794.33	-819.06		129.02	33.93	22
1992	-1677.90	-897.73	-718.40		123.54	33.93	22
1993	-1677.90	-1004.19	-605.42		136.56	33.93	22
1994	-1677.90	-1109.78	-497.79		140.65	33.93	22
1995	-1677.90	-1228.57	-383.66		131.33	33.93	22
1996	-1677.90	-1349.50	-273.75		109.29	33.93	22
1997	-1677.90	-1459.52	-172.65		91.44	33.93	22
1998	-1677.90	-1571.46	-75.96		60.95	33.93	22

Table 7. Effect of Structural Break: Subsample estimates

OCA Model						
dP/dX						
	1982-1991			1992-1999		
	Float	Inter	Fixed	Float	Inter	Fixed
gdp	3.77 (6.6)	14.56▲ (13.7)	-18.33▼ (14.6)	1.27 (1.4)	9.55▲ (9.3)	-10.81▼ (10.7)
open	-0.03 (1.0)	0.12▲ (2.8)	-0.09▼ (1.7)	-0.33▼ (5.6)	0.25▲ (4.7)	0.09 (1.8)
infdif	0.11 (1.8)	0.60▲ (4.2)	-0.71▼ (4.2)	0.07 (0.7)	0.39▲ (3.7)	-0.46▼ (3.5)
gcf	0.19 (2.1)	0.69▲ (2.8)	-0.87▼ (2.8)	0.04 (0.6)	0.04 (0.7)	-0.08 (1.3)
rerv	28.42 (6.1)	40.82▲ (3.9)	-69.24▼ (5.7)	9.68▲ (2.8)	-8.01▼ (1.8)	-1.67 (0.4)
LRT	460.18			240.69		
Pseudo-R²	0.270			0.136		
AIC	1.343			1.915		

Table 8. Frequency of regimes (OCA)

Frequency of regimes: OCA Model
(1982–1991)

	Two poles		Intermediate
Increase	0 (0.00)		5 (1.00)
in	Fixed	Float	
Variables	0 (0.00)	0 (0.00)	
	Two poles		Intermediate
Decrease	5 (1.00)		0 (0.00)
in	Fixed	Float	
Variables	5 (1.00)	0 (0.00)	
	Two poles		Intermediate
Total	5 (0.50)		5 (0.50)
	Fixed	Float	
	5 (0.50)	0 (0.00)	

Frequency of regimes: OCA Model
(1992–1999)

	Two poles		Intermediate
Increase	1 (0.25)		3 (0.75)
in	Fixed	Float	
Variables	0 (0.00)	1 (0.25)	
	Two poles		Intermediate
Decrease	3 (0.75)		1 (0.25)
in	Fixed	Float	
Variables	2 (0.50)	1 (0.25)	
	Two poles		Intermediate
Total	4 (0.50)		4 (0.50)
	Fixed	Float	
	2 (0.25)	2 (0.25)	

Table 9. Effect of Structural Break: Subsample estimates

CC Model						
dP/dX						
	1982-1994			1995-1999		
	Float	Inter	Fixed	Float	Inter	Fixed
gov	-0.49▼ (3.2)	-0.28 (1.2)	0.77▲ (3.0)	-1.70▼ (4.1)	1.13▲ (2.6)	0.57 (1.3)
bnkc	0.12 (5.4)	0.17▲ (4.3)	-0.28▼ (6.2)	0.11▲ (2.2)	-0.13▼ (2.1)	0.02 (0.4)
dgdg	-0.45▼ (2.8)	0.49▲ (1.9)	-0.04 (0.1)	-1.20▼ (3.0)	1.18▲ (2.7)	0.02 (0.1)
rsv	-0.71 (1.7)	1.52▲ (2.6)	-0.81 (1.2)	-2.98▼ (3.0)	2.05▲ (1.8)	0.93 (0.9)
cab	0.90▲ (5.9)	0.52 (2.2)	-1.41▼ (5.5)	0.23 (0.6)	1.10▲ (2.6)	-1.32▼ (3.5)
fliab	0.05 (2.3)	0.08▲ (1.9)	-0.14▼ (2.7)	0.37▲ (3.9)	-0.37▼ (2.9)	0.00 (0.0)
fdi	0.28 (1.7)	0.76▲ (1.8)	-1.04▼ (2.4)	-1.98▼ (2.1)	-0.02 (0.0)	2.00▲ (2.2)
dev	10.75▲ (4.6)	4.00 (0.9)	-14.76▼ (3.0)	-3.12 (1.3)	-5.71▼ (1.8)	8.82▲ (2.3)
intf	-2.32▼ (6.3)	0.20 (0.4)	2.12▲ (3.8)	0.61 (0.3)	4.51▲ (1.9)	-5.11▼ (2.2)
dgdpg	-0.73▼ (2.8)	-0.63 (1.5)	1.36▲ (3.1)	0.98 (0.8)	-0.40 (0.3)	-0.58 (0.4)
LRT	213.37			97.20		
Pseudo-R ²	0.088			0.089		
AIC	1.815			2.063		

Table 10. Frequency of regimes (CC)

Frequency of regimes: CC Model
(1982-1994)

	Two poles		Intermediate
Increase	5 (0.50)		5 (0.50)
In	Fixed	Float	
	3	2	
Variables	(0.30)	(0.20)	
	Two poles		Intermediate
Decrease	9 (1.00)		0 (0.00)
in	Fixed	Float	
	5	4	
Variables	(0.56)	(0.44)	
	Two poles		Intermediate
Total	14 (0.74)		5 (0.26)
	Fixed	Float	
	8 (0.42)	6 (0.32)	

Frequency of regimes: CC Model
(1995-1999)

	Two poles		Intermediate
Increase	4 (0.44)		5 (0.56)
in	Fixed	Float	
	2	2	
Variables	(0.22)	(0.22)	
	Two poles		Intermediate
Decrease	6 (0.67)		3 (0.33)
in	Fixed	Float	
	2	4	
Variables	(0.22)	(0.44)	
	Two poles		Intermediate
Total	10 (0.56)		8 (0.44)
	Fixed	Float	
	4 (0.22)	6 (0.33)	

Figure 1. Changing exchange rate regime

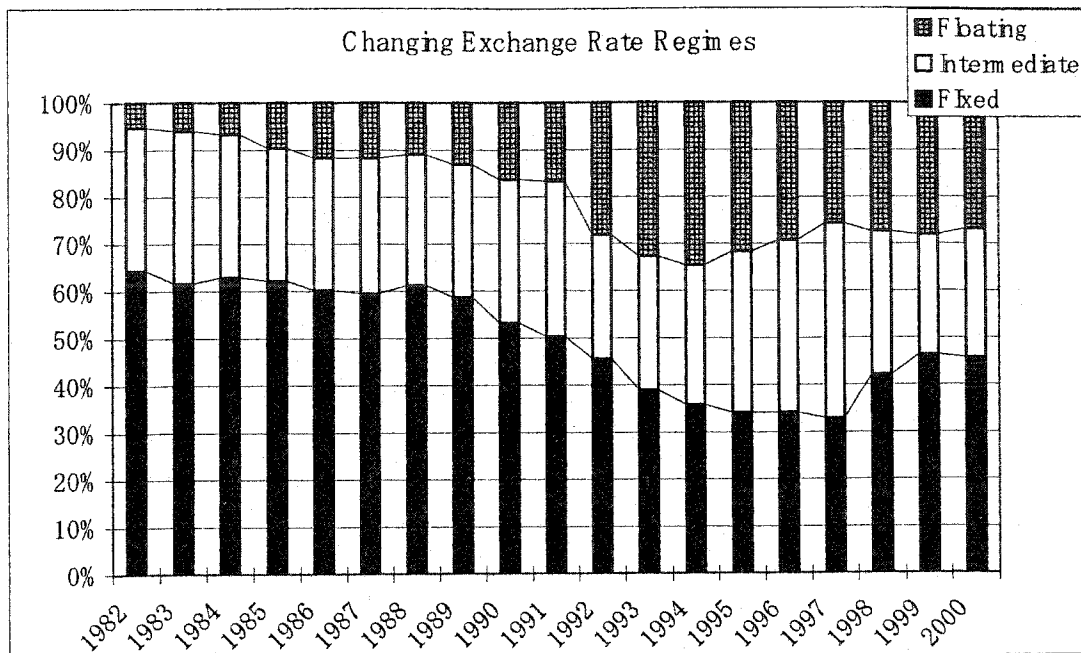


Figure 2. Modified Absolute Marginal Effects: OCA variables (1982-1999)

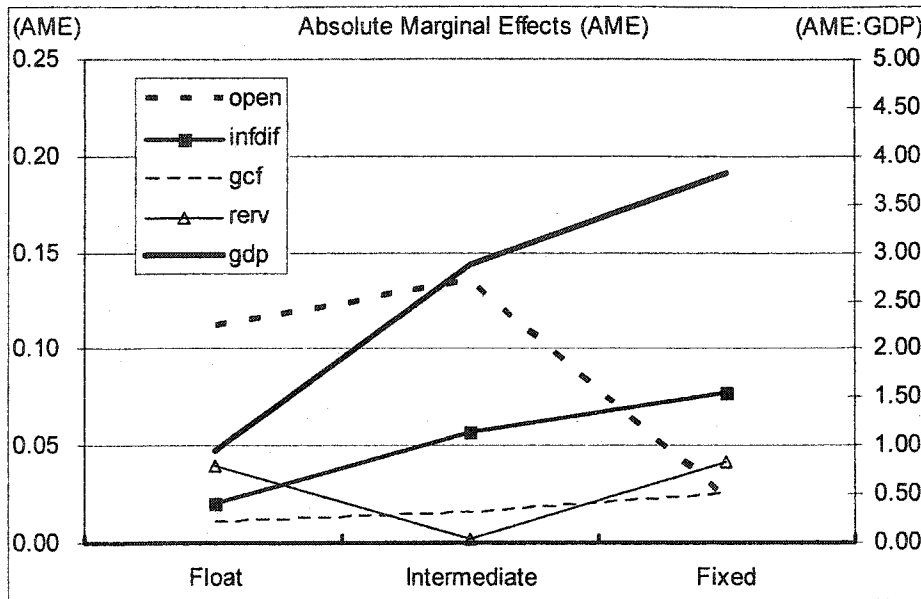


Figure 3. Modified Absolute Marginal Effects: CC variables (1982-1999)

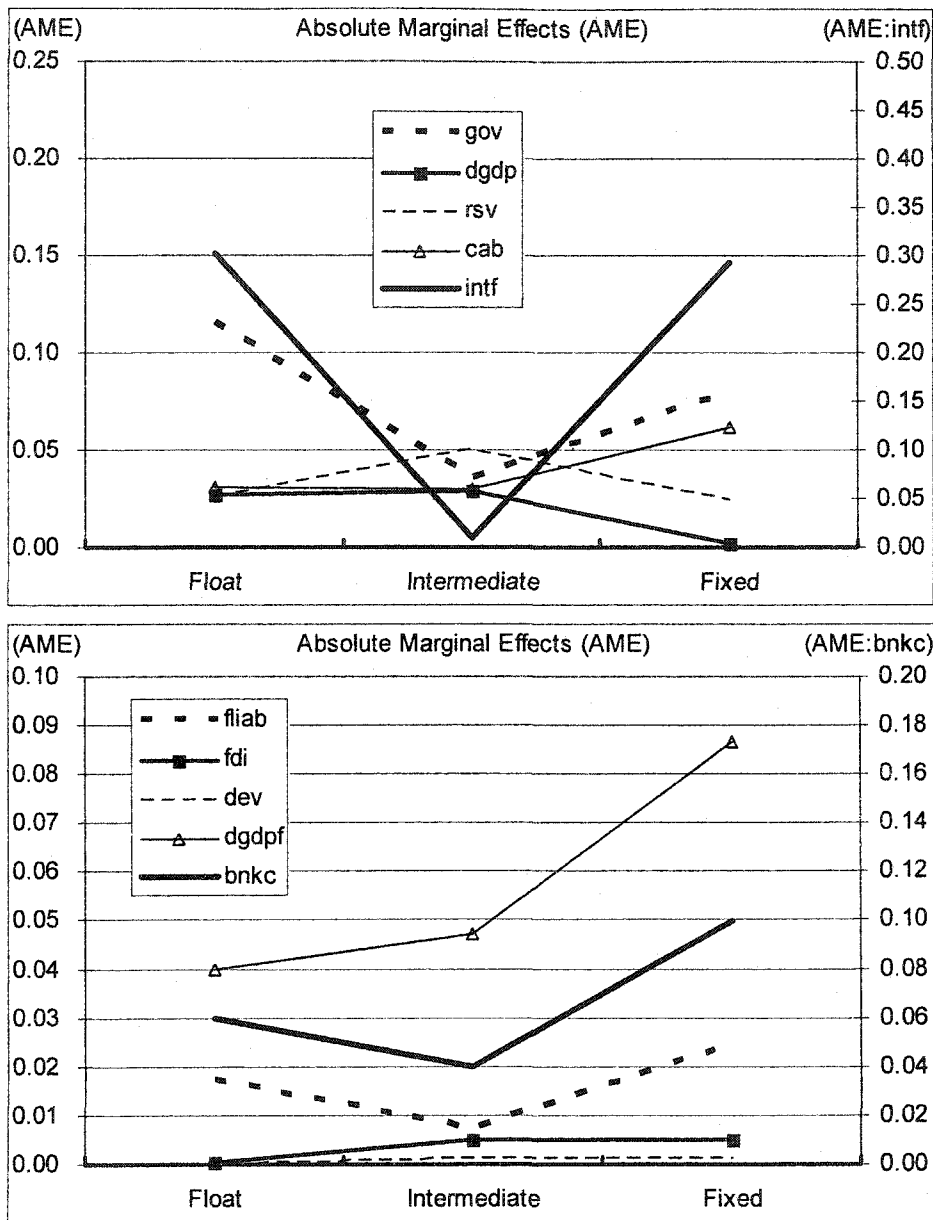
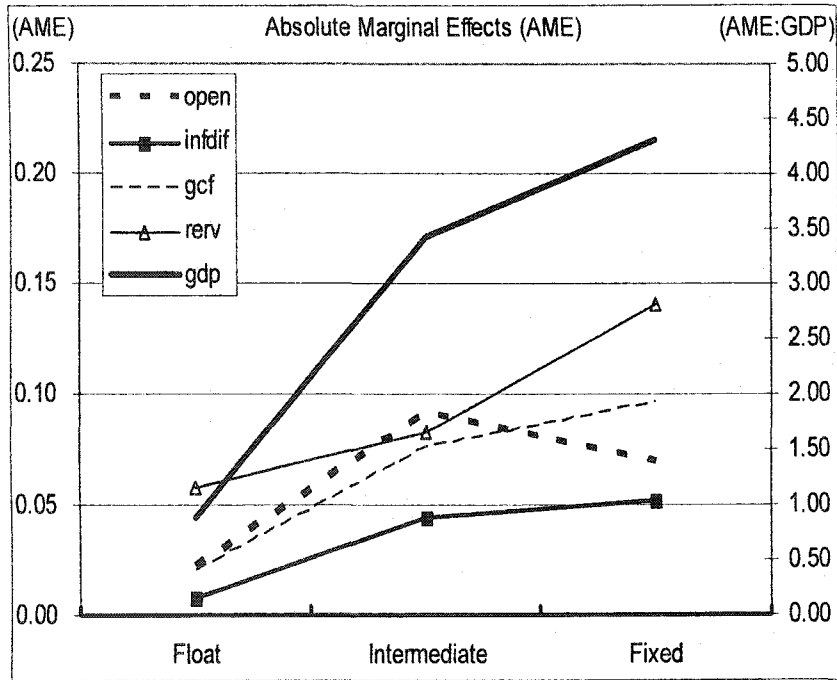


Figure 4. Modified Absolute Marginal Effects: OCA variables

(1982-1991)



(1992-1999)

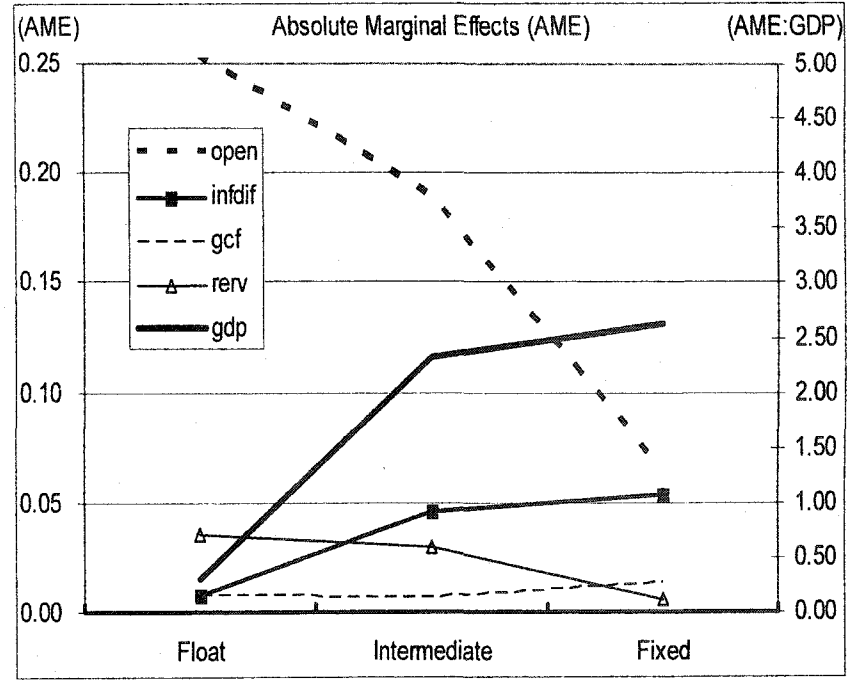
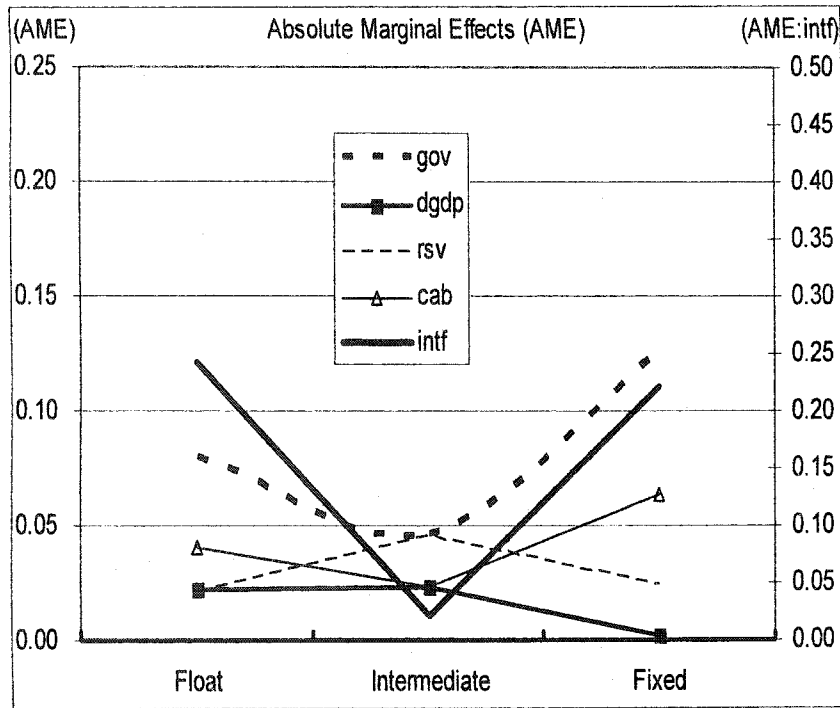


Figure 5. Modified Absolute Marginal Effects: CC variables

(1982-1994)



(1995-1999)

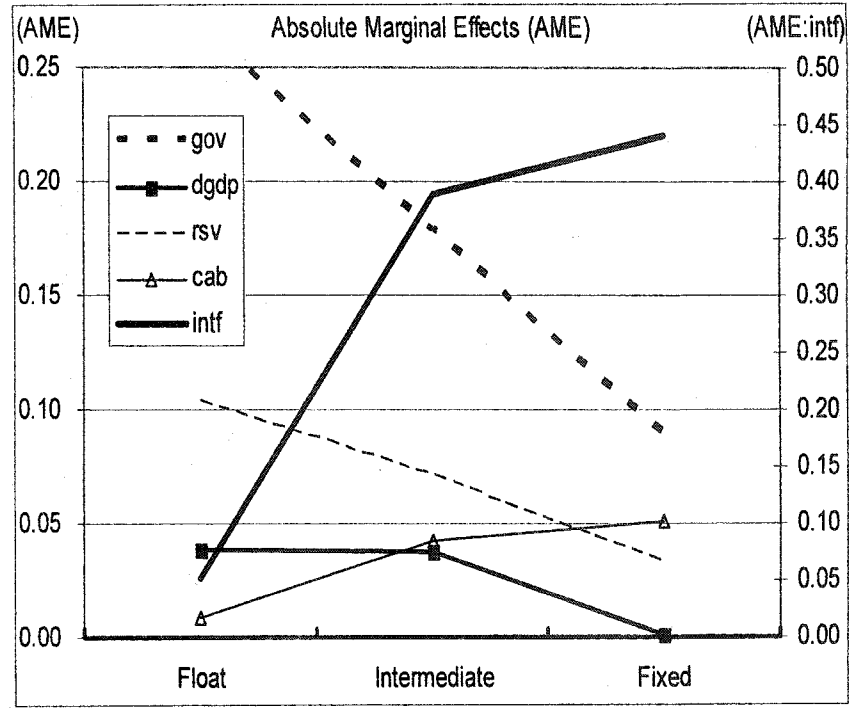
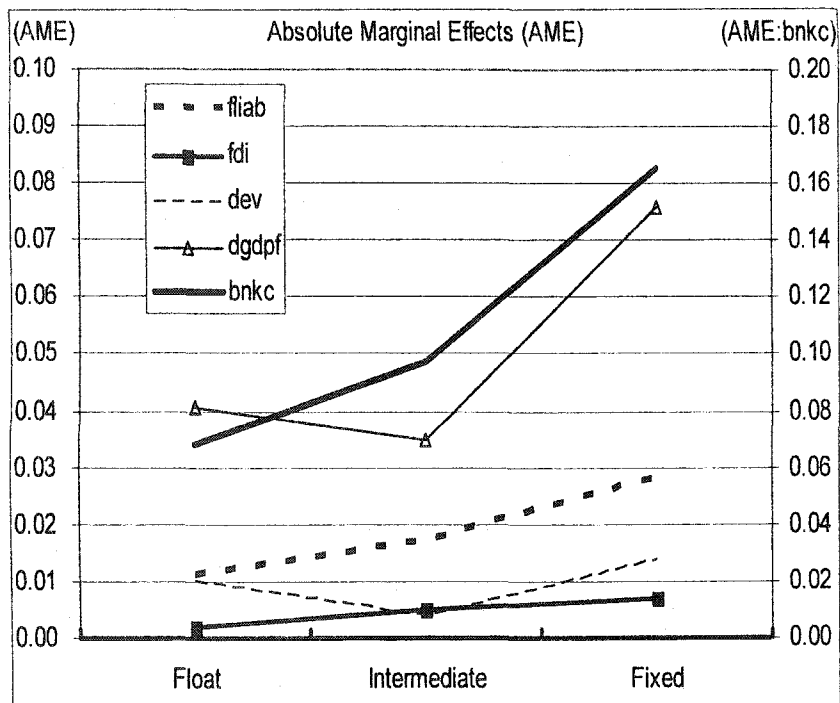
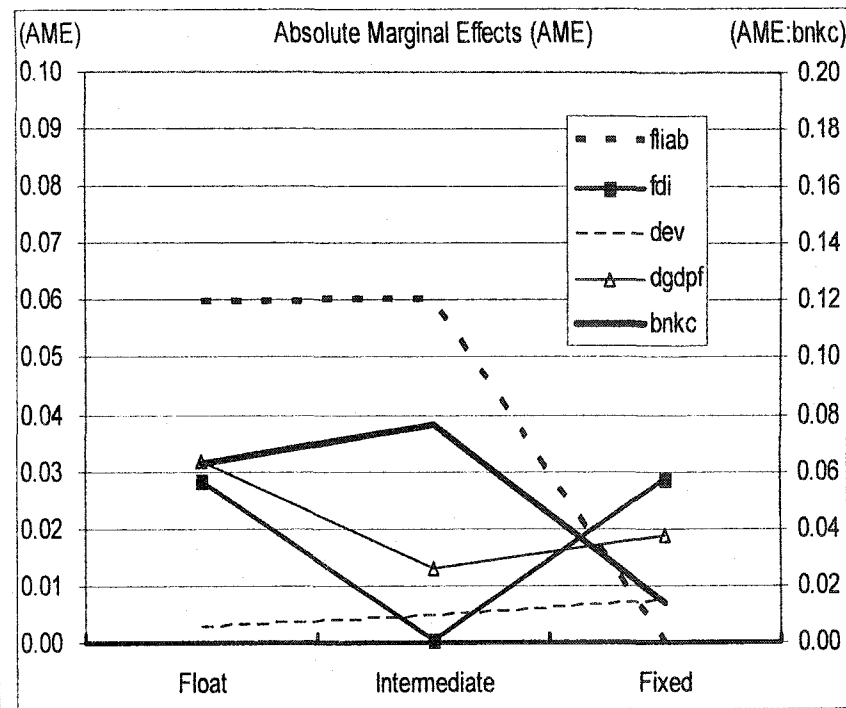


Figure 5. (Continued)

(1982-1994)



(1995-1999)



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