# CHAPTER V

# MONEY MARKET INTEGRATION

## A. Introduction

As discussed earlier, one alternative meaning of market integration implies that assets in integrated markets must be priced globally whereas assets in segmented market must be priced locally. The study in this chapter seeks to provide additional evidence of this alternative view with respect to the money market since there is a trend towards increasing financial capital mobility around the world. One approach used in the literature of money market integration concerns how domestic interest rates are determined. We expect that with the process of financial liberalization, market forces should play a relatively greater role in the determination of interest rates.

## B. The Edwards and Khan Model (1985)

The most striking model to investigate this issue is the model of Edwards and Khan (1985). This model nests the behavior of interest rates to depend on a weighted average of domestic and foreign factors. As a result, they attempt to interpret this weight as the degree of openness prevailing in the market. However, it should be noted that there remain some deficiencies in their estimation.

The general approach of measuring openness by examining the relative influence of foreign and domestic interest rates was initially developed by Edwards and Khan (1985). Their model involves a regression of money balance on a closed economy interest rate and a foreign interest rate. The idea behind the Edwards and Khan strategy is that behavior of interest rates should differ under an integrated market scheme and a segmented market scheme. The model can provide insight about what should be expected when capital controls (which we consider as one of the investment barriers in Chapter 3) are eliminated. Their intention is interesting since it nests the influence of foreign factors and domestic monetary conditions on interest rate, thus, it is appropriate for testing in a country that has evidence of partially segmentation to the world. The measurement of openness is the weight on the foreign interest rate. They also present empirical findings that explain the determination of nominal interest rates in two developing countries: Singapore and Columbia. The results indicate that in Singapore, only open economy factors appear to influence nominal interest rates; in Columbia, both domestic factors and open economy conditions appear to matter.

Before discussing the deficiencies, I will first examine the theoretical framework for their model and empirical tests undertaken by other researchers.

**1. Theoretical Framework**

This model takes the interest rates that would prevail under the two extreme cases. The one extreme is a completely open economy. In this case, the interest rate parity condition should hold because of the full arbitrage between domestic and foreign interest rate. The other pole is represented by the completely closed economy. If a nation is closed to the rest of the world, the changes in interest rates will result from domestic money market disequilibrium.

In general, a country under consideration would most likely be a semi-open economy lying between these two extreme cases. In such an environment, both open and closed economic factors will affect the behavior of domestic interest rates. Therefore, these two cases can be linearly combined assuming the weights as a coefficient of openness, $\psi$.

***a) Interest rates in a completely closed economy***

When the capital flows are prohibited in a fully closed economy, the standard Fisher equation can be used to determine the domestic interest rate; external factors have no direct role in this case. The Fisher equation shows that the closed economy nominal interest rate will be determined by conditions prevailing in the domestic money market and by expected inflation. We can specify the nominal interest rate as:

$$i_t = rr_t + \pi^e_t \qquad (1)$$

***b) Interest rates in a completely open economy***

If the economy is completely open and there are no impediments to capital flows, the determination of interest rates will follow the uncovered interest arbitrage relationship, reflecting an influence of foreign factors on the nominal domestic interest rate as follows:

$$i_t = i^*_t + e^*_t \qquad (2)$$

The above relationship will hold in a world with no transaction costs and risk-neutral agents because, in the completely open economy, domestic interest rates and foreign interest rates should be clearly alike. However, if we assume the world of risk aversion, the forward premium should replace the $e^*_t$. However, deviation from this relationship could possibly come from any delay in response due to transaction costs or information lags.

### c) *Interest rate in semi-open economy*

Consider this model:

$$i_t = \psi\,(i^*_t + e^e_t) + (1 - \psi)\,(rr_t + \pi^e_t) \qquad (3)$$

where:
- $i_t$ = domestic nominal interest rate;
- $rr_t$ = domestic real interest rate;
- $\pi^e_t$ = expected domestic inflation;
- $i^*_t$ = foreign nominal interest rate;
- $e^e_t$ = expected rate of depreciation of domestic currency; and
- $\psi$ = a measure of degree of openness (0,1) which is equal 1 if market is integrated and 0 if market is segmented.

The model combines the two polar cases, closed and open economy. The parameter $\psi$, the weight, serves as a measure of the degree of openness of the capital account. This parameter runs from zero to one, with a value of zero if market is a fully closed economy, and a value of one if the market is a fully open economy. The general case lies between these two extreme cases and the parameter $\psi$ will be between zero and one. In order to use the parameter $\psi$ as the degree indication, this parameter has to satisfy the bound of zero to one in the estimation from the data.

The hypothetical closed economy interest rate $i$ is derived in two steps, starting with specification of the real interest rate called the liquidity effect.[19] Thus:

$$rr_t = \rho - \lambda ESM_t + \omega_t \qquad (4)$$

where ESM is defined as the difference between the log of actual real money (M1) balances and the log of desired real money balances (md). The variable $\rho$

[19] *According to Mundel (1963), the real interest rate deviates from its long-run value if there is evidence of disequilibrium of demand and supply for real money balance. Thus, the real rate of interest will be off the long run level temporarily.*

represents the long-run equilibrium real interest rate. Assuming equilibrium in the money market and y is domestic real income, the equilibrium demand for money equal, therefore, is:

$$\log m^d_t = \alpha_0 + \alpha_1 \log y_t - \alpha_2 (\rho - \pi^e_t) - \alpha_3 \pi^e_t \quad (5)$$

Assuming that the stock of real money balance takes the following form:

$$\Delta \log m_t = \beta [\log m^d_t - \log m_{t-1}] \quad (6)$$

where $\Delta$ is a first difference operator, m is the real money balance, $\Delta \log m_t = \log m_t - \log m_{t-1}$ and $\beta$ is the coefficient of adjustment ; $0 \leq \beta \leq 1$.

It should be noted that the above assumption explains an adjustment mechanism for domestic prices if the stock of money is exogenous. To justify this assumption, the possibility of a delayed response of the nominal interest rate to monetary changes has to exist since this assumption suggests a process by which the nominal interest rate return eventually reach its equilibrium level.

Combining equation (4), (5) and (6), the reduced form, in terms of domestic rate, is:

$$i = \gamma_0 + \gamma_1 \log y_t + \gamma_2 \log m_{t-1} + \gamma_3 \pi^e_t + \omega_t \quad (7)$$

where:

$$\gamma_0 = \rho + \lambda (1-\beta)(\alpha - \alpha_2 \rho)$$
$$\gamma_1 = \lambda (1-\beta)\alpha_1$$
$$\gamma_2 = -\lambda(1-\beta)$$
$$\gamma_3 = (1 - \lambda (1-\beta)(\alpha_2 - \alpha_3))$$

When estimating equation (7), the sign of coefficients are expected to be positive for $\gamma_1$ and negative for $\gamma_2$. However, the sign of $\gamma_3$ is ambiguous depending on whether $\lambda(1-\beta)(\alpha_2 - \alpha_3)$ is greater or less than unity.

Replacing the hypothetical open economy interest rate in Equation (2) by assuming the possibility of deviation of interest rate parity from information lags which will delay any changes in the foreign rate or in exchange rate expectations, the basic framework is as follows:

$$\Delta i_t = \theta \, [ \, (i^*_t + e^*_t) - i_{t-1} \, ] \qquad (8.1)$$
$$i_t = \theta \, (i^*_t + e^*_t) + (1-\theta) i_{t-1} \qquad (8.2)$$

where θ is a speed of adjustment parameter which varies from zero to one. The parameter θ will approach unity if the financial market adjusts rapidly.

Using all above equations, the solution of Equation (3) in reduced form of domestic interest rate is expressed as:

$$i_t = \delta_0 + \delta_1(i^*_t + e^*_t) + \delta_2 \log y_t + \delta_3 \log m_{t-1} + \delta_4 \pi^e_t + \delta_5 \, i_{t-1} + \varepsilon_t \quad (9)$$

where:
$\delta_0 = (1-\psi) \, \partial_0$;
$\delta_1 = \psi\theta$;
$\delta_2 = (1-\psi) \, \partial_1$;
$\delta_3 = (1-\psi) \, \partial_2$;
$\delta_4 = (1-\psi) \, \partial_3$;
$\delta_5 = \psi \, (1-\theta)$; and
$\varepsilon_t$ is a random error term.

The expression of domestic interest rate as in Equation (9) is proposed for a semi-open economy in which both domestic and world influences play an important role. However, it should be noted that the degree of openness or the weighted average of the uncovered interest parity rate and the determination of domestic rates in a hypothetical closed economy is constant. If the economy is open to the rest of the would, the degree of openness equals unity. As a result, $\delta_1$, $\delta_2$, $\delta_3$, $\delta_4$ become zero and Equation (9) collapses to the interest rate parity condition. On the other hand, ψ will be zero if the economy is fully closed and Equation (9) reduces to the hypothetical closed economy Equation (7). It should be noted that the model in Equation (9) should better determine the domestic interest rate compared to Equation (7). The reason is that Equation (9) is nesting the external factors and the internal factors to describe the behavior of return whereas in Equation (7), the model limits the explanatory variables to only the domestic monetary and expected inflation. When estimating Equation (9), $e^{*}$ is the expected rate of change of the exchange rate, however, if assumed agents are risk averse, $e^{*}$ should be replaced by the forward premium. The unobservable $\pi^{e}$, the expected rate of inflation, can be specified in various ways. Since the theory prefers no method over another, the choice of calculation for this variable in my study is subjected to a strict form of rational expectation: perfect foresight.

## 2. Empirical Tests and Extensions of the Edward and Khan Model

Hague and Montiel (1990) extend the Edwards and Khan model by assuming the domestic (nominal) market-clearing interest rate ( $i$ ) to be the weighted average of the uncovered interest parity rate ( $i^{*}$ ) and the domestic market-clearing interest rate that would be observed if economy were completely closed ( $i'$ ). Their model is as follows:

$$i = \psi i^{*} + (1-\psi)\, i' \qquad (10.1)$$

Then ;

$$i - i' = \psi(i^{*} - i') \qquad (10.2)$$

where:

| | | | |
|---|---|---|---|
| | $i$ | = | domestic nominal interest rate; |
| | $i^{*}$ | = | uncovered interest parity; |
| | $\psi$ | = | a measure of degree of openness (0,1); and |
| | $i'$ | = | domestic nominal interest rate that would be observed if economy were fully closed. |

The point to note is that they also allow the degree of openness ($\psi$) to be a variable coefficient with its value varying due to various measures of financial liberalization. The time varying technique is done using Kalman filter.

Equation (10) can be estimated directly to determine the key parameter $\psi$ as an index of financial openness. The problem of estimating this equation is that it requires the observation of domestic market-clearing interest rates. In general, the domestic market clearing interest rates in developing countries are not available since the rates from markets are generally subject to legal control. Hague and Montiel (1990) avoid this problem by assuming the money demand function (shown below) represents unobserved true domestic interest rate:

$$\ln (M^D/P) = \alpha_0 + \alpha_1 i + \alpha_2 ln(y) + \alpha_3 ln^{(M/P)-1} \quad (11)$$

where: $\alpha_0 < 0$ and $\alpha_2$ , $\alpha_3 > 0$;
y = domestic real output;
P = domestic price level; and
$M^D$ = demand for money.

Reisen and Yeches (1993), who use the extended model suggested by Hague and Montiel (1990) to test in Korea and Taiwan, overcome the problem by using the interest rate measured from the unobserved market (curb market). Direct observation of domestic market-changing interest rates is not possible due to the absence of organized securities markets. However, they propose a constant markup to the uncovered interest rate parity term because of differences in asset quality between local and abroad as below:

$$i = \psi\,(i^* + \alpha) + (1+\psi)I' \quad (12)$$

Hataiseree and Phipps (1992) examine the degree of international capital mobility in Thailand. They use the model pioneered by Edwards and Khan to estimate capital mobility during 1980 to 1992 using cointegration techniques. Their purpose is to avoid the problem of nonstationarity of the data employed in the model. Thus, the cointegration technique should be the appropriate estimation technique. In this model, they still interpret the coefficient on the foreign interest rate as the constant parameter considering the degree of openness. They conclude that both the fully closed and the fully open hypothesis were rejected.

We also replicate the test of Edward and Khan (1985) in Thailand. The results are reported in Appendix 8. Although not a unique in itself and the interpretation of the model is not supported intuitively, the replication test will at least shed some light on the factors that should be included in the revised model.

### 3. Critique of the Edwards and Khan Model

As described above, the most striking model to investigate this issue is the model of Edwards and Khan (1985). This model nests the behavior of interest rates to depend on a weighted average of domestic and foreign factors. As a result, they attempt to interpret this weight as the 'degree of openness' prevailing in the market. The degree of openness will provide some information on the degree of integration of the domestic market with the world financial market. However, it should be noted that there remain some limitations in their estimation.

The most important limitation is that they refer the weight on the local and global factors as a measure of the degree of openness of the capital account. The weights are claimed to be degree of integration. In the case of a fully open economy, the weight ($\psi$) will equal unity whereas in the case of a fully closed economy, the weight ($\psi$) will reduce to zero. However, the economy being studied cannot be observed as being in either state since being either 'integrated' or 'segmented' is unobservable. According to the model setting, variable $\psi$, should be a state variable which equals either one nor zero. Since it is a state variable, it cannot be observed. Therefore, the attempts to estimate this number are meaningless. Moreover, the studies following the Edwards and Khan approach do not have an explicit bound on this weight. It is possible to have the weight ($\psi$) that is larger than unity or less than zero. Left unbounded, one may wonder how should we interpret the results. Thus, studies following the Edwards and Khan approach should not be reliable if they do not realize these problems.

Another limitation is that the model cannot capture changes in the amount of openness. As expected, the liberalization processes should yield a higher degree of integration over time. Thus, the assumption of a constant degree of openness is not reliable and should be modified to be time-varying. Although Hague and Montiel (1990) and Reisen and Yeches (1993) attempted to overcome this limitation, they do not recognize the problems that I have mentioned. They still derive coefficients of openness by denoting them as the time-varying variables.

Aside from the unambiguous measurement of market integration that presented here, the important requirement in estimation in their extended versions is the observation of domestic market-clearing interest rates. However, in most developing countries, organized securities markets are usually subject to legal controls. Therefore, it is impossible to find the domestic market-clearing interest rate which is one of the exogenous variables in the extended model of Hague and Montiel (1996). Although Reisen and Yeches (1993) suggest using the interest rate from the unorganized curb market, this approach poses another problem because the published curb rate is unavailable in most developing countries such as Thailand. Moreover, one objection to the extended approach of Reisen and Yeches (1993) is that they estimate their model using a Kalman filter technique to obtain time-varying parameters. In general, studies using this technique always find it difficult to calculate standard errors and must rely on ad hoc techniques for detecting structural breaks in the varying parameters.

## C. A New Technique Based on the Edwards and Khan Model

Our study seeks to avoid these problem while still keeping the intention to measure the degree of openness in the money market. In particular, I avoid these problem by employing the Markov Switching methodology. With the Markov Switching methodology, I am able to modify Edwards and Khan's model to estimate the degree of openness as a time-varying parameter, instead of usual constant parameter presented in their model.

In order to determine the degree of openness in Thai money market, I will follow the intention of the Edwards and Khan approach with a more accurate estimation. In addition, as we know that Thailand has recently undergone a liberalization process characterized by the relaxation of existing capital controls, the removal of such restrictions should yield a higher degree of integration. To the extent that we expect the market to be more integrated, the constant measurement of openness assumption is clearly inappropriate. Therefore, the technique that I employ here should avoid all of these problems. The purposed technique is the Markov Switching technique.

### 1. Markov Switching Technique

One attractive intention for my study is the intention to measure the amount of integration by using Edwards and Khan's approach to nest the behavior of interest rates between the two extreme cases: fully closed and fully open. However, their suggested estimation and interpretation are explicitly wrong. Thus, before proceeding to follow their point of view, we should discuss clearly why we have to modify the estimation technique. First of all, to estimate the original model, the parameter $\psi$ is viewed as the openness indicator; it should run from zero to unity. However, the techniques suggested by Edwards and Khan or other subsequent studies such as Hataiseree and Phipps (1996) do not impose the bound (0,1) to the parameter $\psi$. Estimation from the data may give an openness parameter ($\psi$) out of bounds, violating the model specifications. More straightforwardly, the parameter $\psi$ should be the state variable with values of either zero (segmented) or unity (integrated); a result between zero and unity should have no meaning relative to degree of openness. Therefore, the consideration of $\psi$ as the degree of openness would lead to wrong interpretation.

Therefore, our main contribution in this chapter is to propose the appropriate technique to modify the issue while still keep the interesting intention of the previous model to measure the degree of openness. The Markov Switching technique will be used to examine the behavior of interest rates and model liberalization as a change in regime between segmentation and integration. The outcomes from the estimation will be the probability of being in each regime for each period in order to consider the time-varying degree of integration.

In order to employ the Markov Switching technique, I must consider an economy governed by a stochastic process. The interest rate is governed by policies regarding the integration of domestic markets with the rest of the world. The policies are presented as two states. State 1 is the state in which domestic markets are integrated whereas state 0 is the state in which domestic markets are segmented. Since the model of interest rates under conditions combines the behavior of domestic interest rate in two extreme cases, the two-state model of Markov Switching should be flexible enough to provide an adequate determination. I, therefore, determine the interest rate assuming the two state Markov Switching estimation.

In this framework, the degree of openness will be referred to as the conditional probability of being in the integrated regime. From this viewpoint, the degree of openness is unobservable; we have to refer from the information we have. The use of conditional probability of being in the integrated regime also satisfies our belief that the degree of openness should be time varying and bounded between zero and one. In addition, the time-varying degree of openness inferred from the probability are reasonable in all environments compared to the extension suggested by Edwards and Khan. These authors suggest making degree of openness a function of time which would fit the data only if the level and intensity of capital controls vary smoothly and gradually over the period of study. Inferring the degree of openness from the probability is more appropriate. The model would not break down if the changes in capital restrictions were erratic as the case of our sample country, Thailand, which has had some dramatic changes during 1988-1992.

This section of my study builds on an approach introduced in Hamilton (1989) for analyzing discrete qualities of time series. The Markov technique offers many opportunities to examine the stochastic properties of time series in a nonstationary framework. The parameters are subjected to occasional discrete shifts. The probability law governing these shifts also explicitly states dynamic behavior of its own. The model can be used to analyze when the shifts occurred and to measure parameters characterizing the different regimes and the probability law for the transition between regimes. At each point in time, there may be a positive probability of a regime switch that is governed by switching probability.

Applying the Markov switching technique to the empirical work has significant benefits. In previous studies, the results obtained from fitting such regime-switching models to economic and financial time series prove to be flexible enough to incorporate patterns of jumps and persistent variance that coexist in the data. For example, Hamilton (1989) proposes to describe the stochastic process of real GNP in the US from 1953 to 1984 as a process of switching between two regimes of positive and negative growth rates. He found that the Markov switching model can fit data fairly well.

In other samples, the switch in regime can be applied to the study of interest rates such as in Gray (1996). He develops a generalized regime-switching model of the short-term interest rate. The short-term rates are allowed to exhibit both mean reversion and conditional heteroskedasticity. His model proves to better fit the pattern of the data compared to the existing model. Other applications of the Markov switching approach includes studies of exchange rates and other studies in economic topics.[20]

Although the Markov model has been used to explore many new and interesting questions, none of the previous literature apply the technique in directly investigating factors that determine interest rates. Usually, the univariate model is used in the study of interest rate behavior but they do not explore any economic

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[20] *For example, Engel and Hamilton (1990) apply the model in exchange rate time series, proposing a measure of capital market integration arising from a conditional regime switching model.*

variables that might interact with interest rates within the Markov Structure. Hence, I will use a multivariate specification and allow monetary variables and foreign interest rates to affect domestic interest rates.

## 2. The Model

The two-state Markov switching model is applied to describe the series of Thai nominal interest rates from 1980 to 1996 as coming from two distributions, each of which represents a distinct market state: integration and segmentation. The Markov structure can be represented as below:

$$i_t = S_t (i^*_t + e_t) + (1-S_t)(rr_t + \pi^e_t) + \varepsilon_t \qquad \varepsilon_t \sim \text{i.i.d. } N(0,\sigma^2)$$
$$\Delta i_t = S_t \Delta (i^*_t + e^*_t) + (1- S_t) \Delta ( rr_t + \pi^e_t) + \Delta\varepsilon \qquad \Delta\varepsilon_t \sim \text{i.i.d. } N(0, 2\sigma^2)$$

where: $S_t$ = 1 when market is in integrated regime (state 1)
= 0 when market is in segmented regime (state 0); and
$\Delta$ is the lagged difference.

From the model, $S_t$ is an unobserved state variable which takes on the value of one when markets are integrated and value of zero when markets are segmented.[21] Thus, there are 2 possible regimes from which nominal domestic rates might have been drawn. In the first regime, markets are integrated and nominal interest rates are given by interest rate parity. In the second regime, markets are segmented and nominal interest rates are from the Fisher equations. One assumption must be added: changes in regime are the result of processes largely unrelated to past realizations of the series and as not themselves directly observable. The independent vector and the variance-covariance matrix ($\Omega$) were functions of the state:

$$i_t \mid s_t \sim N\left(x_{s_t}, \Omega_{s_t}\right), \quad s_t = 1,0$$

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[21] *St follows a Markov process with constant transition probability developed by Hamilton (1990).*

such that

$$P(i_t|z_t;\theta) = \frac{1}{[2\pi]^{(n/2)}|\Omega_{S_t}|^{(1/2)}} \exp \frac{-[i_t - X_{S_t}]'\Omega^{(-1)}S_t[i_t - X_{S_t}]}{2}$$

Here n denotes the number of variables and θ consists of independent variables used to explain the domestic rate in each regime, and the diagonals and lower triangular blocks of $\Omega_1$ and $\Omega_0$. $X_{S_t}$ are the factors used to explain the behavior of interest rate which differ under different regime. It is desirable to structure the state variable $S_t$ to be the realization of a first order Markov process with transition probabilities equal:

$$\text{Prob}[S_t = 1 \mid S_{t-1} = 1] = P_{11}$$
$$\text{Prob}[S_t = 0 \mid S_{t-1} = 1] = P_{10}$$
$$\text{Prob}[S_t = 0 \mid S_{t-1} = 0] = P_{00}$$
$$\text{Prob}[S_t = 1 \mid S_{t-1} = 0] = P_{01}$$

with

$$P_{11} + P_{10} = P_{00} + P_{01} = 1$$

This set of transition probabilities must be inferred from the data together with other coefficients in the estimation process. However, there may be a natural concern that a change in regime should be represented as a permanent change rather than the cycling back and forth between the integrated state and the segmented state. Although the model implies the fluctuating behavior of the domestic rate, it allows the possibility of a permanent change as a special case if $P_{01}$ or $P_{10}$ equals zero. However, the single shift can also occur if $P_{01}$ or $P_{10}$ is quite close to zero. Thus, the model is flexible enough to allow this possibility.

Before proceeding the measurement of degree of openness, we have to test the specification of the model. If the interest rate in one period is independent of the state that prevailed in the previous period, the interest rate follows a random walk. If the hypothesis is rejected, the existence of two different regimes is confirmed. The null hypothesis is:

$$H_0: 1 - P_{00} = P_{11}$$

**3. The Data**

The data employed are quarterly data sampled from 1980 to 1995:

| | |
|---|---|
| i | - three-month interbank rate of Thailand (%); |
| i* | - three-month Eurodollar rate (%); |
| pc | - expected inflation rate for Thailand measured as $pc_t - pc_{t-4}$ (log); |
| $\pi^e$ | - Thailand's consumer price index (log); and |
| e | - spot exchange rate of the Thai baht against the US dollar (log). |

$rr_t + \pi^e_t$ implies by equation (9) which is the reduced form of domestic interest rate. It is expressed as : $rr_t + \pi^e_t + C_3\, \pi^e_t$. The data definition and sources are as follows;

*i* - three-month interbank rate of Thailand (percentage) which obtain from the Bank of Thailand Monthly Statistical Bulletin;

*i** - three-month Eurodollar rate (percentage) taken from Datastream International of the Dun and Bradstreet Corporation;

M1 - narrow definition of money, defined as currency in circulation plus demand deposits (billions of baht) from the Bank of Thailand;

pc - Thailand's consumer price index (log) from the Bank of Thailand;

m - real money balances (log), defined as log M1-pc;

Y - Gross Domestic Product (GDP) of Thailand (billion of baht); (Since the data for GDP are not available on a quarterly basis they are interpreted as described in Bank of Thailand (1991) and obtained from Bank of Thailand.)

$\pi^e$ - expected inflation rate for Thailand (percentage) measured as $pc_t - pc_{t-4}$, (This is one of the possible measurement of the actual rate of inflation in the quarterly basis. It has been found to perform well.); and

e - spot exchange rate of the Thai baht against the US dollar (log) come from Datastream International of the Dun and Bradstreet Corporation.

## 4. The Estimation and Results

For the equation:

$$\Delta i_t = S_t[\beta_1 \Delta (i_t + c^{\circ}_t)] + (1-S_t)[\beta_2 C + \beta_3 \Delta \ln Y_t + \beta_4 \Delta \pi^{e}_t + \beta_5 \Delta \ln m_{t-1}] + \Delta\varepsilon_t$$

The unobserved state variable , $S_t$ , takes on the value of one when markets are integrated and value of two when markets are segmented. Then $\psi_t$ is the conditional probability of being integrated (regime 1), $\psi_t = \text{prob}[S_t = 1 \mid \Omega_t]$. $\psi_t$ is inferred from the data with constant transition probability. The transition probability is:

$$P_{11} = \text{Prob}[S_t = 1 \mid S_{t-1} = 1]$$
$$P_{00} = \text{Prob}[S_t = 0 \mid S_{t-1} = 0];$$

where $\Omega_t$ is the conditioning information. The statistic is from a likelihood ratio test and has 5 degrees of freedom. All variables in the model are standardized.

The regime switching literature typically uses maximum likelihood (ML) estimation. The log likelihood function can be constructed recursively. This is done by choosing a 'starting' value or initial conditions for the probability process. The whole series of probabilities of being in each regime can then build up recursively. The result for estimating the Markov switching regime model are presented in Table 5-1 and its standard error is shown in parenthesis. Even though the transition probabilities are constant in the model, the regime probability (which we refer to as the degree of openness) varies through time as new information changes. Econometrically, it infers the relative likelihood of the two regimes.

**Table 5-1: Switching Model of Nominal Interest Rate**

| State | (1) Integration | (2) Segmentation |
|---|---|---|
| $\beta_1$ | 0.3259<br>(0.21918) | |
| $\beta_2$ | | 0.0510<br>(0.06347) |
| $\beta_3$ | | 0.2183<br>(0.09808) |
| $\beta_4$ | | 0.0462<br>(0.11104) |
| $\beta_5$ | | -0.1748<br>(0.21020) |
| std. dev. | 1.0285<br>(0.36537) | 2.1402<br>(0.0000) |
| | P11 = 0.997 (0.20738) | |
| | P00 = 0.953 (0.09716) | |
| | P1 = 0<br>(Probability of being in regime 1 of the first observation) | |
| | log likelihood - 92.94168 | |

The results show the persistence in both regimes with $P_{11}$ and $P_{00}$ both exceeding 0.9. The regimes tend to be separated by differential variance with the standard deviation of regime 2 being higher than the standard deviation of regime 1. The sign of the coefficient parameters also provide an interesting economic result. For regime 1 (integration), the domestic rates depend on the foreign rate plus the depreciation of the currency. The sign of the coefficient parameter implies the positive correlation between the domestic and foreign rates. In regime 2, the domestic rates vary with the domestic factors. Domestic interest rates have a positive correlation with Gross Domestic Product (GDP) and expected inflation whereas domestic interest rate is negatively correlated to the lag of money. The sign of these coefficient parameters are as we expected, as discussed earlier. Two states are clearly distinguished in interest rate series. The variance of interest rate is significantly higher in state zero (segmented) than in state one (integrated). The evidence shows that in the integrated state, the domestic interest rate is explained quite well by the interest rate parity. Thus, the deviation from what the parity predicts is lower compared to the deviation from the equations that use only the domestic monetary condition to explain the domestic rates.

The evidence confirms our belief that with the fixed regime of exchange rates that prevailed in our market, one of the important observations of the increasing capital flow to the market is the domestic interest rate. Therefore, in the open economy, the difference from parity should be narrow whereas in a closed economy there may be other significant variables that explain the domestic rate.

In estimating regime switching models, a conditional probability is of interest. The smoothing probabilities (Prob [$S_t = 1 \mid \Omega_t$]) are interpreted to determine if and when regime switches occur. Table 5-2 shows the smoothed probability whereas Figure 5-1 contains points of smoothed probability. Figure 5-1 points towards one period during which the process was in the integrated regime, 1989-1996. This period has an explanation in the context of the deregulated period. The example of important liberalization policies is the three year financial reform plan which was officially achieved beginning in 1990.

Table 5-2: Degree of Openness

| Period | Degree of Openness (Probability of being in regime 1) |
|---|---|
| 1980-Q1 | 0.0141 |
| 1980-Q2 | 0.0382 |
| 1980-Q3 | 0.0156 |
| 1980-Q4 | 0.0439 |
| 1981-Q1 | 0.0153 |
| 1981-Q2 | 0.0318 |
| 1981-Q3 | 0.0972 |
| 1981-Q4 | 0.1979 |
| 1982-Q1 | 0.1326 |
| 1982-Q2 | 0.1479 |
| 1982-Q3 | 0.2205 |
| 1982-Q4 | 0.3267 |
| 1983-Q1 | 0.2371 |
| 1983-Q2 | 0.1495 |
| 1983-Q3 | 0.1378 |
| 1983-Q4 | 0.0990 |
| 1984-Q1 | 0.2359 |
| 1984-Q2 | 0.3438 |
| 1984-Q3 | 0.2984 |
| 1984-Q4 | 0.1761 |
| 1985-Q1 | 0.1536 |
| 1985-Q2 | 0.1516 |

| Period | Degree of Openness (Probability of being in regime 1) |
|---|---|
| 1985-Q3 | 0.1649 |
| 1985-Q4 | 0.0942 |
| 1986-Q1 | 0.1236 |
| 1986-Q2 | 0.0873 |
| 1986-Q3 | 0.0940 |
| 1986-Q4 | 0.1186 |
| 1987-Q1 | 0.1629 |
| 1987-Q2 | 0.0748 |
| 1987-Q3 | 0.1563 |
| 1987-Q4 | 0.2066 |
| 1988-Q1 | 0.1450 |
| 1988-Q2 | 0.2537 |
| 1988-Q3 | 0.3921 |
| 1988-Q4 | 0.2320 |
| 1989-Q1 | 0.3457 |
| 1989-Q2 | 0.3724 |
| 1989-Q3 | 0.5930 |
| 1989-Q4 | 0.3789 |
| 1990-Q1 | 0.4833 |
| 1990-Q2 | 0.5407 |
| 1990-Q3 | 0.5227 |
| 1990-04 | 0.4998 |
| 1991-Q1 | 0.8921 |
| 1991-Q2 | 0.7247 |

| Period | Degree of Openness (Probability of being in regime 1) |
|---|---|
| 1991-Q3 | 0.9233 |
| 1991-Q4 | 0.9291 |
| 1992-Q1 | 0.9858 |
| 1992-Q2 | 0.9989 |
| 1992-Q3 | 0.9936 |
| 1992-Q4 | 0.9999 |
| 1993-Q1 | 0.9970 |
| 1993-Q2 | 0.9989 |
| 1993-Q3 | 0.9999 |
| 1993-Q4 | 1.0000 |
| 1994-Q1 | 1.0000 |
| 1994-Q2 | 1.0000 |
| 1994-Q3 | 1.0000 |
| 1994-Q4 | 1.0000 |
| 1995-Q1 | 1.0000 |
| 1995-Q2 | 1.0000 |
| 1995-Q3 | 0.9940 |
| 1995-Q4 | 0.9992 |
| 1996-Q1 | 0.9859 |
| 1996-Q2 | 0.9232 |
| 1996-Q3 | 0.9713 |

The probability of switching states is low ($P_{01} = 0.003$, $P_{10} = 0.047$) and the expected duration of a regime is quite long. The large and highly significant estimates of $P_{11}$ and $P_{00}$ also suggest that nominal interest rates are highly dependent on the realization of the state variable in the previous period. To test the specification, the null hypothesis that the data can be adequately described by a random walk ($P_{00} = 1 - P_{11}$) can be rejected at any reasonable significance levels.

Thus, the existence of two regime switching is confirmed in the data. Moreover, the probability that the beginning of the sample is drawn from state one is low. This period corresponds to an early 1980s market with tight capital controls and a lack of assets traded. The probabilities that the data are drawn from state one rise smoothly from 1988 onwards. This finding is consistent with the fact that the Thai authorities relaxed several capital controls to deregulate the financial markets over this period. Moreover, at that time, Thailand with its booming stock market, was one of the world's fastest growing economies. In 1991, the estimated probability of being in regime 1 increased sharply. This evidence reflects the liberalization measures; for example, it may be due to Thailand's declaration of acceptance of the IMF obligation or adoption of double tax treaties taxes. Finally, the probability becomes unity by the end of 1993 which is the first year after the liberalization of all types of interest rates by Bank of Thailand. The probability remains unity until the third quarter of 1995, when it begins to fall by small amount. The explanation for the slight drop may stem from a political crisis during that period.

In conclusion, the evidence from estimation confirms our prior hypothesis that the Thai market has grown more integrated over time. The results also give significant information that there is a sharp increase in the integration parameter in 1992 which coincides with the effectively completed deregulation on all types of interest rates. In addition, the three year financial reform plan was officially achieved in 1990. The further tests are added to make the conclusive results. The same methodology is performed by changing the foreign factor from the three-month Eurodollar rate quoted in US. dollar to three-month Eurodollar rate quoted in D-mark and Yen. The results are plotted in Figures 5-2 and 5-3, respectively.

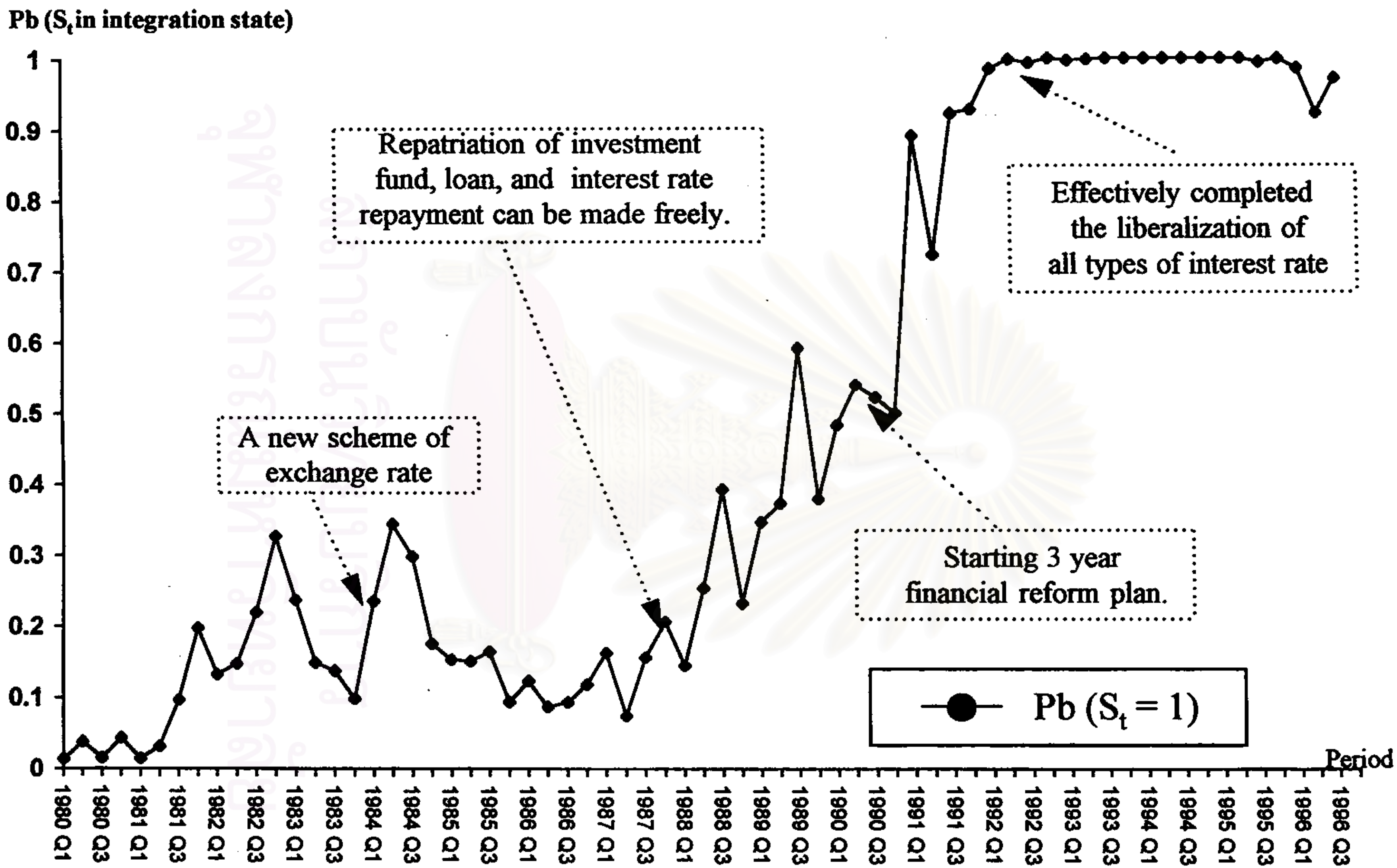


Figure 5.1 Thai and Euro dallar Interest Rate

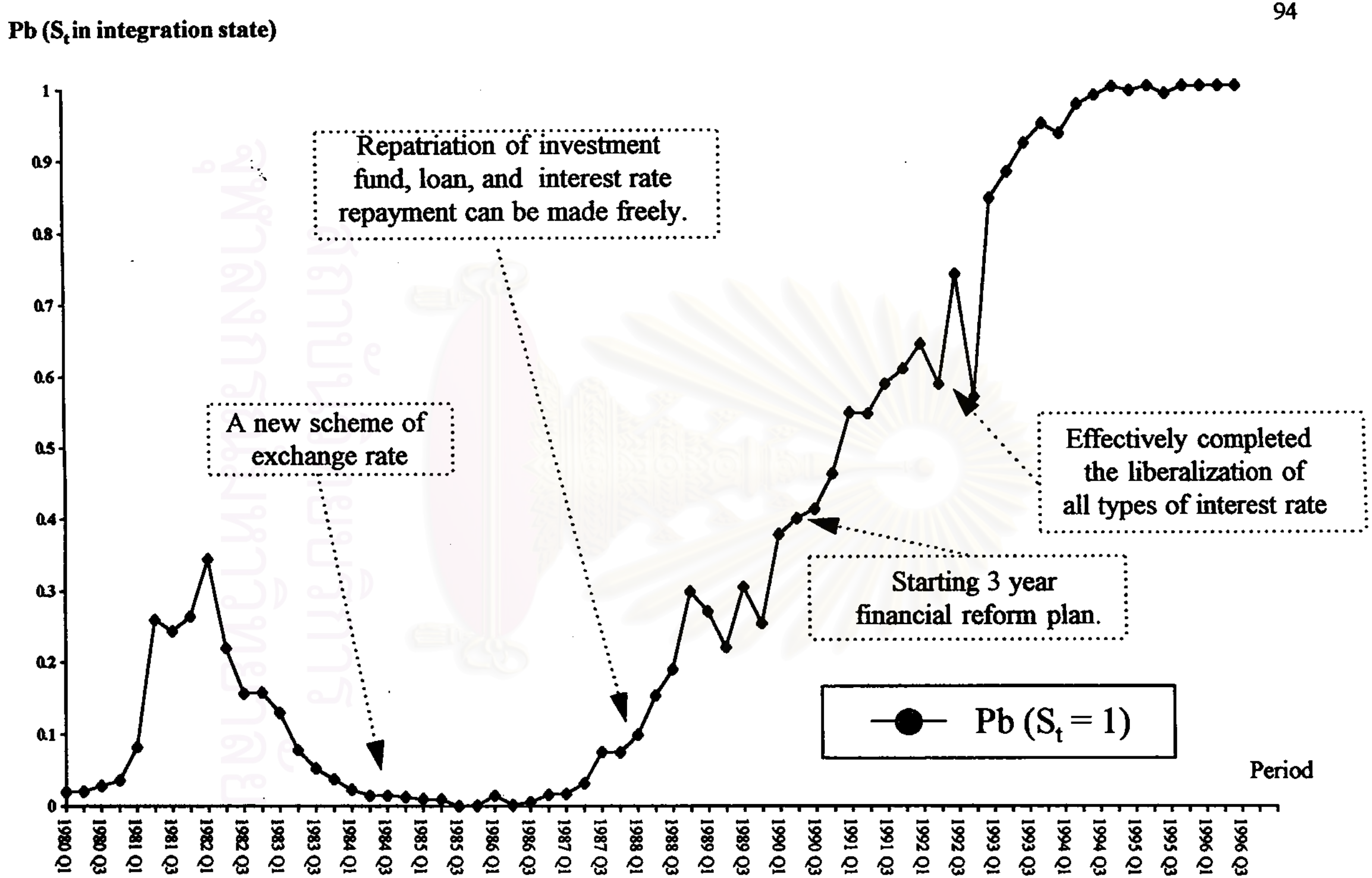


Figure 5.2 Thai and Euro D-Mark Interest Rate

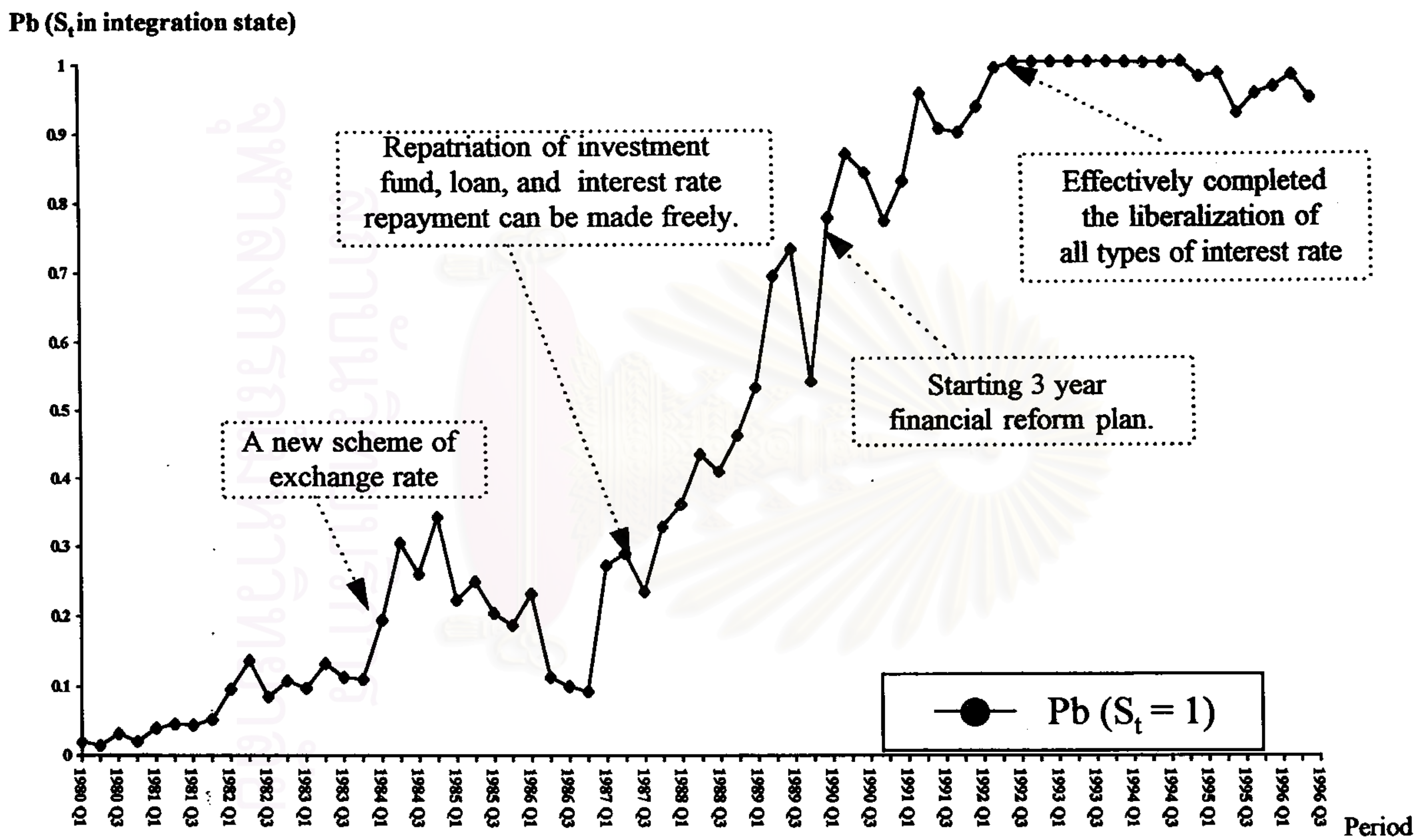


Figure 5.3 Thai and Euro Yen Interest Rate

**D. Summary**

The degree to which a nation is integrated into the rest of the world has changed over time. Generally, all previous literature that tests for market integration has used one of three frameworks: all markets are fully integrated; markets are fully closed; or local market are semi-open with the degree of openness being constant. In my study, I propose the model allowing for time-varying market integration. The time-varying degree of openness is applied from the model first outlined by Edward and Khan (1985). The model nests the polar cases of fully closed and fully open economy. The new technique that applies the standard switching regime technique pioneered by Hamilton (1989) allows for the degree of openness to change through time. The results indicate time-varying integration for sample data. These findings should shed some light for authorities and others concerned about the effects of regulatory changes. Thailand has removed or relaxed various capital controls or restrictions in the last decade, therefore, our study can be used to answer whether these policy changes had a discernible affect on the degree of openness of the country.