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Abstract:

Given the absence of publicly available information on foreign exchange intervention, we propose an index of central bank intervention in the exchange market to classify exchange rate regimes adopted by four East Asian economies. We revisit an old debate on whether these crisis-effected East Asia countries have indeed returned to their pre-1997 rigid exchange rate policies. If, instead, there had been evidences of a policy shift to a more flexible regime, was the move voluntary, or mainly due to high market pressures on the currency? Our findings clearly reject the "hollow middle" hypothesis.

JEL Classifications: F31, F41

Key Words: Exchange Market Intervention; Exchange Rate Regimes; East Asian Countries

1. Introduction

There has been a great deal of efforts expended in developing behavioural classifications of exchange rate regimes by either looking exclusively at the behaviour of nominal exchange rates, or considering fluctuations in both the nominal exchange rates and foreign exchange reserves (Reinhart and Rogoff (2004) and Levy-Yeyati and Sturzenegger (2005)). Viewing from a rather narrow perspective, these considerable efforts seem to be primarily motivated by a crucial recognition of the shortcoming of the Annual Report on Exchange Rate Arrangements and Exchange Restrictions of the International Monetary Fund (IMF).[1]

The urgency has however been driven by much more than just the need to construct a robust classification of the exchange rate regime. With more developing countries have moved to liberalize their economies in the last two decades and at relatively more rapid phases than in the past, the types of exchange rate regimes adopted by them have been repetitively demonstrated to have significant influences on the eventual bearings of the financial liberalization on the development phases of their domestic economies. Early works such as Eichengreen (1994), Diaz-Alejandro (1985), Chang and Valesco (2000) and Wyplosz (2001) contend that it is crucial to realize *ex ante* that liberalization rocks the exchange markets, and building some form of exchange rate flexibility (either by floating or by being prepared to realign pegs) into the liberalization programme is, therefore, essential.

Providing more up-to-date evidences, a work by di Giovanni and Shambaugh (2008) highlights the real cost to the loss of monetary autonomy that comes with the pegged exchange rate policy. They demonstrate that annual real output growth in countries (both developed and developing economies) is negatively associated with

[1] Often regarded as the primary source of information on the official or *de-jure* exchange rate policies pursued by member countries, the IMF Annual Report on Exchange Rate Arrangements and Exchange Restriction has often been blamed for taking the face value on what the countries announce until late 1990s.In view of this, the IMF moved to a *de-facto* classification in 1999, and aimed to describe what member countries actually do rather than what they say that they do (Genberg and Swoboda (2004)).

interest rates in their major trading partners, but this effect holds only for countries with fixed exchange rate.

However, the underlying concern here, as discussed earlier, is on the identification of the regime. Can we estimate how much more (or less) flexible the exchange rate regime of a country has indeed become during the past few years? Furthermore, can we consistently classify countries' *de-facto* regimes of exchange rate and separate the flexible from the dirty float regimes? Calvo and Reinhart (2002) for instance show that many countries which declare a flowing exchange rate regime in fact heavily manage their currencies. Failing to appropriately classify the *de-facto* regime of exchange rate would arguably weaken the analyses and, therefore, undermine our understanding of the link between the exchange rate regime and the overall benefits of the financial liberalization on the development of the domestic economy.

Despite the numerous attempts to classify exchange rate regimes, we have not, however, seen conclusive and consistent findings (Table 2). Kawai and Akiyama (2000) for instance failed to conclusively classify the regime adopted in Indonesia in 1999. Bubula and Otker-Robe (2002), on the other hand, categorize the exchange rate regime in Indonesia for that same year as independently floating. In addition, shortcomings associated with the methodologies, in particular with the underlying statistical assumptions of the testing, were often found on early studies.[2]

For this study, our approach will be to verify the type of exchange rate regimes adopted by four East Asian countries, namely Indonesia, Korea, Singapore and Thailand, through the examination of the exchange market intervention activities of the monetary authorities of each country. Given the absence of publicly available information on the timing and the size of the intervention in the foreign exchange market during the observation period, we will have to first construct an index of

[2] Refer to section 2 on the Literature Reviews.

central bank exchange market intervention by borrowing relevant concepts originally introduced by the seminal work of Girton-Roper (1977).

To trace how volatilities of different components of the intervention index evolve overtime, we apply the Markov-Switching ARCH (SWARCH) procedure. This empirical approach significantly departs from those taken by previous works that have also attempted to construct measures of indices of intervention (see for instance, Weymark (1997) and Bayoumi and Eichengreen (1998))[3]. The application of the SWARCH allows us to move away from static analyses to capture the shift in the policy preference of the monetary authorities of these East Asian economies. The transition from one exchange rate regime to another and the policy instruments being employed will be explicitly captured by the SWARCH results.

Once we have generated the intervention index for each country case, the next task is to calculate regime thresholds for each currency. The idea here is to estimate a threshold where we can systematically categorize a regime characterized by excessive intervention activities of the monetary authority and separate it from that of low exchange market intervention regime. Given the potential diversities between the behaviours of the four currencies and the activities of the monetary authorities of these countries, it is imperative that we avoid imposing a "common regional set" of thresholds for all currencies without the full understanding of the statistical properties of each currency.

In particular, due the non-normality of the statistical distribution of the intervention index series, we have to avoid relying on parametric measurements, such as variance and standard deviation where they are prone to outliers and structural breaks, in identifying the threshold levels. Accordingly, we apply the Extreme Value Theory (EVT) and adopt a modified estimator proposed by Huisman, Koedijk, Kool, and Palm (2001) ---henceforth HKKP. The application of HKKP

[3] To our knowledge only Masson (2001) has adopted the Markov-approach. Bubula and Otker-Robe (2002) follow Masson (2001) in their empirical approach.

enables us to generate more consistent analyses even with relatively small sample sizes.

The construction of the intervention index and the rigorous testing enable us to generate further critical assessments of the exchange rate policy, beyond previously discussed. Instead of just revealing evidences that some of these crisis-effected countries in East Asia have already moved to a more flexible regime in recent years, the more insightful and pertinent policy concerns will be to examine whether the shift from a rigid policy to a flexible one has indeed been a "voluntary" policy decision, not due to the presence of strong market pressures on the local currency. In short, our study aims to further examine the degree and the credibility of the policy commitment of the central bank to move to a more flexible exchange rate regime.[4]

The outline of the paper is as follows. A brief literature review will be presented in section 2. The next section discusses the basic concepts behind the construction of the intervention index. The two key empirical tools, namely, the SWARCH and the EVT, are discussed in section 4. Data and empirical test results are presented in section 5. Based on the findings reported in section 5, we evaluate the exchange regimes of the four East Asian economies in section 6. A brief concluding section ends the paper.

2. Literature Review

Previous studies that have examined the actual or *de-facto* exchange rate arrangements in place in most of the countries in East Asia have proceeded in two ways (Table 1). One approach is to test if the countries assigned weights either to a specific currency or to a basket of currencies using a simple regression model.

[4] Reinhart and Rogoff (2004)) has also highlighted the need for the future researches in this area to examine further the nature of the shift from a rigid exchange rate to a flexible regime, in particular, whether the shift has indeed been a voluntary one.

Originally developed and applied by Frankel and Wei in a series of studies (1993, 1994, and 1995), the regression model estimates an equation of the form:

$$\Delta e_t^j = \alpha + \beta_1 \Delta e_t^{USD} + \beta_2 \Delta e_t^{DM} + \beta_3 \Delta e_t^{JY} + \beta_4 \Delta e_t^{FF} + \beta_5 \Delta e_t^{UKP} + u_t \qquad (1)$$

Where Δe_t^j is the monthly change in the log exchange rate of currency *j* in month *t*, α is a constant term, β_k (k = 1, 2, .., 5) is the coefficient on the monthly change in the log exchange rate of currency *k*, and u_t is the residual term. The superscripts *USD*, *DM*, *JY*, *FF*, and *UKP* refer to the dollar, the deutschemark, the yen, the French franc, and the U.K. pound, respectively. All exchange rates are expressed in terms of a certain numeraire currency, usually the Swiss franc.

The intuition behind the model is that the coefficient estimates can be interpreted as the weights assigned by the respective authorities to the corresponding currencies in their exchange rate policies (Kawai and Akiyama, 2000). In doing so, one can then identify to which specific currency or a basket of currencies that monetary authorities have tended to stabilise their exchange rates.

The Frankel-Wei model does not come without its criticisms. First, McCauley (2001) pointed out that the high estimated coefficients (weights) for the U.S. dollar does not necessarily imply that these currencies were pegging to the U.S. dollar. Instead, these statistics may suggest that the East Asian currencies belong to the U.S. dollar bloc, "or at least that they have not slipped from the dollar bloc into the euro bloc" (McCauley, p. 47). McCauley's basis for this distinction between bloc membership and de-facto pegging (the latter being the preferred interpretation of McKinnon among others) is that "currencies can float freely and yet belong to a bloc" (p.46). The paper further argues that "if belonging to the dollar bloc is taken to be the same as being pegged to the dollar, then the Canadian and Australian dollars must be considered pegged to the U.S. dollar" (p. 46).

The second criticism has something to do with the choice of the numeraire currency. The problem with this empirical strategy is that the numeraire currency should not be linked to any of the currencies in the basket (Benassy-Quere and Coeure, 2000)[5]. For instance in Equation 1, the Swiss franc, as the numeraire currency, is linked to the DM/euro and the U.S. dollar.

The other alternative approach is to assess the degree of commitment by countries to exchange rate stabilisation by arriving at a statistical descriptive measure of observed volatilities in exchange rates, stock of foreign exchange reserves and interest rates. The basic idea behind this approach is that exchange rate stabilisation is not observed through movements alone (or the lack of it) in the nominal exchange rate, but also through interventions in the foreign exchange market and monetary policy actions which moderate or suppressed supposed movements in the nominal exchange rate. There is a scant of studies (e.g., Baig (2001) and Hernandez and Montiel (2003)) that have directly used this approach.[6] However, the two studies also have their own limitations.

First, these studies adopted standard deviations of the volatility measurements as the commonly used parametric measure of volatility. However, any standard deviation measure is a form of averaging and is only an appropriate measure when the conventional parametric assumption of normal distribution needed to employ such a measurement is met.[7] In fact, as early as the 1960s, the non-normality of any speculative price series such as the exchange rate and the interest rates has already been clearly recognised.[8]

[5] In one of the earlier Frankel-Wei (1995) paper, they also used the Swiss franc as the numeraire, but this was arguably appropriate as they only had the U.S. dollar and the Japanese yen as the exogenous variables.

[6] McKinnon and Schnabl (2002) can also be added to these two studies, however, they only looked at exchange rate volatility.

[7] Hernandez and Montiel (2003) used, aside from the standard deviation, the range and mean absolute change of the respective changes in exchange rate, stock of foreign exchange reserves and interest rate, while, Baig (2001) used only the standard deviation of the changes of the same three series.

[8] See, for example, the collection of papers by Mandelbrot (1963, 1964, 1967), Fama (1965, 1970) among others.

Second, it is customary practice of these studies to compare the observed volatility outcomes of the East Asian countries' exchange rates, stock of foreign exchange reserves, and interest rates across a benchmark of acknowledged 'clean' floaters, which are also mostly developed countries with more advanced and well-developed financial markets. However, this approach rests on the strong implicit assumption that the shocks experienced by these countries were uniform over time and across countries, which is an unlikely case.[9]

As will be elaborated further in the next section, our approach will also involve examining three key indicators, namely the foreign exchange reserve, the interest rate, and the nominal exchange rate. Instead of looking at those indicators individually however, we will employ them to construct an intervention index of the central bank for each individual country case. The Markov-Switching ARCH and the Extreme Value Theory (EVT) methodologies will then be applied to measure the index and to estimate the appropriate maximum and minimum thresholds.

3. Intervention Index

In their seminal work, Girton-Roper (1977) show that any excess demand for foreign exchange can be fulfilled through non-mutually exclusive conduits. If market pressures on a particular currency, or often referred to as speculative pressures, have successfully targeted a currency, then there would likely be a sharp depreciation of the domestic currency. However, at other times, the attack can be repelled or warded off through raising interest rates and/or running down on the foreign exchange reserves.

Therefore, volatility alone in the nominal exchange rate understates the magnitude of speculative attacks as this excludes episodes of unsuccessful attacks. Government policies manifested through interest rate policy actions in the money market and purchase or sell of international reserves in the foreign exchange market,

[9] This argument was also recognized by Hernandez and Montiel (2003).

moderate supposed large movements in exchange rates. In the same manner, considering in isolation, movements in reserves and interest rate aside from exchange rates also offer only a partial view of the severity of shocks in the economy.

Based on that seminal idea of Girton-Roper (1977), we can generate two sets of measures or proxies. First, by combining the information gathered from the foreign exchange reserve position of the central bank and its key policy interest rate, one can develop a measure of the monetary authority's propensity to intervene and manage the fluctuations of the local currency. Second, we can also add the information on the exchange rate fluctuations of the local currency to the monetary authority's intervention objectives in order to construct a reasonable estimate of the extent of currency attacks on the market, or commonly referred to as the index of exchange market pressure (EMP).[10]

It is important to note however that the definition of EMP in our study is more closely in line with that of Weymark (1997), whereby the exchange market pressure measures the total excess demand for the domestic currency in the international market as the exchange rate change that would have been required to remove the excess demand in the absence of market intervention by the monetary authority. Girton-Ropter (1977) instead defines its EMP as a measure of excess demand for money in the domestic money market, hence focusing solely on pressures arising from the domestic economy.

To construct the intervention index, we first estimate the "smoothed" probabilities of each key indicator (interest rate, reserve, and exchange rate) to be in the high-volatility state by adopting the markov-regime switching ARCH (to be elaborated further in the next section). A large (small) value for the smoothed probability of high-volatility state of the exchange rate at time t, for instance, suggests

[10] This general idea of exchange market pressure index has been well developed by early studies such as Eichengreen, B., Rose, A., and Wyplosz (1995), Kaminsky, Lizondo, and Reinhart (1998) and Weymark (1998).

that there is a high (low) probability of volatile exchange rate during that specific period (t). This is a useful measure as it conveys information about the nature of the market and the policy stance.

Next, taking the ratio of the smoothed probabilities of high volatility state of the monetary authority intervention and the exchange market pressure, we arrive at the intervention index of the monetary authority (Equation 2):

$$\text{Index of Intervention } (INTV) = \frac{p^H_{reserves} + p^H_{\text{int}\,r}}{p^H_{exr} + p^H_{reserves} + p^H_{\text{int}\,r}} \qquad (2)$$

Where: $p^H_{exr}, p^H_{reserves}, p^H_{\text{int}\,r}$ are the smoothed probabilities that the conditional variance of the changes in exchange rate, reserves, and interest rates, respectively, are in a high-volatility state at period (t). The denominator ($p^H_{exr} + p^H_{reserves} + p^H_{\text{int}\,r}$) captures the smoothed probability of a high exchange market pressure on the currency. It is the probability of the 'total' pressure place upon by market shocks on the exchange rate, and is measured as the sum of the smoothed probabilities of the high variability in exchange rate (p^H_{exr}) and the smoothed probabilities of the high variability of the monetary policy actions in the exchange markets ($p^H_{reserves} + p^H_{\text{int}\,r}$) (Glick and Wihlbourg, 1997).

Our INTV index denotes that when analysing exchange rate policy, examining alone the behaviour of the exchange rate offers us only a partial picture. The exchange rate volatility can be low because of government policy actions manifested through monetary policy and interventions in the foreign exchange market $\left(p^H_{reserves} + p^H_{\text{int}\,r}\right)$, or because there are relatively few shocks or modest exchange market pressures $\left(p^H_{exr} + p^H_{reserves} + p^H_{\text{int}\,r}\right)$. Thus, to clasify a country's exchange rate policy, we need, at the very least, to look both at the information conveyed by the exchange rate changes and the intervention activities of the central bank (Willett, 2004).

There are a number of advantages of adopting the INTV index. First, the inclusion of the interest rate variable in the INTV index extends earlier models, such as that of Bayoumi and Eichengreen (1998) and Weymark (1997). Given the frequent use of interest rate adjustments to defend the local currency, especially during times of heavy market pressures against the local currency, it is vital that we include this policy instrument in our INTV index.[11]

Second, early studies constructed their indices of exchange market pressure and intervention index by including actual percentage changes of the key relevant variables. Since the volatility of one variable, such as the monthly changes in the exchange rate, may completely dominate the others, early indices place a strong emphasis on the weights of the three variables/ components of the index. The weight assigned varies from one study to another, and it is often unclear as to how the weight was calculated.

In contrast, our INTV index relies on the probability of each of its components to be in its high volatile state. The probability of each series is equally ranged from 0 to 1 at any point of time, including the crisis period. An INTV index closes to one (zero) should suggest that there is a high (low) propensity to intervene, and thus suggesting a rigid (flexible) exchange rate regime. Hence, the INTV index is simpler to construct, does not rely on any arbitrary weighting scheme and is therefore more transparently generated.

Thirdly, the application of time-varying smoothed probabilities of the markov-regime switching ARCH means that our index does not require a priori dating of crisis, speculative attack periods or abrupt shift from one type of exchange rate

[11] Kaminsky and Reinhart (1996) did not include the interest rate component in their application due to the lack of complete interest data for the countries that they examined. Eichengreen, Rose and Wyplosz (1995), on the other hand, include the level of domestic interest rate in their index of exchange market pressure.

regime to another. The dynamics of the smoothed probabilities of each variable means that the INTV index will endogenously capture the trends and signal the timing of the following possible events: a significant rise in market pressure (i.e. the speculative attack periods); a rise in the intervention activities of the monetary authority; and more importantly a shift to a different regime of exchange rate. Lastly, given the construction of the INTV index, different possible scenarios on the regime classifications can be conveniently derived, as will be shown in the empirical section of the paper.

One caveat must be added here. As for any economic indicators or indexes, the accuracy of the INTV index would highly depend on the quality of the "determinant" variables, in particular the reserve and the interest rate. In the absence of publicly available information on intervention in the foreign exchange market, we follow Calvo and Reinhart (2002) in using changes in reserves as the imperfect measure of foreign exchange intervention, while intervention in money markets is measured by changes in interest rates.[12]

These indicators are imperfect measure as we recognize that *not all* movements or changes in reserve or interest rate are due to or associated with interventions to defend or smooth the fluctuations of the local currency. However, only few central banks have in fact publicly announced their foreign exchange intervention activities. These are largely monetary authorities from the industrialized economies, such as Japan, the United States, Switzerland, Canada and Australia.[13]

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[12] As will be discussed in section 5, line 11 of the IMF-IFS is used as the measure of the stock of foreign exchange reserves instead of line 1Ld (international reserves data). The advantage of using line 11 is that it includes borrowed money, which can be used for foreign exchange intervention, while, line 1Ld may change due to a host of other reasons not entirely connected to intervention such as, fluctuations in valuations, accrual of interest earnings, and money in the IMF that can or cannot be used. We thank Charles Wyplosz for pointing this out.

[13] Refer to Frenkel, Pierdzioch, and Stadtmann (2005), Fatum (2005), Pierdzioch and Stadtmann (2003) and Kearns and Rigobon (2005).

None of the central banks from the emerging markets in East Asia has transparently disclosed their intervention activities.[14]

4. SWARCH and Extreme Value Theory

4.1 Markov-Regime Switching ARCH (SWARCH)

Hamilton and Susmel (1994) proposed an extension of the standard ARCH model which can incorporate regime shifts. In their model, the parameters of the ARCH process are allowed to switch between discrete numbers of states, with the transitions between states governed by a finite-order Markov process. Hamilton and Susmel called this the switching ARCH or, simply, SWARCH model. For this study, the Markov representation allows us to compresses the history of exchange rate regimes into a single matrix that can then be employed to capture the shifts and the transition stages from one exchange rate regime to another.

The SWARCH model can be described by the following system of equations:

$$\Delta r_t = \phi_0 + \phi_1 \Delta r_{t-1} + \varepsilon_t, \qquad \varepsilon_t | I_{t-1} \sim N(0, h_t) \tag{3}$$

$$\varepsilon_t = u_t \sqrt{g(s_t)} \qquad s = 1, ..., K \tag{4}$$

$$u_t = \sqrt{h_t} v_t; \qquad v_t \sim N(0,1) \tag{5}$$

$$h_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i u_{t-i}^2 \tag{6}$$

Equation (3) assumes that the return (r_t) follows a first-order autoregressive scheme. The returns innovations (ε_t) are assumed to follow an ARCH process with conditional variance h_t^2 where h_t^2 depends linearly on *q* past squared errors, i.e., u_{t-i}^2. In standard ARCH models, the parameters are constant across regimes. In the

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[14] Therefore it is difficult for instance to distangle interest rate adjustments to manage exchange rate volatilities form those measures taken to stabilize inflation and output-gap. But it is still pertinent that the interest rate variable be included in measuring intervention activities of the central banks, as argued by the past literatures discussed earlier and also will be shown further in the empirical section.

SWARCH model, however, the ARCH parameters are allowed to switch endogenously between a set of discrete states (K). The move from one state to another represents a change in the scale of the volatility process. This is represented above by *g(s$_t$)* as the constant switching or variance factor, which depends on the state variable, $s_t = 1,....,K$. In this representation, a normalization is imposed such that $g(1) = 1$ and $g(s_t) \geq 1$ for $s_t = 1,....,K$. Hence, State 1 may be viewed as the low volatility state. For $s_t \neq 1$, $g(s_t)$ therefore indicates the magnitude of volatility at s_t relative to the low volatility state.

Following Hamilton and Susmel (1994), s_t is assumed to follow an unobserved first-order *K*-Markov process, which can be described by transition probabilities, $P(s_t = j / s_{t-1} = i, s_{t-2} = k,..., y_{t-1,} y_{t-2,...}) = p(s_t = j / s_{t-1} = i) = p_{ij}$. Each probability number, (p_{ij}), is the probability that State i is followed by State j. Define the probability transition matrix as follows:

$$P = \begin{pmatrix} p_{11} & \cdots & p_{k1} \\ \vdots & \ddots & \vdots \\ p_{1k} & \cdots & p_{kk} \end{pmatrix} \quad (7)$$

The sum of elements in each and every row in the above matrix should be equal to 1.

One of the objectives of the SWARCH model is to predict the probability of occurrence of a state for each period, where it was shown by Hamilton and Susmel (1994) to be a by-product of a non-linear Markov-switching filter. For example, the inference that is based on information available or observed at time (t) is called the 'filter probability'. Alternatively, the inference using all sample observations is called the 'smoothed probability'. The full sample smoothed probability represents the probability that the conditional variance was in state s_t at date (t), given all sample of observations. Since the basis for the construction of the INTV index (Equation 2) is expressed through the smoothed probabilities of the conditional variance being at the high-volatility state, the index is in effect constrained between 0 and 1.

4.2 Intervention Threshold: Application of Extreme Value Theory

The next empirical challenge is to compare and contrast the pre-1997 exchange regime with that of the post-1997 regime. The challenge here is to calculate the levels of INTV index that can be considered as High and Low INTV, suggesting less and more flexible exchange rate regimes, respectively. Without properly generating thresholds of High and Low levels of INTV index, the classification of the regimes based on the intervention index will be done in an ad-hoc manner.

The conventional approach of generating these thresholds is by simply employing the mean and the standard deviations of the INTV index. Studies such as Baig (2001) and Hernandez and Montiel (2003) employed thresholds using the mean and standard deviations in their own definition of an INTV index.[15] The principal assumption of normal distribution however must hold for the application of the mean and standard deviation to be appropriate for any analyses on the series. However, as earlier mentioned, studies have documented that exchange rates, interest rates and foreign exchange reserves are not normally distributed.[16]

To generate thresholds that are statistically consistent with the underlying INTV series, we adopt the Extreme Value Theory (EVT) approach. This is a non-parametic approach which would allow us to generate the maximum/high and minimum/low thresholds of the INTV index for each of the country cases without any a-priori assumption about the distribution of the series.

[15] Similarly, early studies such as Eichengreen, Rose and Wyplosz (1995) and Kaminsky, Lizondo and Reinhart (1998) also apply the mean and standard deviation measures to examine thresholds for the index of exchange market pressure.
[16] Refer to Footnote 7 and Pontines and Siregar (2007).

Given the relatively small observation size that we have for this study, we apply the modified tail index estimator proposed by Huisman, Koedijk, Kool, and Palm (2001) ---henceforth HKKP---, which is unbiased in small sample cases. The HKKP methodology starts with the Hill (1975) estimator:

$$\gamma(k) = \frac{1}{k}\sum_{j=1}^{k} \ln(x(n-j+1) - \ln(x(n-k)) \qquad (8)$$

Where we assume that there is a sample of n positive independent observations drawn from some unknown fat-tailed distribution. Let the parameter γ be the tail-index of the distribution, and $x(i)$ be the ith-order statistic such that $x(i-1) \leq x(i)$ for $i = 2,......,n.$ k is the pre-specified number of tail observations. Naturally, the choice of k is crucial to obtain an unbiased estimate of the tail-index.

HKKP (2001) shows that for a general class of distribution functions the asymptotic expected value of the conventional hill estimator to be biased and increasing monotonically with k. Similarly, the asymptotic variance of the Hill estimator to be proportional to $\left(\frac{1}{k}\right)$. Generally, this problem will only be resolved when the sample size goes to infinity for given k.

For our small sample observations, HKKP (2001) introduces an estimator that overcomes the problem of the need to select a “single” optimal k in small sample observations. HKKP (2001) proposes that for values of k smaller than some threshold value κ, the bias of the conventional Hill estimate of γ increases almost linearly in k and can be approximated by:

$$\gamma(k) = \beta_0 + \beta_1 k + \varepsilon(k), \qquad k = 1, 2, ..., \kappa \qquad (9)$$

where: β_0 and β_1 are the intercept and the estimate coefficient. $\varepsilon(k)$ is a disturbance term. HKKP (2001) also shows that the modified Hill estimator is quite robust with the choice of κ to be around $\left(\frac{n}{2}\right)$. Accordingly, for our empirics, we propose to compute $\gamma(k)$ for a range value of k from 1 to κ (roughly equal to $\left(\frac{n}{2}\right)$).

Given our need to calculate the "high" and "low" thresholds of INTV index, our choice of κ for the high threshold will contain the high or large observations of γ, associated with the large/high INTV index. Conversely, the low threshold will be the group of observation with the lower set of γ.

To estimate Equation (9), HKKP (2001) adopted the Weighted Least Squares (WLS), instead of the Ordinary Least Squares (OLS), to deal with the potential heteroscedasticity in the error term $(\varepsilon(k))$ of Equation (9). The weight has $\left(\sqrt{1}, \sqrt{2}, \ldots\ldots \sqrt{k}\right)$ as diagonal elements and zeros elsewhere. The estimate of γ from the WLS regression is an approximately unbiased estimate of the tail-index.

5. Empirics

Before turning into each set of testing, it is important to again lay out the key objectives and the rationales behing the empirical approaches adopted in the paper. Definitely, the estimation of the intervention index (Equation 2) can be pursued by either panel or individual time-series approaches. However, as indicated in the introduction, the task here is to classify each individual exchange rate regime adopted by the four East Asian economies from January 1985 to August 2007. Therefore, rather than treating all four East Asian countries as a panel, it would be more appropriate to estimate the intervention index (Equation 2) separately for each country. A number of apparent reasons as to why individual time-series testing is more suitable than panel testing to meet the primary tasks of this paper:

a) It is important to recognize that each country may have its own unique experience with the management of its exchange rate policy. Eventhough, all of them for instance may have adopted rigid exchange rate policy, but the degrees of rigidity vary from one country to another, as will be shown in the later part of the paper.

b) Estimating the components of the intervention index for each indiividual country enables us to understand the types of monetary policy instruments being employed at different periods by the monetary authorities of each of these economies in managing their currencies.

c) Given the possible diversities in the regimes adopted by the four economies, it is imperative that we avoid imposing a “common regional set” of thresholds for all currencies without prior understanding of the statistical properties of each currency –a common limitation of the panel testing.

5.1 Data

The data consist of monthly time series of nominal exchange rate expressed in local currency per U.S. dollar, overnight money market rates as the measure of domestic interest rates, and foreign assets of monetary authorities as the measure of foreign exchange reserves for Indonesia, Korea, Singapore and Thailand. The sample observations cover the period from January 1985 to August 2007, and were gathered from the IMF International Financial Statistics. In Table 2, summary statistics are presented for the monthly percentage changes of exchange rates and foreign exchange reserves, and first-differences of the interest rates.

In addition, Table 2 also contains information on the mean, standard deviation, skewness coefficient, kurtosis coefficient, Jarque-Bera normality test (JB), and Ljung-Box (LB) test. All three series for the four countries show non-normality (note the JB test results), and the kurtosis coefficient indicates fat-tailedness, which is also behind the rejection of normality. The Ljung-Box (LB) statistics suggest significant autocorrelation with the exceptions of Indonesia (reserves), Korea (reserves) and Singapore (exchange rate and interest rate). The Ljung-Box (LBS) statistics, for the squared levels, are also significant, with the exceptions of Indonesia (exchange rate, reserves), Korea (exchange rate) and Singapore (reserves). This is largely taken as evidence for an ARCH-type process for the conditional variance.

5.2 SWARCH Test Results and INTV Index

Next we proceed in using the (SWARCH) model of Hamilton and Susmel (1994). Tables 3-5 present the estimates from the Markov-switching ARCH. To incorporate regime shifts in the conditional variance, two and three states were estimated. Estimation was performed with both the normal and the *t*-distribution, with different lags. In order to arrive at the most plausible specification in describing the conditional volatility, a bottom-up strategy following Krolzig (1997) was pursued. The starting point is to formally test the null hypothesis of no regime switch ($m = 1$) against the alternative of a regime switch ($m = 2$). The test for the hypothesis of no regime switching is a likelihood ratio test comparing the standard ARCH model with the Markov-switching ARCH.[17] In all cases, conventional likelihood ratio test suggest that the null hypothesis of no regime switching can, indeed, be rejected.

We then proceed to test the null hypothesis of two regimes ($m = 2$) against the alternative of three regimes ($m = 3$). On the basis of this test, most of the three series, i.e., monthly percentage changes of exchange rates and foreign exchange reserves, and first-differences of the interest rates, for the individual countries examined are adequately characterized as having at most two-volatility regimes, with the exceptions of the Indonesian rupiah and the Korean overnight money market

[17] A word of caution is necessary in interpreting this result. In Markov switching models, the usual regularity conditions justifying the use of classical tests such as the likelihood ratio test are violated. This is because, under the null hypothesis of only one state, the transition probabilities are not identified, implying that the sample likelihood function is flat with respect to these parameters. As in Hamilton and Susmel (1994), the likelihood ratio test results mentioned here should be treated more as a descriptive summary than formal statistical tests.

rate. The coefficient estimates are in general statistically significant (Tables 3-5). The estimated transition probability of each state is quite high, suggesting that the states are highly persistent. For instance, the transition probability in the case of the Indonesian rupiah indicates that when the current regime is at state 1, there is a 94% chance that the sample for the next period will stay at state 1.

In addition, from the estimates, one can also compute the expected duration of each volatility state as $\left(\frac{1}{1-p_{ii}}\right)$. For example, state 1 for the Indonesian rupiah is expected to last on average for $(1 - 0.94)^{-1} \approx 17$ months, state 2 can be expected to last on average for 10 months, and state 3 can be expected to last for 25 months (Table 3). Thus, state 3 (the high volatility state) will persist longer than states 1 (low volatility state) and 2 (medium volatility state). Finally, as a diagnostic test, Ljung-Box *Q*-statistics were tested for the standardised residuals, LB(24), and for the squared standardised residuals, LBS(24). Noticed that by using the SWARCH model, evidence of autocorrelation were either clearly reduced or eliminated.

5.3 The EVT Thresholds and the Scenarios

Based on the SWARCH test results, we can compute the estimated probabilities of high variability in exchange rate, reserve and interest rate during the observation period. From these estimated probabilities, the intervention (INTV) index can accordingly be constructed for each country (Figures 1-4). A higher INTV implies a higher propensity to intervene and thus a rigid exchange rate regime.

The question now is at what level that the INTV index can be considered as high (or low). Given the non-normal distribution of the key series, namely the exchange rate, reserve and interest rate shown in Table 2, it is not surprising that we also find the INTV series for each of these economies to be non-normally distributed.[18] Mean and standard deviation are therefore not going to be accurate and appropriate indicators to generate thresholds separating the high levels of intervention from the low levels of intervention. This is where the EVT approach can be utilized.

Employing the concept of the extreme value theory discussed earlier, we are able to calculate the "extreme maximum and minimum" of the INTV index for each country. The numbers in Table 6 suggest that the threshold for a high INTV index fall between a rather tight range, from 89 percent for the case of Indonesia to 98 percent for Singapore. In contrast, we find the range for the thresholds for the low INTV index to be substantial. In one end, the threshold for the low INTV for Korea is around 10 percent. The minimum threshold for the INTV index for Singapore, on the other end, is estimated to be around 69 percent. The wide ranges of thresholds underscore the importance of estimating individual thresholds, before forming an appropriate regional threshold.

A set of possible scenarios can be generated from the High and Low INTV classifications depicted in Table 6. To start with, it is arguably appropriate to conclude that INTV indexes to be at least (at most) around 90 percent (10 percent) can be considered a high (low) intervention scenario. There are two possible rationales behind the high INTV index:

(a). Scenario #1: High and Successful Intervention Efforts. A high $(INTV)$ index, created by the high value of $\left(p^{H}_{reserves} + p^{H}_{\text{int}\,r}\right)$, leads to a stable local currency (low $\left(p^{H}_{exr}\right)$). Here, we can conclusively argue that there is an attempt by the monetary authority to intervene and offset 'market forces' and hence, successfully limit exchange rate flexibility.

[18] For the sake of brevity, we do not present the descriptive statistics for the INTV indices. They can be made available upon request.

(b). Scenario #2: Inconclusive case. A high $(INTV)$ Index due to low values for both $(p^H_{reserves} + p^H_{\text{int}\,r})$ and $(p^H_{exr} + p^H_{reserves} + p^H_{\text{int}\,r})$. Under this circumstance, hardly anything conclusive can be argued about the commitment of the monetary authority. The situation may prevail when for instance there is no significant shock in the foreign exchange market, and, consequently, no significant exchange market activities undertaken by the monetary authority. Therefore, one cannot say much about the policy as the low $(p^H_{reserves} + p^H_{\text{int}\,r})$, or the lack of intervention policies, occurs because there is no need to intervene due to relatively calm market condition, reflected by low $(p^H_{exr} + p^H_{reserves} + p^H_{\text{int}\,r})$.

On the other extreme, we have to estimate the regional minimum or low threshold of the INTV index ---henceforth refer to as Scenario #3. Given the wide ranges of the low INTV thresholds generated from the four East Asian countries, we propose to pick the lowest rate, i.e. the ten percent threshold of Korea, to be the minimum threshold. Thus, under Scenario #3, when Intervention Index (INTV) is low due to a low value of $(p^H_{reserves} + p^H_{\text{int}\,r})$ and a high $(p^H_{exr} + p^H_{reserves} + p^H_{\text{int}\,r})$, we can confidently conclude that the monetary authority is adopting a flexible exchange rate policy.

However, we have to add a caveat here. Under few circumstances, we may not be able to conclusively assert that the central bank has voluntarily adopted the flexible policy stance. For instance, under the situation when there is a high probability of a very volatile local currency and a low probability of a successful exchange market intervention, the policy maker may reluctantly keep their foreign exchange market intervention activities to a minimum level, and thus avoiding the high cost of intervention. Hence, we need to carefully examine the probabilities of each component of the index to squeeze as much information about the nature of the market and the monetary policy stance.

In addition to the earlier three possibilities, we can also add one more Scenario (#4) to capture the period of high foreign exchange market pressures, including the periods of currency and financial crises. More importantly, we can also apply this category to capture the period of managed or dirty floating ---the middle regimes. Under this scenario, the INTV index is going to fall between the low and the high thresholds, $(High > INTV > Low)$. This situation appears when at least two of the three components of the INTV index $(p^H_{exr}, p^H_{reserves}, p^H_{\text{int}\,r})$ are relatively high. During the crisis or volatile period, the monetary authorities are often found to be very active in trying to keep the local currency stable (thus high $(p^H_{reserves} + p^H_{\text{int}\,r})$). However, the attacks on the local currency are very severe, reflected by the persistently volatile exchange rate ---high (p^H_{exr}), hence keeping the INTV index between the minimum (10 percent) and the maximum (90 percent) thresholds.

6. What the empirical results say about the exchange rate regime

6.1 Indonesia

The persistently high $(INTV)$ index, well above (0.90), from 1985 to1996, seems to suggest that the monetary authority had adopted an active intervention strategy to keep rupiah stable (Figure 1 and Table 7). When we decompose the intervention index into its three key components, it also becomes very clear that the Bank of Indonesia, the central bank, adjusted its key intervention interest rate to manage rupiah. We do know that all the way until 1995, the intervention spread for the rupiah of Bank Indonesia was only 3 percent at the most from the central parity, suggesting a fairly rigid exchange rate regime adopted by the monetary authority during this period. During this period of 10 years, we can therefore conclusively conclude that the Bank Indonesia has adopted the rigid exchange rate regime --- Scenario #1.

To introduce a bit more flexibility in its exchange rate regime, the intervention spread band was widened three times from 3 percent in December 1995 to 5 percent in June 1996, and to 8 percent in September 1996 (Djiwandono (2000)). The central bank further allowed rupiah to move more freely again in July 1997 by further extending the intervention band to 12 percent.

During the peak period and the early recovery stage from the East Asian currency crisis, from 1997 to 2001, we notice a relatively lower $(INTV)$ index, reaching the lowest index in 2000 at around (0.465). During this period, the central banks employed both its key rate and foreign exchange reserves to try to manage the rupiah, but to no avail. The smooth probability of the rupiah (p_{exr}^{H})shot up to the level as high as (0.989) in 1998 from the very modest rate of at most around (0.008) in early to mid-1990s. This period represents Scenario #4, where the $(INTV)$ index was averaging below the maximum threshold due to a combination of volatile exchange rate pressure (p_{exr}^{H}) and high intervention $(p_{reserves}^{H} + p_{\text{int}\,r}^{H})$ index. From the smooth probabilities, we can also conclude that the rupiah foreign exchange market experienced its most volatile and extreme market pressure in 1998, with each of all three components of the$(INTV)$ index, $(p_{exr}^{H}, p_{reserves}^{H}, p_{\text{int}\,r}^{H})$ ranged between (0.969) to (0.989).

From early 2002 to August 2007, we found conclusive evidence that the Bank of Indonesia has returned to its pre-1997 policy of tight exchange rate management (Scenario 1). The annual smooth probability of the$(INTV)$ rose to (0.99) in 2003 to 2006. More importantly, as in 1990-1996, the monetary authority reverted back to the policy of frequent adjustment to its key interest rate ---with the average smooth probability of the interest rate well above (0.90) between January 2002 to December 2006--- to tightly manage the fluctuations of the Indonesian rupiah.

6.2 Korea

Looking at Table 8 and Figure 2, the high smoothed probability of the INTV index for the period from 1985 to 1994 suggests that the monetary policy authority had always been active in the money market to rigidly manage the won ---Scenario #1. The role of interest rate policy was very dominant during this period, as suggested by the high $\left(p_{\text{int}\,r}^{H}\right)$. Starting in 1990, the monetary authority in Korea also adopted the so-called market-average system (MARS) where the won/U.S. dollar nominal exchange rate was allowed to fluctuate within a specified band of the basic rate which was revised daily (Dornbusch and Park (1999)). When this system was first introduced, the won/U.S. dollar was allowed to vary within a very narrow $\pm$ 0.4 percent of the basic rate. In the mid-1990s, the band was widened to $\pm$2.25 percent. With the INTV index averaging well above 90 percent level and the average smoothed probability of the won around 0 percent, the Bank of Korea (BOK) was indeed successful in tightly managing the won rate against the US dollar from mid of 1980s to late 1994.

Between 1995 to 1996, the won had become significantly more volatile, despite the continued effort of the monetary authority to manage it by actively adjusting the interest rate. The average $\left(INTV\right)$ index during these two years has fallen dramatically to around (0.54), as a result of strong pressure in the foreign exchange market. Given the persistently high smooth probability of the $\left(p_{\text{int}\,r}^{H}\right)$, we would still categorize this period as the rigid exchange rate period, although the central bank was clearly less successful in reining the volatility of the won compared to the previous years.

On November 20th, 1997, clearly feeling the rising pressures of the early stages of the 1997 East Asia currency crisis, the BOK widened the MARS band to about $\pm$10 percent. In addition to the interest rate policy, the monetary authority began to actively conduct open market operation by selling its foreign exchange reserve. The smoothed probability of the reserve $\left(p_{reserves}^{H}\right)$ hovered around 2 percent from early to mid-1990s, and jumped significantly in 1997 to around 57 percent. The band was finally abolished on the 16th of December 1997, when Korea was officially in a crisis.

At the height of the crisis, January 1998 until December 1998, the $(INTV)$ index was averaging above (0.60), with two of the components of the $(INTV)$ index, $\left(p_{exr}^{H}, p_{\text{int}\,r}^{H}\right)$, were extremely high at around (0.988). It also became obvious that the monetary authority had started to directly intervene in the foreign exchange market, as suggested by a significant rise in the smoothed probability of reserves from around (0.06) for the period of 1995-1996 to about (0.55) for the period of January 1998 to December 1998. We can therefore conclude that the levels of the smoothed probabilities for all three components of the INTV index during the period of 1997-1998 are consistent with the Crisis Scenario (Scenario #4).

In 1999, Korea began the recovery process, and returned to a more stable macroeconomic environment. Despite the presence of persistently high volatility in the foreign exchange market $\left(p_{exr}^{H} > 99\right)$, the intervention of the BOK was clearly reduced as compared from the levels reported during 1997-1998. The $(INTV)$ index is still close to 15 percent, still slightly above the minimum threshold for the flexible exchange rate regime category.

The post-2000 exchange rate regime can clearly be characterized as the flexible / floating period with no evidences of government interventions reported from the smoothed probabilities ---low values for both $\left(p_{reserves}^{H}\right)$ and $\left(p_{\text{int}\,r}^{H}\right)$. In the presence of volatile won market, the $(INTV)$ index was averaging at its lowest level during the last two decades, averaging less than 1 percent from January 2000 to July 2007. This leads us to conclude that Korea has voluntarily moved to a *de-facto* flexible regime (Scenario #3). Annual Report publication of the BOK from 2000 to

2006 describes its exchange rate regime to the effect that while it stands ready to undertake appropriate measures to avoid abrupt fluctuations in its exchange rate, the won, in principle, is allowed to fluctuate freely according to its demand and supply in the foreign exchange market.

6.3 Singapore

It is clear from these statistics that the rigid management of the exchange rate policy continued to be the centrepiece of the monetary policy in the country until 2007 (Table 9 and Figure 3). With the exception of the crisis period of 1997-1998 and parts of 2001, the INTV index for Singapore was persistently well above 90 percent. These statistics are consistent with a number of official reports and studies conducted at Monetary Authority of Singapore (MAS), which all suggest that the MAS periodically intervened in the foreign exchange market with the extent of the foreign exchange intervention determined by the exchange rate target bounded by an undisclosed band (MAS 1999, 2000, 2001, 2003, 2004 and 2007).

From the average smoothed probabilities presented in Table 9, we can also construe that the MAS actively employed both the reserve and the interest rate policy to manage the exchange rate of the local currency for the large part of the past two decades. It is also interesting to note here that during the pre-1997 financial crisis, the interest rate was the main instrument of the monetary authority, reflected by the high smoothed probability. A different practice emerged from January 1999 to August 2007. During this period, the reserve has clearly become the primary instrument to manage the Singapore dollar to maintain the rigid exchange rate policy. Between 1999 to 2007, the foreign exchange reserve of the country (minus gold) has increased by more than US$ 100 billion to reach a total of around US$ 226 billion in late 2007.

6.4 Thailand

In general, our test results confirm that the Bank of Thailand, like the other three East Asian economies' central banks, has intervened actively to tightly manage the baht from 1985 to 1996 (Table 10). The average smoothed probability of the $(INTV)$ for 1991-1996 was well above 99 percent and the active intervention in the money market (via adjustments in the interest rate) helped keep the average smoothed probability of the $\left(p_{exr}^{H}\right)$ well below 1 percent (Scenario #1).

From the empirical findings, we can also conclude that the exchange rate regime was under Scenario #4 (the Crisis case) during 1997- 1999. These three years saw the full efforts of the central bank to defend the local currency by adjusting its key interest rate and selling off of foreign exchange reserves, as suggested by the high smoothed probabilities of interest rate and reserve. Despite the massive intervention efforts, the baht lost its value substantially against the US dollar and was very volatile.

Since 2000, we saw evidences of less rigid exchange rate regime. The level of smooth probability for the $(INTV)$ranged between (0.42) to slightly above (0.60), significantly lower than the level during the pre-1997 period, and at the same time the currency market continued to be very volatile with the smoothed probability of $\left(p_{exr}^{H}\right)$ at around (0.99), except for 2007. We can therefore conclude that the Bank of Thailand remained active in managing the volatility of its currency, but the exchange rate regime has arguably been less rigid since 2000 (Scenario #4). We also note however that there was an increase in intervention in 2005 and 2006. In addition, while for most of 2000-2004, the intervention was predominantly in the money market via frequent adjustments in the key interest rate, the reserve position was also more volatile in 2005 and 2006, suggesting active intervention through open market operation of the foreign exchange reserves.

7. Brief Concluding Remarks

Frankel, et.al. (2001) nails it right at the very heart of the challenge when they argued that credibility and transparency are the core of the current debate about exchange rate regimes. Like many other studies in the past, their work also emphasizes the difficulties facing the efforts to verify the de-facto exchange rate regime being adopted by a country.

Our paper revisited the debate on the de-facto versus de-jure exchange rate regimes adopted by four countries in East Asia, namely Indonesia, Thailand, Singapore and South-Korea. The study has empirically extended early studies in two fronts. The first one is with the employment of SWARCH and the Extreme Value testing to estimate the degree of the foreign exchange intervention and the thresholds. The second extension is with the up-to-date data coverage by including observations up to mid of 2007.

The study is able to conclusively conclude that only Korea has shifted to adopt a de-facto flexible exchange rate regime during the post-1997 period. In contrast, Indonesia and Singapore have returned to their pre-1997 rigid exchange rate regimes. While there are evidences that Thailand has relaxed their degree of intervention since the 1997 financial crisis, but the intervention activities remain significant, suggesting more of a dirty float rather than a flexible exchange rate strategy. In short, we reject the “hollow middle” hypothesis (Eichengreen (1994)).

Indonesia, Thailand and South-Korea have officially announced their intentions to adopt the inflation targeting (IT) strategy as the anchor of their monetary policies during the post-1997 financial crisis. Confirming the findings of this study, Sharma and Siregar (2008), however, found dominant weights still assigned to the exchange rate volatility in the reaction functions of the Bank of Indonesia and the Bank of Thailand, suggesting rather lack of commitment to the IT policy. It would be interesting for future researches to examine further which of the nominal anchors, i.e. between the inflation targeting and the rigid exchange rate regime, would be a more appropriate policy to serve these East Asian economies.

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Table 1: Summary of Findings of Studies (*with exclusive focus on East Asia alone*) Regarding the Post-crisis Exchange Rate Regimes In Some East Asian Countries

Studies	Observation Period	Method(s)	Indonesia	Korea	Singapore	Thailand
Kawai and Akiyama (2000)	January 1999-December 1999	Frankel-Wei	Inconclusive	U.S.Dollar-peg reversion	U.S. Dollar-peg reversion	U.S.Dollar-peg reversion
Gan Wee Beng (2000)	July 2, 1997 – September 30, 1999	Simplified and Modified Version of Frankel-Wei	Greater Flexibility	Greater Flexibility	Greater Flexibility	Greater Flexibility
Baig (2001)	1999-2000	Standard Deviation and Frankel-Wei	Inconclusive	U.S. Dollar-peg reversion	Not Included	Increased Flexibility
McKinnon (2001)	1999-May 2000	Frankel-Wei	Still in quasi-crisis mode	High-frequency dollar-peg reversion	High-frequency dollar-peg reversion	High-frequency dollar-peg reversion
Ogawa (2001)	Various sub-periods from July 1998 – September 2000	Frankel-Wei	U.S. Dollar-peg reversion	U.S. Dollar-peg reversion	U.S. Dollar-peg reversion	U.S. Dollar-peg reversion
McKinnon and Schnabl (2002)	January 1, 1999 – April 22, 2002	Standard Deviation and Frankel-Wei	Floating	High-frequency U.S. dollar- peg reversion	High-frequency U.S. dollar- peg reversion	High-frequency U.S. dollar- peg reversion
Kawai (2002)	1999-June 2002	Frankel-Wei	Floating	Managed Floating	Managed Float	Managed Floating
Hernandez and Montiel (2003)	1999-2001	Standard Deviation	Managed Float	Managed Float	Not Included	Managed Float
Fukuda and Ohno (2003)	Various sub-periods from February 2, 1998 – September 5, 2002	Frankel-Wei	Not Included	U.S. Dollar- peg reversion	U.S. Dollar- peg reversion	U.S. Dollar- peg reversion
Kim, Kim, and Wang (forthcoming)	Two sample periods: January 1999-June 2001; January 1999-December 2003	Structural VAR (SVAR)	Increased Flexibility	Increased Flexibility	Increased Flexibility	Increased Flexibility

Table: 1 (cont'd)
Summary of Findings of Studies (*Non- exclusive focus on East Asia*)
Regarding the Post-crisis Exchange Rate Regimes In Some East Asian Countries

	IMF Classification based on Bubula and Otker-Robe (2002)				
	1999	**2000**	**2001**	**2002**	**2003**
Indonesia	Independently Floating	Independently Floating	Managed Floating	Managed Floating	Managed Floating
Korea	Independently Floating	Independently Floating	Independently Floating	Independently Floating	Independently Floating
Singapore	Managed Floating	Managed Floating	Managed Floating	Managed Floating	Managed Floating
Thailand	Managed Floating	Managed Floating	Managed Floating	Managed Floating	Managed Floating
	Levy-Yeyati and Sturzenegger Classification (2005)				
	1999	**2000**	**2001**	**2002**	**2003**
Indonesia	Intermediate Dirty/Crawling Peg	Intermediate Dirty/Crawling Peg	--------	--------	---------
Korea	Fix	Fix	--------	--------	---------
Singapore	Fix	Fix	--------	--------	---------
Thailand	Float	Float	-------	--------	---------
	Reinhart-Rogoff Classification (2004)				
	Indonesia		**Korea**	**Singapore**	**Thailand**
Periods	**August 1997-March 1999**	**April 1999-December 2001**	**July 1998-December 2001**	**December 1998-December 2001**	**January 1998-December 2001**
	Freely Falling/Freely Floating	Freely Floating	Freely Floating	Managed Floating	Managed Floating

Table 2:
Univariate Statistics on Exchange Rates (EXR), Reserves, and Interest Rates (INT)

	Mean	Std. Dev.	Skewness	Kurtosis	JB Normality Test	LB(24)	LBS(24)
Indonesia							
EXR	1.046	8.029	7.096	80.473	70047.7**	59.44**	17.38
Reserves	1.912	9.861	4.519	42.692	18711.6**	32.98	13.19
INT	-0.017	4.859	2.859	48.729	23981.6**	47.43**	47.95**
Korea							
EXR	0.092	3.364	8.912	117.218	150897**	78.21**	7.83
Reserves	2.024	6.800	0.957	9.242	479.556**	31.68	111.19**
INT	-0.016	1.061	1.202	14.06	1441.28**	43.93**	49.38**
Singapore							
EXR	-0.128	1.273	0.272	7.212	203.654**	33.32	160.3**
Reserves	0.849	1.07	0.041	3.773	6.829*	60.06**	30.07
INT	-0.01	0.528	0.178	19.354	3021.25**	29.66	69.88**
Thailand							
EXR	0.116	2.647	2.691	26.762	6702.87**	57.35**	262.62**
Reserves	1.443	4.286	0.123	13.156	1165.31**	122.03**	375.29**
INT	-0.03	1.973	0.36	15.14	1669.95**	70.93**	130.81**

Notes: EXR and Reserves in percentage changes and INT in first-difference.

JB-normality test: Jarque-Bera test, which is distributed χ^2_2.

LB(24): Ljung-Box test for EXR, Reserves and INT with 24 lags, which is distributed χ^2_{24}.

LBS(24): Ljung-Box test for squared of EXR, Reserves and INT with 24 lags, which is distributed χ^2_{24}.

**, * significant at the 1 and 5 percent level, respectively.

Table 3:
Regime switching ARCH regressions for percentage changes in exchange rates

	Rupiah Normal SWARCH (3,1)	**Won Normal SWARCH (2,2)**	**Singapore dollar Normal SWARCH (2,1)**	**Thailand baht Student *t* SWARCH (2,1)**
ϕ_0	0.21** (0.02)	-0.02 (0.04)	-0.14* (0.06)	-0.02 (0.04)
ϕ_1	0.35** (0.04)	0.57** (0.06)	0.26** (0.06)	0.29** (0.08)
α_0	0.02** (0.00)	0.08** (0.03)	0.68** (0.11)	0.29** (0.10)
α_1	0.66** (0.18)	0.61** (0.26)	0.13 (0.16)	0.25 (0.15)
α_2		0.24** (0.11)		
p_{11}	0.94	0.97	0.98	0.99
p_{22}	0.90	0.98	0.83	0.99
p_{33}	0.96	---	---	---
LR test (m = 1 vs m = 2)	578.08**	117.1**	33.7**	53.67**
LR test (m = 2 vs. m = 3)	43.4**	-2.64	-0.92	-21.02
df	---	---	---	3.51
LB(24)	14.1	37.41*	8.93	26.75
LBS(24)	43.4**	22.96	24.49	5.13

Notes: Standard errors in parentheses.

LR test: Likelihood ratio test which is distributed χ_r^2.

LB(24): Ljung-Box test for EXR, Reserves and INT with 24 lags, which is distributed χ_{24}^2.

LBS(24): Ljung-Box test for squared of EXR, Reserves and INT with 24 lags, which is distributed χ_{24}^2.

**, * significant at the 1 and 5 percent level, respectively.

Table 4:
Regime switching ARCH regressions for percentage changes in reserves

	Indonesia Normal SWARCH (2,1)	**Korea Student *t* SWARCH (2,1)**	**Singapore Student *t* SWARCH (2,2)**	**Thailand Normal SWARCH (2,2)**
ϕ_0	1.19** (0.29)	1.31** (0.28)	0.67** (0.09)	1.31** (0.17)
ϕ_1	0.01 (0.07)	-0.00 (0.08)	0.21** (0.07)	-0.04 (0.07)
α_0	13.71** (2.4)	11.58** (1.54)	0.61** (0.11)	2.63** (0.61)
α_1	0.38** (0.13)	0.20* (0.1)	0.16* (0.08)	0.21 (0.12)
α_2			0.00 (0.08)	0.24* (0.12)
p_{11}	0.98	0.99	0.99	0.98
p_{22}	0.87	0.98	0.98	0.98
LR test ($m = 1$ vs $m = 2$)	160.28**	22.08**	6.16*	11.6**
LR test ($m = 2$ vs. $m = 3$)	5.75	-76.9	-12.3	2.94
df	---	7.18	14.37	---
LB(24)	37.54*	35.64	38.05*	49.48**
LBS(24)	8.39	19.6	24.62	28.40

Notes: Standard errors in parentheses.

LR test: Likelihood ratio test which distributed χ^2_r.

LB(24): Ljung-Box test for EXR, Reserves and INT with 24 lags, which is distributed χ^2_{24}.

LBS(24): Ljung-Box test for squared of EXR, Reserves and INT with 24 lags, which is distributed χ^2_{24}.

**, * significant at the 1 and 5 percent level, respectively.

Table 5:
Regime switching ARCH regressions for first-difference in interest rates

	Indonesia Student *t* SWARCH (2,1)	**Korea Normal SWARCH (3,1)**	**Singapore Normal SWARCH (2,2)**	**Thailand Student *t* SWARCH (2,2)**
ϕ_0	0.00 (0.02)	0.00 (0.00)	0.002 (0.01)	0.01 (0.02)
ϕ_1	-0.06** (0.01)	0.16** (0.04)	-0.03 (0.12)	0.17 (0.08)
α_0	0.03 (0.04)	0.0002** (0.00)	0.01** (0.00)	0.02* (0.01)
α_1	3.38 (4.50)	0.43** (0.16)	0.48 (0.30)	0.89** (0.24)
α_2	---	---	0.22* (0.11)	0.32* (0.15)
p_{11}	0.89	0.65	0.81	0.99
p_{22}	0.24	0.70	0.75	0.99
p_{33}	---	0.95	---	---
LR test ($m = 1$ vs $m = 2$)	16.24**	124.74**	92.03**	22.92**
LR test ($m = 2$ vs. $m = 3$)	0.0	29.58**	0.37	No convergence for 3 regimes
df	2.37	---	---	
LB(24)	32.92	21.42	19.32	21.19
LBS(24)	23.29	6.17	37.62*	37.87*

Notes: Standard errors in parentheses.

LR test: Likelihood ratio test which is distributed χ^2_r.

LB(24): Ljung-Box test for EXR, Reserves and INT with 24 lags, which is distributed χ^2_{24}.

LBS(24): Ljung-Box test for squared of EXR, Reserves and INT with 24 lags, which is distributed χ^2_{24}.

**, * significant at the 1 and 5 percent level, respectively.

Table 6: EVT Thresholds of INTV Index

Country	Maximum	Minimum
Indonesia	0.89	0.42
Korea	0.90	0.10
Thailand	0.94	0.35
Singapore	0.98	0.67

Source: Authors' own calculation

Table 7: Monthly Average Smoothed Probabilities and INTV Index for Indonesia

	Intervention $(INTV)$	Interest Rate $p^H_{\text{int}\,r}$	Rupiah p^H_{exr}	Foreign Exchange Reserve $p^H_{reserves}$
1985-1990	0.978	0.869	0.059	0.199
1991	0.999	0.918	0.0003	0.229
1992	0.999	0.882	0.0000	0.003
1993	0.999	0.928	0.0000	0.003
1994	0.999	0.853	0.0000	0.006
1995	0.999	0.896	0.0000	0.003
1996	0.989	0.834	0.008	0.009
1997	0.772	0.848	0.503	0.181
1998	0.662	0.969	0.989	0.972
1999	0.605	0.791	0.968	0.749
2000	0.465	0.834	0.946	0.017
2001	0.561	0.815	0.904	0.384
2002	0.905	0.939	0.103	0.006
2003	0.999	0.971	0.0001	0.002
2004	0.997	0.900	0.002	0.002
2005	0.999	0.882	0.0003	0.003
2006	0.999	0.859	0.0007	0.016
2007 (up to August)	0.659	0.606	0.006	0.002

Source: Authors' own calculation

Table 8: Monthly Average Smoothed Probabilities and INTV Index for Korea

	Intervention $(INTV)$	**Interest Rate** $p^{H}_{\text{int}\,r}$	**Won** p^{H}_{exr}	**Foreign Exchange Reserve** $p^{H}_{reserves}$
1985-1990	0.977	0.651	0.040	0.721
1991	0.996	0.998	0.004	0.002
1992	0.823	0.451	0.0008	0.0009
1993	0.999	0.995	0.0007	0.0007
1994	0.997	0.999	0.003	0.0005
1995	0.561	0.978	0.844	0.0032
1996	0.519	0.999	0.940	0.017
1997	0.624	0.998	0.919	0.573
1998	0.613	0.988	0.998	0.642
1999	0.146	0.211	0.991	0.049
2000	0.003	0.0006	0.976	0.003
2001	0.004	0.002	0.996	0.002
2002	0.0009	0.0003	0.996	0.0006
2003	0.018	0.0006	0.987	0.0177
2004	0.004	0.0006	0.983	0.003
2005	0.0009	0.0005	0.955	0.0004
2006	0.0011	0.0006	0.991	0.0005
2007 (up to July)	0.003	0.003	0.578	0.0008

Source: Authors' own calculation

Table 9: Monthly Average Smoothed Probabilities and INTV Index for Singapore

	Intervention $(INTV)$	Interest Rate $p^{H}_{\text{int}\,r}$	Singapore Dollar p^{H}_{exr}	Foreign Exchange Reserve $p^{H}_{reserves}$
1985-1990	0.942	0.638	0.046	0.101
1991	0.924	0.812	0.050	0.080
1992	0.991	0.666	0.005	0.043
1993	0.981	0.592	0.008	0.015
1994	0.995	0.818	0.004	0.007
1995	0.979	0.728	0.012	0.006
1996	0.995	0.640	0.003	0.005
1997	0.729	0.940	0.488	0.019
1998	0.518	0.817	0.910	0.156
1999	0.952	0.809	0.059	0.729
2000	0.994	0.447	0.009	0.984
2001	0.836	0.553	0.361	0.991
2002	0.993	0.375	0.009	0.987
2003	0.972	0.072	0.031	0.979
2004	0.993	0.286	0.008	0.960
2005	0.988	0.415	0.012	0.722
2006	0.977	0.051	0.008	0.246
2007 (up to August)	0.985	0.567	0.010	0.178

Source: Authors' own calculation

Table 10: Monthly Average Smoothed Probabilities and INTV Index for Thailand

	Intervention $(INTV)$	Interest Rate $p^H_{\text{int}\,r}$	Baht p^H_{exr}	Foreign Exchange Reserve $p^H_{reserves}$
1985-1990	0.949	0.929	0.142	0.846
1991	0.999	0.995	0.0005	0.149
1992	0.999	0.861	0.0001	0.029
1993	0.999	0.932	0.0001	0.013
1994	0.999	0.956	0.0001	0.007
1995	0.999	0.957	0.0004	0.023
1996	0.998	0.936	0.003	0.131
1997	0.778	0.988	0.625	0.904
1998	0.652	0.931	0.999	0.949
1999	0.655	0.968	0.999	0.936
2000	0.572	0.922	0.999	0.454
2001	0.467	0.859	0.999	0.042
2002	0.477	0.909	0.999	0.013
2003	0.444	0.807	0.999	0.031
2004	0.459	0.811	0.999	0.068
2005	0.621	0.996	0.998	0.643
2006	0.637	0.924	0.999	0.845
2007 (up to August)	0.416	0.624	0.665	0.479

Source: Authors' own calculation

Figure 1:
Probability of Intervention Estimates for Indonesia

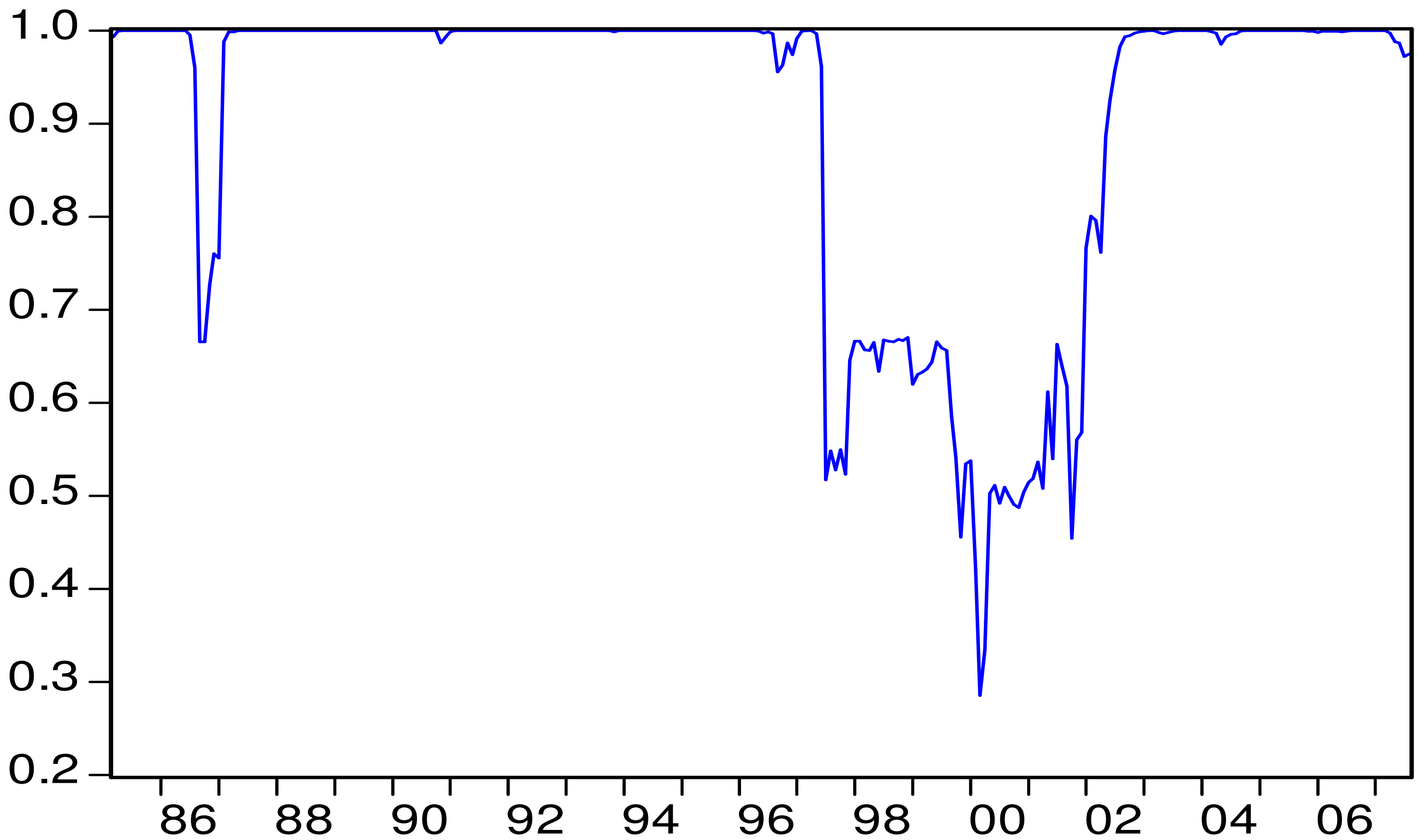

Figure 2:
Probability of Intervention Estimates for Korea

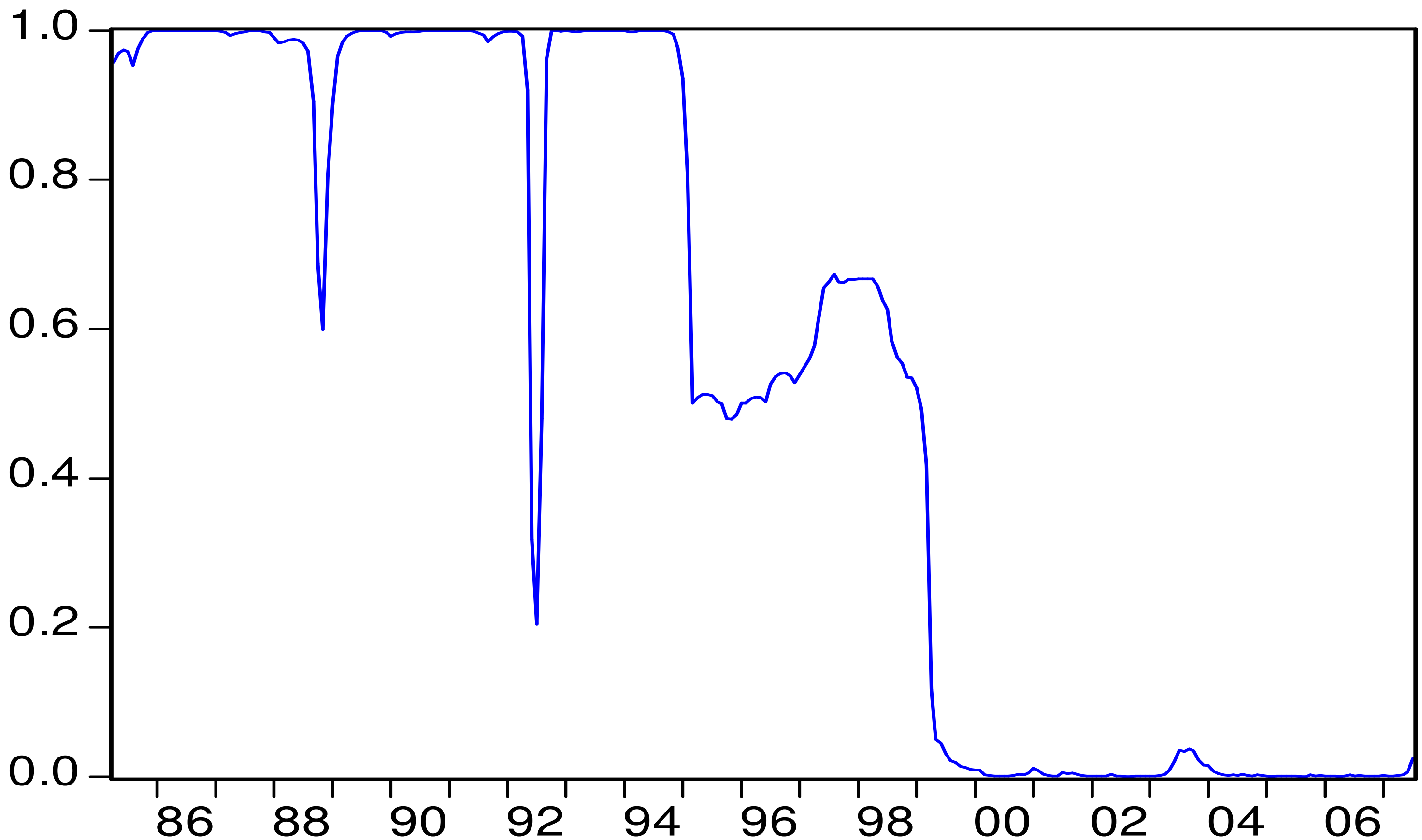

Figure 3:
Probability of Intervention Estimates for Singapore

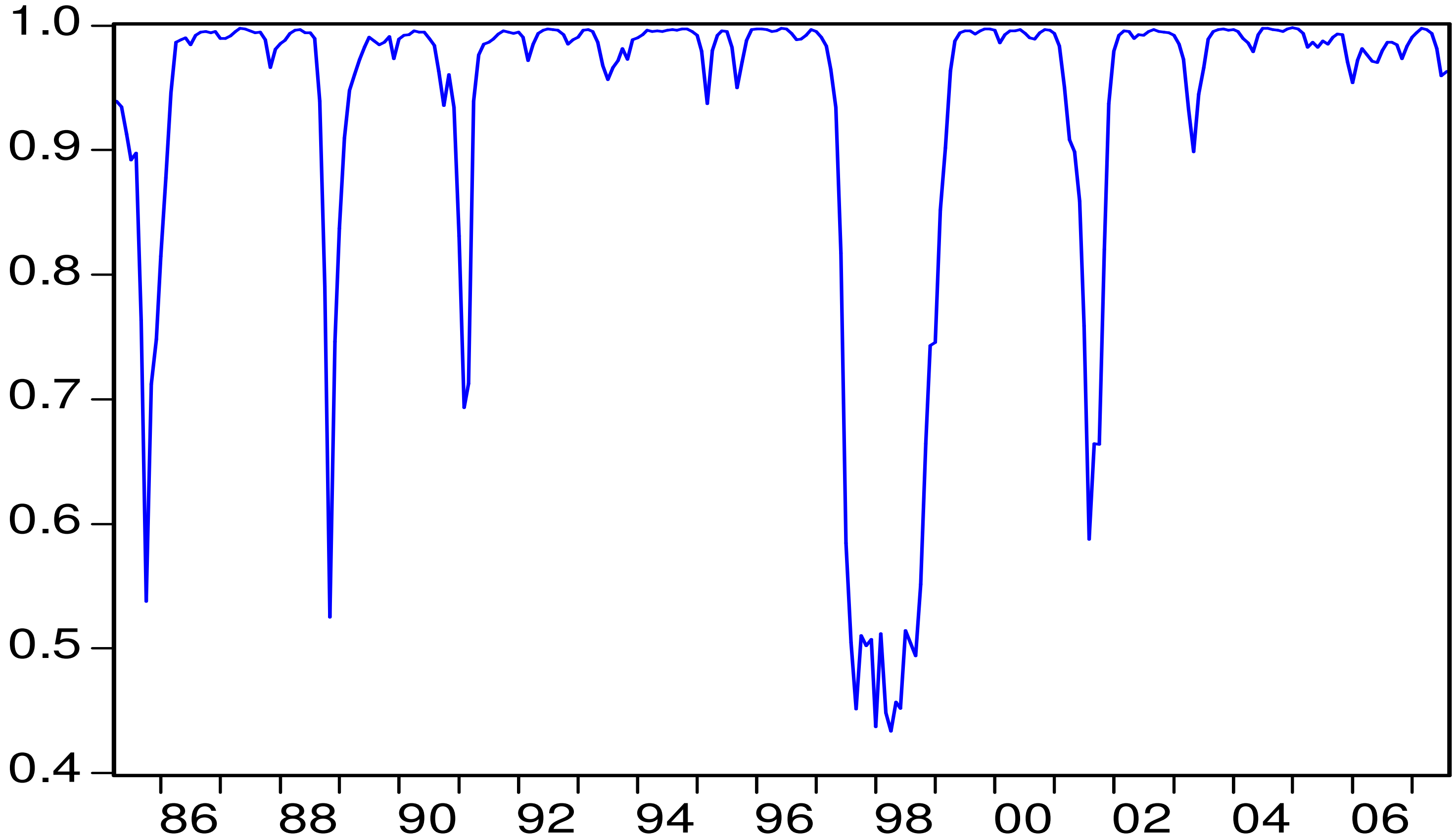

Figure 4:
Probability of Intervention Estimates for Thailand