Estimating Exchange Market Pressure for Asian Countries*

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January 2005

Abstract

Exchange market pressure (EMP), the sum of the exchange rate depreciation and reserve outflows, summarizes the extent of pressure exerted on foreign exchange market. This paper analyzes exchange market pressure in crisis affected Asian countries which contains Indonesia, Japan, Korea, Malaysia, Philippines, Singapore and Thailand from 1990 to 2004. We calculate the exchange market pressure in these countries on the basis of simple small open economy framework proposed by Weymark (1995) using cointerating method and find that there exists cointegrating relationship in money demand in several Asian countries. In the literature of exchange market pressure, the component of the reserve outflows is measured differently. We also calculate the exchange market pressure defined by Girton and Roper (1977), Kaminsky and Reinhart (1999) respectively and compare these results. We can infer that the exchange market pressure index specified by Weymark can identify a currency crisis period more properly than indices specified by Girton and Roper and Kaminsky and Reinhart.

* I am grateful to Professor Masahiro Kawai for helpful comments and suggestions. I also thank the participants in the lunch meeting seminar.

1 Introduction

In countries that adopt intermediate exchange regimes, policy authorities conduct exchange market intervention to maintain the nominal exchange rate stability. When a speculative attack occurs, not only the change in the nominal exchange rates but also the change in the domestic monetary component such as the reserve money or the domestic interest rates should be considered to measure pressure exerted on the currency. Girton and Roper(1977) propose an exchange market pressure index composed of simple sum of the change in the nominal exchange rate and the change in the foreign exchange reserves scaled by the base money. Based on assumptions of a small-country, they measured the volume of intervention necessary to achieve any desired exchange rate target. On the other hand, Kaminsky and Reinhart(1999) measures exchange market pressure as a weighted sum of the change in the nominal exchange rate and the change in the foreign exchange reserves. The weight is determined by ratio of volatility to avoid sudden currency depreciation or large reserve loss dominating the movement of index. This measure of exchange market pressure is widely used in literature of financial crisis and contagion. (Eichengreen, Rose and Wyplosz(1996) et.al)

However, neither of these specifications of the exchange market pressure can capture the magnitude of pressure accurately, due to the fact that Kaminsky and Reinhart's measure of exchange market pressure ignores the effect of the change in the domestic credit created by the change in the net foreign asset of monetary authority and Girton and Roper's measure of exchange market pressure are based on the special assumption that the money multiplier is constant over time. Weymark(1995) proposed a method of measuring exchange market pressure consistent with simple model of a small open economy. It is shown that the weight of the change in the nominal exchange rates and the change in the foreign exchange reserves as proportion of inherited money stock is determined in the model.

The objective of this paper is to estimate exchange market pressure for crisis affected Asian countries which contain Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, and Thailand from 1990 to 2004 based on monthly data. In the period of Asian financial crisis occurred in 1997, these countries except Japan were suffered from the tremendous pressure of depreciation created by massive speculative attacks. Especially, Indonesia, Korea and Thailand were forced to abandon their de facto fixed exchange rate regimes and shift to the floating exchange regimes. Malaysia adopted an unprecedented capital control policy in September 1998 to insulate domestic money market from the volatility of international capital flow. To measure the extent of pressure exerted on these countries precisely, we should consider not only the change in the nominal exchange rates but also the change in the foreign exchange reserves or the change in the domestic money stock created by the change in foreign exchange reserves. Following the discussion above, we use Weymark's small open economy framework to calculate the exchange market pressure for these countries. Calculating the exchange market pressure, we analyze cointegrating relationships in the money demand and the price equation.

We also calculate the exchange market pressure indices for Asian countries measured by Girton and Roper's method and Kaminsky and Reinhart's method, and compare these three indices.

This paper is organized as follows. In section 2, we briefly review the literature of exchange market pressure: Girton and Roper model, Kaminsky and Reinhart specification and Weymark's model. To estimate the exchange market pressure proposed by Weymark, we analyze cointegrating relationship in the money demand and the price equation. Before analyzing the cointegrating relationship, test of unit root is conducted in section 3 and we confirm that most variables have unit root. Section 3 also provides the results of c test of cointegration proposed by Johansen. We find that cointegrating relationship in real money demand, domestic output and domestic interest rate in several Asian countries and calculate measure of exchange market pressure consistent with Weymark's model by applying dynamic OLS estimation method. In section 4, we compare these three indices of exchange market pressure. A brief summary and concluding remark is found in section 5.

2 Measuring exchange market pressure

2.1 Girton and Roper model

Girton and Roper(1977) consider simple two country model. They specify exchange market pressure as a sum of the change in the nominal exchange rate and change in the foreign exchange reserves. Monetary equilibrium condition can be written as

$$H_t = R_t + D_t = P_t \cdot Y_t^{\beta} exp(-\alpha \cdot i_t) \tag{1}$$

where H_t denotes the supply of base money issued by monetary authority in period t, R_t denotes the base money created against the net purchase of foreign assets, D_t denotes the base money created by domestic credit expansion, P_t denotes the price level, Y_t denotes the real income and i_t denotes the domestic interest rate. Transforming this equation into logarithms and differentiating it with respect to time, we have

$$\Delta h_t = \Delta r_t^{GR} + \Delta d_t^{GR} = \Delta p_t + \beta \Delta y_t - \alpha \Delta i_t \tag{2}$$

where h_t denotes the log of base money, r_t denotes the log of base money created by net foreign assets, d_t denotes the log of base money created by domestic credit expansion, p_t denotes the log of price level, y_t denotes the log of real income, $\Delta r_t^{GR} = R_t/H_t \cdot \Delta r_t$ and $\Delta d_t^{GR} = D_t/H_t \cdot \Delta d_t$ [*1]. To examine the monetary interaction between countries, we subtract monetary equilibrium condition (equation (2)) in foreign country from monetary equilibrium condition (equation (2)) in home country. We obtain

$$\Delta r_t^{GR} - \Delta r_t^{*GR} = -\Delta d_t^{GR} + \Delta d_t^{*GR} + \beta \Delta y_t - \beta^* \Delta y_t^* + \Delta p_t - \Delta p_t^* - \alpha(\Delta i_t - \Delta i_t^*) \tag{3}$$

[*1] Notations are slightly changed from Girton and Roper's original paper in order to compare with other exchange market pressure indices.

where asterisk (*) denotes the foreign values. α and α^* are assumed to be equal. We introduce the further notation, Δe_t that denotes the rate of depreciation of the home currency in terms of the foreign currency, θ_t that denotes differential inflation rate adjusted for exchange rate changes ($\Delta p_t - \Delta p_t^* - \Delta e_t$), and δ_t that denotes change in uncovered interest rate differential ($\Delta i_t - \Delta i_t^*$). Equation (3) can be rewritten as

$$\Delta r_t^{GR} - \Delta r_t^{*GR} - \Delta e_t = -\Delta d_t^{GR} + \Delta d_t^{*GR} + \beta \Delta y_t - \beta^* \Delta y_t^* + \theta_t - \alpha \delta_t. \tag{4}$$

This equation shows the volume of disequilibrium in foreign exchange market that must be removed through market intervention or change in the nominal exchange rate. The left hand side of equation (4) is referred to exchange market pressure. We also assume that foreign country is a key currency country and has ability to force all adjustment burdens on home country that has made efforts to stabilize the exchange rate. Then equation (4) can be rewritten as

$$EMP_t^{GR} \equiv \Delta e_t - \Delta r_t^{GR} = -\Delta d_t^{GR} + \Delta h_t^* + \beta \Delta y_t - \beta^* \Delta y_t^* + \theta_t - \alpha \delta_t. \tag{5}$$

Girton and Roper define exchange market pressure as $\Delta r_t^{GR} - \Delta e_t$. We multiply it by -1 in accordance with other EMP indices, so that the positive EMP implies the currency is under the pressure of depreciation or loss of the foreign exchange reserves.

2.2 Specification of Kaminsky and Reinhart

Kaminsky and Reinhart(1999) specify exchange market pressure as a weighted average of the rate of change in the exchange rate, Δe_t and in the foreign exchange reserves, Δr_t^{KR}, with weight such that the two components of the index have equal sample volatilities.

$$EMP_t^{KR} \equiv \Delta e_t - \frac{\sigma_e}{\sigma_r} \Delta r_t^{KR} \tag{6}$$

where σ_e is the standard deviation of the rate of change in the nominal exchange rate and σ_r is the standard deviation of the rate of change in the foreign exchange reserves. Since changes in the nominal exchange rate enter with a positive weight, changes in the foreign exchange reserves have negative weight. Positive exchange market pressure index indicates that the currency is under the pressure of depreciation.

2.3 Weymark's Model

Weymark(1995) generalize the measure of exchange market pressure proposed by Girton and Roper. The model employed by Weymark is one of a small open economy in which the domestic price level is influenced by both the level of foreign country and the exchange rate. The purchasing power parity does not necessarily hold. The gross domestic product, the foreign price level, the foreign interest rate and the domestic credit are assumed to be exogenous. It is also assumed that the domestic financial market is well developed and the domestic assets and the foreign assets are completely substitutable. The foreign and the domestic interest rates are linked through an uncovered interest rate parity condition.

The model is characterized by four equations below.

$$m_t^d = p_t + b_1 y_t - b_2 i_t + \nu_t \tag{7}$$

$$p_t = a_0 + a_1 p_t^* + a_2 e_t \tag{8}$$

$$i_t = i_t^* + E[e_{t+1}|t] - e_t \tag{9}$$

$$m_t^s = m_{t-1}^s + \Delta d_t^W + \Delta r_t^W \tag{10}$$

where m_t denotes the log of the money stock in period t (superscript "s" denotes supply, and "d" denotes demand), p_t denotes the log of the domestic price level, y_t denotes the log of the gross domestic output, i_t denotes the domestic interest rate, ν_t denotes a stochastic shock against the money stock, e_t denotes the log of the nominal exchange rate measured by home currency. An asterisk(*) denotes foreign value and $E[e_{t+1}|t]$ denotes expectation of exchange rate in period t+1 which agent expect conditional on the information obtained in period t. Supply of the money is determined by the foreign exchange reserves and the domestic credit created by monetary authority.

$$\Delta d_t^W = [\mu_t D_t - \mu_{t-1} D_{t-1}]/M_{t-1} \tag{11}$$

where μ_t denotes money multiplier in period t, D_t denotes domestic credit supplied by monetary authority in period t, and M_{t-1} denotes money stock in period t-1. Similarly, the definition of Δr_t^W is given by the equation below.

$$\Delta r_t^W = [\mu_t R_t - \mu_{t-1} R_{t-1}]/M_{t-1} \tag{12}$$

where μ_t denotes the money multiplier in period t, R_t denotes the net foreign exchange reserves of monetary authority in period t, and M_{t-1} denotes the money stock in period t-1. Substitute equation (8) and equation (9) to equation (7), we obtain

$$m_t^d = a_0 + a_1 p_t^* + (a_2 + b_2)e_t + b_1 y_t - b_2 i_t^* - b_2 E[e_{t+1}|t] + \nu_t. \tag{13}$$

Under the assumption that the money market clears continuously,

$$m_t^d = m_t^s = m_t \quad for \quad all \quad t. \tag{14}$$

Substituting equation (10) and equation (13) into equation (14), we obtain equilibrium condition of money market

$$a_0 + a_1 p_1^* + (a_2 + b_2)e_t + b_1 y_t - b_2 i_t^* - b_2 E[e_{t+1}|t] + v_t = m_{t-1} + \Delta d_t^W + \Delta r_t^W \tag{15}$$

Taking the first order differences of the left hand side of equation (15) and divide by $1/(a_2 + b_2)$ to normalize, we have

$$EMP_t^W \equiv \Delta e_t - \frac{1}{a_2 + b_2}\Delta r_t^W = \frac{1}{a_2 + b_2}(\Delta d_t^W - a_1 \Delta p_t^* - b_1 \Delta y_t + b_2 \Delta i_t^* + b_2 \Delta E[e_{t+1}|t] + u_t). \tag{16}$$

where $u_t = -\Delta v_t/(a_2 + b_2)$. Equation (16) shows the magnitude of disequilibrium in the money market that must be removed either by the change in the nominal exchange rate or the change in the money stock created by foreign exchange reserves. Exogenous variables in this equation are change in the foreign price level (Δp_t^*), change in the domestic product (Δy_t), change in the foreign interest rate (Δi_t^*), change in the domestic credit (Δd_t^W) and stochastic disturbance in money demand (u_t). Following the discussion of Girton and Roper, we define a left hand side of equation (16) as an exchange market pressure. There are four independent equations and five endogenous variables; m_t, i_t, p_t, e_t and Δr_t^W. Therefore we cannot solve the model explicitly. However, we are interested in exchange market pressure as an aggregate volume of disequilibrium in the money market which expressed by exogenous variables. The composition of the change in the nominal exchange rate and the change in the money stock created by the foreign exchange reserve scaled by inherited money stock in exchange market pressure depends on the policy authority's reaction function which states the relationship between Δe_t and Δr_t^W. In other words, if we can specify monetary authority's reaction function, we can solve the model explicitly and measure the volume of market intervention necessary to achieve nominal exchange rate stability or the change in the nominal exchange rate when no market intervention is conducted. In this paper, we do not specify the reaction function of monetary authority and estimate exchange market pressure as a disequilibrium in money market.

3 Empirical investigation

In this section, we estimate exchange market pressure for crisis affected Asian countries; Indonesia, Japan, Korea, Malaysia, Philippines, Singapore and Thailand. The data are monthly series from January 1990 to July 2004 except Indonesia and Korea. Sample period for Indonesia is from January 1991 to June 2004 and sample period for Korea is from January 1990 to June 2004. The principal data source is IFS and detailed data description is discussed in Appendix. To estimate exchange market pressure specified by Weymark, we have to derive the coefficient of the domestic interest rate in the money demand equation (b_2 in equation (7)) and coefficient of the exchange rate in the price equation (a_2 in equation (8)) properly. Weymark estimated the first differenced equation by 2SLS estimation method. This paper estimates the equation using the cointegrating method. Before analyzing cointegrating relationship in money demand and the price equation, we first test the existence of unit root in time series we analyze and what the order of integration for each variable is.

3.1 Unit root test

We apply the unit-root test developed by Dickey and Fuller. The results of Augmented Dickey Fuller tests[*2]are presented in Table 1 and Table 2. The null hypothesis is that there exists unit root, therefore, the rejection of null hypothesis indicate that the variable is stationary. An asterisk (*) denotes that the ADF statistic is significant at the five percent level. The test is conducted with 0 to 11 lags and number of optimal augmenting lags is determined to minimize AIC. When we test the existence of unit root in level of interest rate, trend component is excluded.

The results presented in Table 1 and Table 2 suggest that virtually all variables except p_t have unit root. To avoid modeling I(2) variable, we focus on $(m - p)_t$ and find that $(m - p)_t$ had desired I(1) property. In the next subsection, we analyze cointegrating relationship in the money demand equation; $(m-p)_t$, y_t and i_t, and the price equation; p_t, p_t^*, and e_t and try to obtain consistent cointegrating vector.

[*2] ADF tests is carried out in the context of the model: $\Delta y_t = \mu + \gamma y_{t-1} + \sum_{j=1}^{p-1} \phi_j \Delta y_{t-j} + \epsilon_t$

(a) Indonesia (num. of obs.=162)						
variable	e	Δe	m	Δm	y	Δy
specification	const trend	const	const trend	const	const trend	const
num.of lags	11	10	7	6	6	5
adf-t value	-2.27	-3.86^{*}	-0.42	-3.89^{*}	-2.98	-3.39^{*}
variable	p	Δp	i	Δi	(m-p)	Δ(m-p)
specification	const trend	const	const	const	const trend	const
num.of lags	10	9	10	3	7	6
adf-t value	-2.10	-3.91^{*}	−2.83	-6.95^{*}	-0.20	-4.67^{*}
(b) Japan (num. of obs.=175)						
variable	e	Δe	m	Δm	y	Δy
specification	const trend	const	const	const	const trend	const
num.of lags	11	6	11	11	10	11
adf-t value	-2.32	-6.28^{*}	-1.75	-3.91^{*}	-3.37	-4.33^{*}
variable	p	Δp	i	Δi	(m-p)	Δ(m-p)
specification	const trend	const	const	const	const trend	const
num.of lags	11	11	6	5	11	11
adf-t value	−3.35	-2.05	-2.58	-3.29^{*}	-1.06	-4.14^{*}
(c)Korea (num. of obs.=174)						
variable	e	Δe	m	Δm	y	Δy
specification	const trend	const	const trend	const	const	const
num.of lags	11	11	2	11	6	5
adf-t value	-2.14	-4.14^{*}	-0.43	-2.43	-0.45	-4.09^{*}
variable	p	Δp	i	Δi	(m-p)	Δ(m-p)
specification	const trend	const	const	const	const trend	const
num.of lags	9	8	9	8	2	10
adf-t value	-3.10	-4.33^{*}	-1.34	-5.07^{*}	-1.93	-4.10^{*}
(d)Malaysia (num. of obs.=175)						
variable	e	Δe	m	Δm	y	Δy
specification	const trend	const	const trend	const	const trend	const
num.of lags	2	2	2	11	6	4
adf-t value	-1.93	-7.19^{*}	-0.14	-2.28	-3.03	-5.34^{*}
variable	p	Δp	i	Δi	(m-p)	Δ(m-p)
specification	const trend	const	const	const	const trend	const
num.of lags	2	11	6	5	2	2
adf-t value	-0.23	-2.09	-1.48	-5.23^{*}	-0.49	-7.83^{*}

Table. 1 Augmented Dickey-Fuller statistics

(e)Philippines (num. of obs.=175)

variable	e	Δe	m	Δm	y	Δy
specification	const trend	const	const trend	const	const trend	const
num.of lags	2	2	8	11	4	3
adf-t value	-1.91	-6.96^{*}	0.84	-2.06	-2.05	-8.51^{*}
variable	p	Δp	i	Δi	(m-p)	Δ(m-p)
specification	const trend	const	const	const	const trend	const
num.of lags	3	11	7	11	6	10
adf-t value	-0.96	-3.89^{*}	-2.11	-5.50^{*}	-0.35	-4.44^{*}

(f)Singapore (num. of obs.=175)

variable	e	Δe	m	Δm	y	Δy
specification	const trend	const	const trend	const	const trend	const
num.of lags	2	2	2	2	4	3
adf-t value	-2.17	-8.27^{*}	-1.57	-8.88^{*}	-2.75	-7.23^{*}
variable	p	Δp	i	Δi	(m-p)	Δ(m-p)
specification	const trend	const	const	const	const trend	const
num.of lags	4	11	4	3	2	2
adf-t value	-2.12	-2.69	-1.95	-7.61^{*}	-1.69	-8.82^{*}

(g)Thailand (num. of obs.=175)

variable	e	Δe	m	Δm	y	Δy
specification	const trend	const	const trend	const	const trend	const
num.of lags	7	6	2	11	3	2
adf-t value	-2.35	-5.02^{*}	-1.19	-2.15	-1.89	-8.33^{*}
variable	p	Δp	i	Δi	(m-p)	Δ(m-p)
specification	const trend	const	const	const	const trend	const
num.of lags	5	11	8	7	11	10
adf-t value	-0.87	-2.19	-1.80	-5.10^{*}	-2.67	-3.36^{*}

(h)United States (num. of obs.=175)

variable	p	Δp	i	Δi
specification	const	const	const	const
num.of lags	11	10	5	4
adf-t value	-1.92	-3.22^{*}	-2.04	-3.77^{*}

Table. 2 Augmented Dickey-Fuller statistics: continued

3.2 Cointegration analysis

In this section, we conduct Johansen's trace test[*3] to determine the number of cointegrating vectors for money demand and the price equation. In words, Johansen's trace test estimates the cointegrating vector in error correction representation of I(1) system directly by applying maximum likelihood estimate to residuals obtained by canonical regressions. The null hypothesis is that there are r or fewer cointgrating vectors against the alternative hypothesis that there are more than r cointegrating vectors. Johansen's trace test statistics for money demand of Asian countries are summarized in table 3. An asterisk (*) denotes that the trace statistic is significant at the five percent level.

The test is conducted with 0 to 11 lags and number of optimal augmenting lags is determined to minimize AIC. The lag length adopted is 5 for Indonesia, is 6 for Japan, is 6 for Korea, is 1 for Malaysia,

(a)Indonesia			
Eigenvalue	0.12	0.03	0.02
Null hypothesis	$r = 0$	$r \leqq 1$	$r \leqq 2$
Trace statistic	26.14*	7.61	3.04
(b)Japan			
Eigenvalue	0.23	0.04	0.00
Null hypothesis	$r = 0$	$r \leqq 1$	$r \leqq 2$
Trace statistic	43.56*	6.38	0.00
(c)Korea			
Eigenvalue	0.13	0.07	0.00
Null hypothesis	$r = 0$	$r \leqq 1$	$r \leqq 2$
Trace statistic	32.77*	11.56	0.00
(d)Malaysia			
Eigenvalue	0.18	0.04	0.02
Null hypothesis	$r = 0$	$r \leqq 1$	$r \leqq 2$
Trace statistic	43.04*	9.94	3.63
(e)Philippines			
Eigenvalue	0.12	0.06	0.00
Null hypothesis	$r = 0$	$r \leqq 1$	$r \leqq 2$
Trace statistic	29.09*	9.52	0.07
(f)Singapore			
Eigenvalue	0.14	0.05	0.00
Null hypothesis	$r = 0$	$r \leqq 1$	$r \leqq 2$
Trace statistic	34.51*	8.97	0.25
(g)Thailand			
Eigenvalue	0.16	0.07	0.01
Null hypothesis	$r = 0$	$r \leqq 1$	$r \leqq 2$
Trace statistic	38.18*	11.61	0.91

Table. 3 Johansen's trace test statistics for money demand

[*3] For the details of the test procedure, see Maddala and Kim(1998) or Kawai and Ohara(1997)

	Indonesia	Japan	Korea	Malaysia	Philippines	Singapore	Thailand
m-p	1.00	1.00	1.00	1.00	1.00	1.00	1.00
y	-0.26	-0.25	-0.33	-0.37	-0.29	-0.39	-0.22
i	-1.32	3.59	10.44	3.33	0.94	-17.23	-0.27

Table. 4 Estimated cointegrating vectors for money demand

is 7 for Philippines, is 2 for Singapore, and is 6 for Thailand. Results reported in table 3 indicate that null hypothesis of no cointegration is rejected and null hypothesis that indicates the existence of one cointegrating vector is accepted in all countries at the standard level of significance. Therefore we conclude that there is one cointegrating relationship in money demand for Asian countries. These results are consistent with conventional studies that confirm the existence of cointegrating relationship in money demand. Estimated cointegrating vectors are presented in table 4. We normalize the vector using real money stock coefficient. The conventional studies of money demand show that coefficient on the domestic product is positive and coefficient on the domestic interest rate is negative. However, the coefficients on the interest rate of Indonesia, Singapore and Thailand are negative and the coefficient on the interest rate of Singapore is extremely large. The coefficient on the interest rate of Korea is positive, but too large to consider stable long-run relationship between money demand and interest rate. The results of Johansen's trace test on the price equation for Asian countries are also reported in table 5. Similarly, the test is conducted with 0 to 10 lags and number of optimal augmenting lags is determined to minimize AIC and an asterisk (*) denotes that the statistic is significant at five percent level. The lags adopted is 6 for Indonesia, is 5 for Japan , is 2 for Korea, is 1 for Malaysia, is 3 for Philippines, is 2 for Singapore, and is 1 for Thailand. Unlike the case of money demand, we cannot obtain clear evidence that implies existence of one cointegrating relationship. Null hypothesis of no cointegrating relationship is rejected and null hypothesis of one cointegrating relationship is accepted for all countries at the five percent significance level. However, null hypothesis of two cointegrating relationship is rejected for Korea, Philippines and Singapore. This result may suggest that no cointegrating relationship in these countries.

The cointegrating vectors correspond to maximum eigenvalue is reported in table 6. The coefficient on the foreign price level and the nominal exchange rate are negative in all countires except Indonesia. This is consistent with conventional theory of the price equation. However, the coefficients are too large to recognize long-run relationship.

(a) Indonesia			
Eigenvalue	0.19	0.06	0.02
Null hypothesis	r = 0	r ≦ 1	r ≦ 2
Trace statistic	40.54*	11.29	2.70
(b) Japanese			
Eigenvalue	0.17	0.08	0.02
Null hypothesis	r = 0	r ≦ 1	r ≦ 2
Trace statistic	45.27*	16.22	3.63
(c) Korea			
Eigenvalue	0.16	0.05	0.03
Null hypothesis	r = 0	r ≦ 1	r ≦ 2
Trace statistic	42.63*	14.43	5.61*
(d) Malaysia			
Eigenvalue	0.17	0.03	0.00
Null hypothesis	r = 0	r ≦ 1	r ≦ 2
Trace statistic	37.22*	4.98	0.16
(e) Philippine			
Eigenvalue	0.25	0.03	0.03
Null hypothesis	r = 0	r ≦ 1	r ≦ 2
Trace statistic	58.64*	10.41	4.44*
(f) Singapore			
Eigenvalue	0.11	0.06	0.02
Null hypothesis	r = 0	r ≦ 1	r ≦ 2
Trace statistic	35.45*	15.56	4.06*
(g) Thailand			
Eigenvalue	0.15	0.05	0.01
Null hypothesis	r = 0	r ≦ 1	r ≦ 2
Trace statistic	35.78*	8.81	0.86

Table. 5 Johansen's trace test statistics for the price equation

	Indonesia	Japan	Korea	Malaysia	Philippine	Singapore	Thailand
p	1.00	1.00	1.00	1.00	1.00	1.00	1.00
p^*	4.34	-10.28	-17.17	-5.56	-14.68	-5.73	-18.15
e	-0.30	-0.51	-0.57	-0.22	-0.55	-0.10	-0.55

Table. 6 Estimated cointegrating vectors for the price equation

3.3 Estimation by Dynamic OLS

In the previous subsection, we examined whether an I(1) system is cointegrated. We can find stable cointegrating relationships in money demand of several Asian countries. In this subsection, we estimate triangular representation of cointegrating systems. We cannot find valid evidence of cointegraiton for the price equations, consistent estimate can be obtained by applying DOLS estimate method because almost all the variables are assumed to be I(1). The length of the lead and lag are arbitrarily set to 3, so the augmenting cointegrating regression for the money demand equation is represented as

$$m_t - p_t = \mu_1 + \gamma_y y_t + \gamma_i i_t + \beta_{y0}\Delta y_t + \beta_{y,-1}\Delta y_{t+1} + \beta_{y,-2}\Delta y_{t+2} + \beta_{y,-3}\Delta y_{t+3} + \beta_{y1}\Delta y_{t+1} + \beta_{y2}\Delta y_{t-2} + \beta_{y3}\Delta y_{t-3}$$
$$+\beta_{i0}\Delta i_t + \beta_{i,-1}\Delta i_{t+1} + \beta_{i,-2}\Delta i_{t+2} + \beta_{i,-3}\Delta i_{t+3} + \beta_{i1}\Delta i_{t+1} + \beta_{i2}\Delta i_{t-2} + \beta_{i3}\Delta i_{t-3}$$

and the price equation is similarly represented as

$$p_t = \mu_2 + \gamma_{p^*} p_t^* + \gamma_e e_t + \beta_{p^*0}\Delta p_t^* + \beta_{p^*,-1}\Delta p_{t+1}^* + \beta_{p^*,-2}\Delta p_{t+2}^* + \beta_{p^*,-3}\Delta p_{t+3}^* + \beta_{p^*1}\Delta p_{t+1}^* + \beta_{p^*2}\Delta p_{t-2}^* + \beta_{p^*3}\Delta p_{t-3}^*$$
$$+\beta_{e0}\Delta e_t + \beta_{e,-1}\Delta e_{t+1} + \beta_{e,-2}\Delta e_{t+2} + \beta_{e,-3}\Delta e_{t+3} + \beta_{e1}\Delta e_{t+1} + \beta_{e2}\Delta e_{t-2} + \beta_{e3}\Delta e_{t-3}.$$

The estimated coefficients on the domestic output and the domestic interest rate in money demand are reported in table 7. The estimated coefficients on the foreign price level and the nominal exchange rate in money demand are reported in table 8. Using these coefficients obtained by DOLS estimate, we calculate the exchange market pressure index proposed by Weymark. The movements of calculated exchange market pressure for each countries are presented in figure 1 to figure 7 in appendix.

	Indonesia		Japan		Korea		Malaysia	
	γ_y	γ_i	γ_y	γ_i	γ_y	γ_i	γ_y	γ_i
SOLS estimate	0.432	0.286	0.285	-2.697	1.532	-0.814	1.495	1.240
DOLS estimate	0.441	0.344	0.188	-2.704	1.425	-1.747	1.548	2.193
	Philippines		Singapore		Thailand			
	γ_y	γ_i	γ_y	γ_i	γ_y	γ_i		
SOLS estimate	0.967	-0.027	1.098	-1.530	1.346	0.023		
DOLS estimate	0.982	0.203	1.142	-1.115	1.293	-0.414		

Table. 7 Estimated coefficients for the price equation by SOLS and DOLS

	Indonesia		Japan		Korea		Malaysia	
	γ_{p^*}	γ_e	γ_{p^*}	γ_e	γ_{p^*}	γ_e	γ_{p^*}	γ_e
SOLS estimate	3.150	0.608	0.132	-0.064	1.574	0.080	1.125	0.047
DOLS estimate	3.018	0.726	0.092	-0.068	1.536	0.076	1.098	0.054
	Philippines		Singapore		Thailand			
	γ_{p^*}	γ_e	γ_{p^*}	γ_e	γ_{p^*}	γ_e		
SOLS estimate	2.851	-0.042	0.547	-0.156	1.343	0.097		
DOLS estimate	2.773	-0.035	0.520	-0.148	1.282	0.111		

Table. 8 Estimated coefficients for money demand by SOLS and DOLS

4 Comparison of exchange market pressure indices

Kaminsky and Reinhart (1999) define a currency crisis when the index of exchange market pressure is three standard deviations above the mean. In this section, we identify a currency crisis using each market pressure index and compare the results. The change in nominal exchange rate and the change

	Indonesia	Japan	Korea	Malaysia	Philippines	Singapore	Thailand
σ_e	0.091	0.033	0.041	0.029	0.029	0.016	0.036
σ_r	0.044	0.029	0.042	0.053	0.102	0.020	0.034
σ_e/σ_r	2.065	1.136	0.974	0.540	0.287	0.802	1.051
Num. of Obs.	173	175	175	175	175	175	175

Table. 9 Standard deviation of the rate of change in the nominal exchange rate and reserves

in foreign exchange reserves are calculated in table 9. Using the ratio of sample volatility of the change in the nominal exchange rates and the foreign exchange reserves, we calculate the exchange market pressure specified by Kaminsky and Reinhart. The periods that classified as a currency crisis by each exchange marker pressure indices are reported in table 10. The periods in the column EMP^{GR}, EMP^{KR} and EMP^{W} are periods identified as a currency crisis by Girton and Roper's method, by Kaminsky and Reinhart's method, by Weymark's method respectively. We can confirm that enormous pressures of depreciation were put on Indonesia, Korea, Malaysia, Philippines and Thailand through 1997 to 1998 by all indices.

In the case of Indonesia, all indices identify January 1998 as a currency crisis period and indices specified by Kaminsky and Reinhart and Weymark identify May 1998 as a currency crisis period. Considering the fact that the Indonesia rupiah depreciate dramatically through December 1997 to January 1998 and the President Suharto announced his resignation in May 1998, it is quite reasonable

	EMP^{GR}		EMP^{KR}		EMP^{W}	
Indonesia	Mar-90	0.174	Dec-97	0.420	Jan-98	1.177
	Nov-97	0.211	Jan-98	0.617	Jun-98	0.480
	Jan-98	0.187	Jun-98	0.373		
Japan			Mar-90	0.159		
			Mar-91	0.167		
Korea	Nov-97	0.357	Nov-97	0.405	Nov-97	0.322
	Dec-97	0.193	Dec-97	0.551	Dec-97	0.375
Malaysia	Jan-98	0.181	Jul-97	0.152	Dec-97	0.105
	Mar-98	0.189	Jan-98	0.181	Jan-98	0.144
Philippines	Jul-97	0.157	Jan-90	0.172	May-90	0.667
	Dec-97	0.146	Dec-97	0.185	Jul-93	0.407
					Sep-97	0.328
Singapore	May-98	0.062	Dec-97	0.090	Feb-90	0.071
			May-98	0.107		
Thailand	Jul-97	0.127	Jul-97	0.285	Jul-97	0.217
	Aug-97	0.145	Aug-97	0.242	Aug-97	0.237
	Nov-97	0.115	Nov-97	0.202	Dec-97	0.166
	Dec-97	0.116	Jan-98	0.164	Jan-98	0.190
	Jan-98	0.111				

Table. 10 Periods classified as a crisis by each EMP measure

to identify January and May 1998 as crisis periods for Indonesia. The index specified by Kaminsky and Reinhart identifies March 1990 and March 1991 as crisis periods for Japan. However, it is not appropriate to regard these periods as crisis periods because the market intervention conducted by the monetary authority is sterilized and the change in the foreign exchange reserves does not influenced base money. In Japanese case, we can infer that exchange market pressure specified by Girton and Roper and Weymark are more appropriate measure than by Kaminsky and Reinhart. In Korean case, all indices correspondingly indicate that November and December 1997 are the currency crisis periods and in the case of Thailand, all indices similarly indicate that the periods from July 1997 to January 1998 are the currency crisis periods. These identifications of the crisis periods are acceptable because Korean won experienced severe depreciation in December 1997 and Thailand exhausted their foreign exchange reserves and abandon the de facto fixed exchange rate regime in July 1997. Therefore, we can infer that exchange market pressure specified by Weymark can identify a currency crisis period properly than indices specified by Girton and Roper and Kaminsky and Reinhart.

5 Consluding remarks

We have analyzed exchange market pressure for Asian countries along with the model proposed by Weymark using cointegrating estimation. The idea behind the measure of exchange market pressure is that the imbalance between the demand and supply of the domestic currency in the international foreign exchange market is removed by a change in the exchange rate or in the supply of money. Measuring exchange market pressure considering the effect that the increase in foreign exchange reserve influences the volume of domestic money stock is quite reasonable. We have conducted Johansen's trace tests of cointegration in the money demand and the price equation and found that there is cointegrating relationship in money demand in several Asian countries. However, the some of these relationships cannot consider to be stable because the coefficient on the interest rare is not consistent with conventional theory of money demand. We calculate the exchange market pressure using coefficients obtained in dynamic OLS estimation. By comparing calculated exchange market pressure index with other exchange market pressure indices defined by Girton and Roper and Kaminsky and Reinhart, we have showed that we can identify a currency crisis by Weymark's method more properly than by Girton and Roper's method and Kaminsky and Reinhart's method.

Appendix A Data description

The principal data source is International Financial Statistics CD-ROM (IFS). When data is missing from these sources, statistic from the homepage of central-bank is utilized. Price level and interest rate of United States are used as foreign price level and foreign interest rate. Domestic output is substituted by industrial production or manufacturing production. The change in money stock created by the change in foreign exchange reserves (r_t^W) is calculated as $M_t/M_{t-1} \cdot R_t/(R_t + D_t) - R_{t-1}/(R_{t-1} + D_{t-1})$ by substituting $\mu_t = M_t/(R_t + D_t)$. In words, the change in money stock created by the change in foreign exchange reserves is composed of the rate of monetary expansion and the proportion of reserve money to base money. Because of the insufficiency of the data, the proportion of reserve money to base money is substituted by the proportion of net foreign assets to total assets of monetary authority for Malaysia, Singapore and Thailand. Data used in individual country is described as follows.

1. Indonesia
   - m: M2 (IFS line 35L)
   - p: Consumer prices (IFS line 64)
   - y: obtained from Quarterly GDP (IFS line 99b) by spline data fitting
   - e: End-of-period market rate of national currency per U.S. dollar (IFS line ae)
   - i: Call money rate (IFS line 60B)
   - r: Total reserves minus gold (IFS line 1L)
   - $R/(R + D)$: Monetary authority's net foreign asset (IFS line11-IFS line16c) divided by sum of monetary authority's net foreign asset, net government claims (IFS line 12a-IFS line 16d) and claims on deposit money bank (IFS line 12e)
2. Japan
   - m: M2 (IFS line 35L)
   - p: Consumer prices (IFS line 64)
   - y: Industrial production (Seasonally adjusted) (IFS line 66C)
   - e: End-of-period market rate of national currency per U.S. dollar (IFS line ae)
   - i: Money market rate (IFS line 60B)
   - r: Total reserves minus gold (IFS line 1L)
   - $R/(R + D)$: Monetary authority's net foreign asset (IFS line11-IFS line16c) divided by Reserve money(IFS line 14)
3. Korea
   - m: M2 (IFS line 35L)
   - p: Consumer prices (IFS line 64)
   - y: Industrial production (Seasonally adjusted) (IFS line 66C)
   - e: End-of-period market rate of national currency per U.S. dollar (IFS line ae)

- i: Money market rate (IFS line 60B)
- r: Total reserves minus gold (IFS line 1L)
- $R/(R+D)$: Monetary authority's net foreign asset (IFS line11-IFS line16c) divided by sum of monetary authority's net foreign asset, net government claims (IFS line 12a-IFS line 16d) and claims on deposit money bank (IFS line 12e)

4. Malaysia
   - m: M2 (IFS line 35L)
   - p: Consumer prices (IFS line 64)
   - y: Industrial production (IFS line 66) (Seasonally adjusted by X-12a)
   - e: End-of-period market rate of national currency per U.S. dollar (IFS line ae)
   - i: Interbank overnight money rate (IFS line 60B)
   - r: Total reserves minus gold (IFS line 1L)
   - $R/(R+D)$: Monetary authority's net foreign asset (IFS line11-IFS line16c) minus capital account (IFS line 17a) divided by sum of monetary authority's net foreign asset, net government claims (IFS line 12a-IFS line 16d) and claims on deposit money bank(IFS line 12e), nonbank financial institutions (IFS line 12g), and private sector(IFS line 12b)
5. Philippines
   - m: M2 (IFS line 35L)
   - p: Consumer prices (IFS line 64)
   - y: Manufacturing production (IFS line 66) (Seasonally adjusted by X-12a)
   - e: End-of-period market rate of national currency per U.S. dollar (IFS line ae)
   - i: Money market rate (IFS line 60B)
   - r: Total reserves minus gold (IFS line 1L)
   - $R/(R+D)$: Monetary authority's net foreign asset (IFS line11-IFS line16c) minus capital account (IFS line 17a) divided by sum of monetary authority's net foreign asset, net government claims (IFS line 12a-IFS line 16d) and claims on deposit money bank(IFS line 12e), nonbank financial institutions (IFS line 12g), and private sector (IFS line 12b)
6. Singapore
   - m: M2 (IFS line 35L)
   - p: Consumer prices (IFS line 64)
   - y: Manufacturing production (IFS line 66) (Seasonally adjusted by X-12a)
   - e: End-of-period market rate of national currency per U.S. dollar (IFS line ae)
   - i: Interbank rate (IFS line 60B)
   - r: Total reserves minus gold (IFS line 1L)
   - $R/(R+D)$: Monetary authority's net foreign asset (IFS line11-IFS line16c) divided by total assets of the monetary authority (IFS line11+IFS line12)
7. Thailand

- m: M2 (IFS line 35L)
- p: Consumer prices (IFS line 64)
- y: Industrial production (Obtained from the homepage of the Bank of Thailand) (Seasonally adjusted by X-12a)
- e: End-of-period market rate of national currency per U.S. dollar (IFS line ae)
- i: Money market rate (IFS line 60B)
- r: Total reserves minus gold (IFS line 1L)
- $R/(R+D)$:Monetary authority's net foreign asset divided by total assets of the monetary authority (Obtained from the homepage of the Bank of Thailand)

8. United States
   - p: Consumer prices (IFS line 64)
   - i: federal funds rate (IFS line 60B)

Appendix B Movements of the exchange market pressure

EMP1, EMP2 and EMP3 denote exchange market pressure calculated by Girton and Roper's method, Kaminsky and Reinhart's method, and Weymark's method respectively.

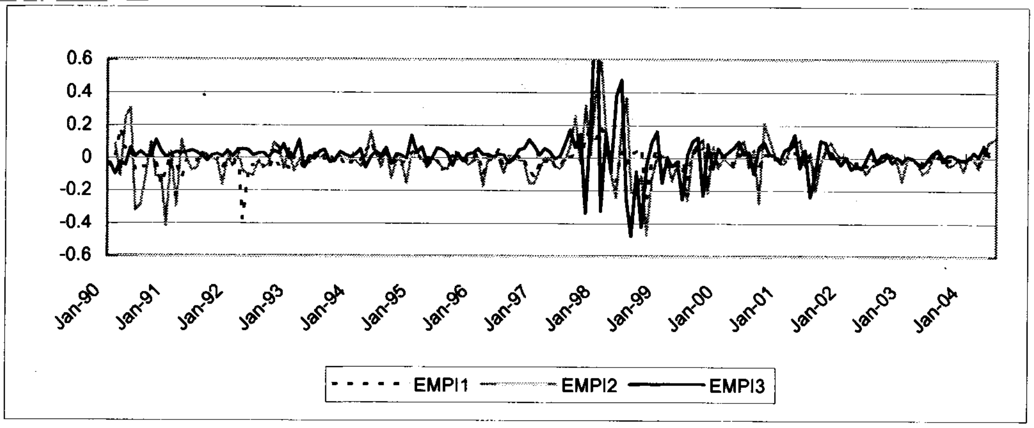

Fig. 1 Calculated exchange market pressure for Indonesia

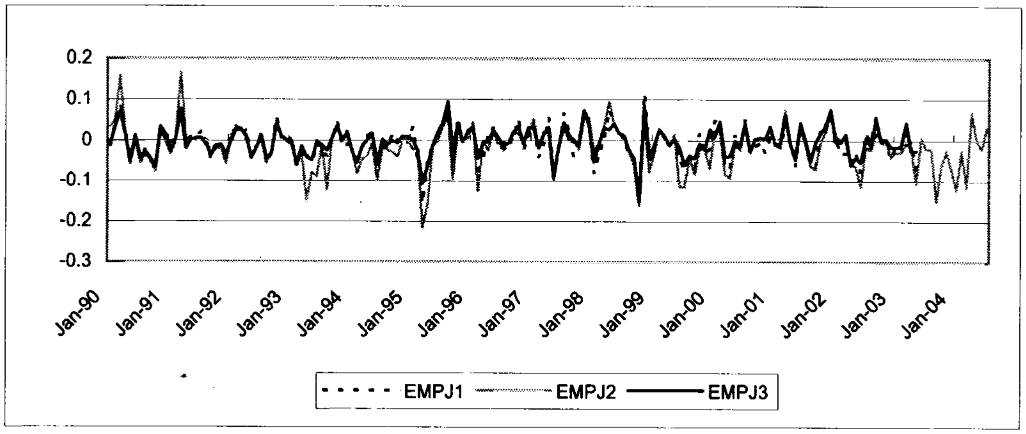

Fig. 2 Calculated exchange market pressure for Japan

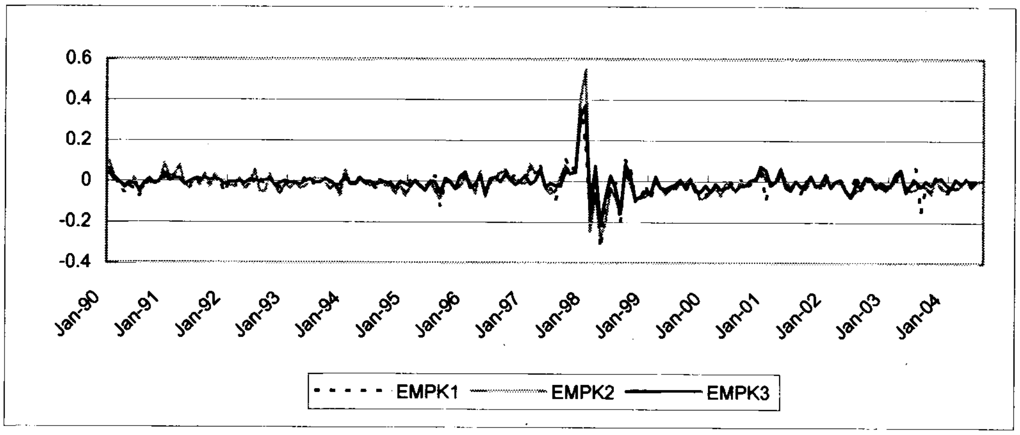

Fig. 3 Calculated exchange market pressure for Korea

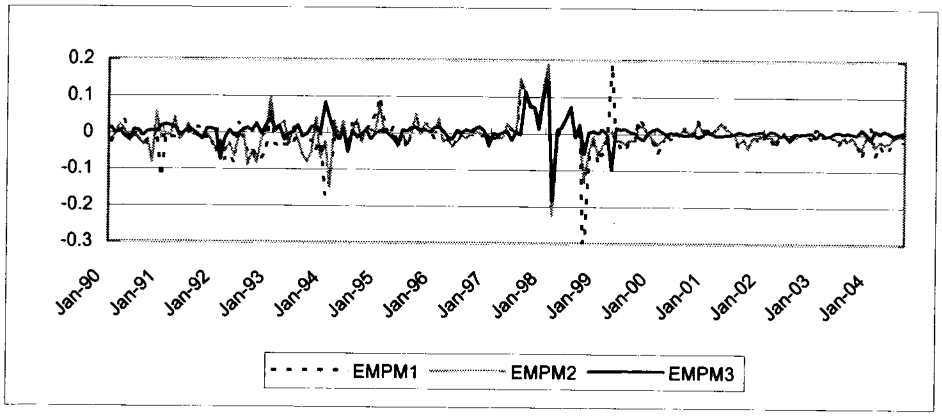

Fig. 4 Calculated exchange market pressure for Malaysia

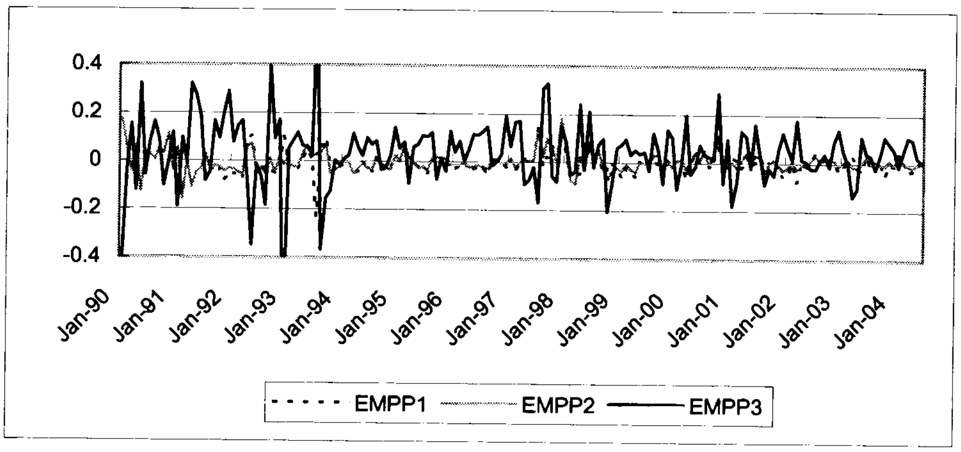

Fig. 5 Calculated exchange market pressure for Phillipines

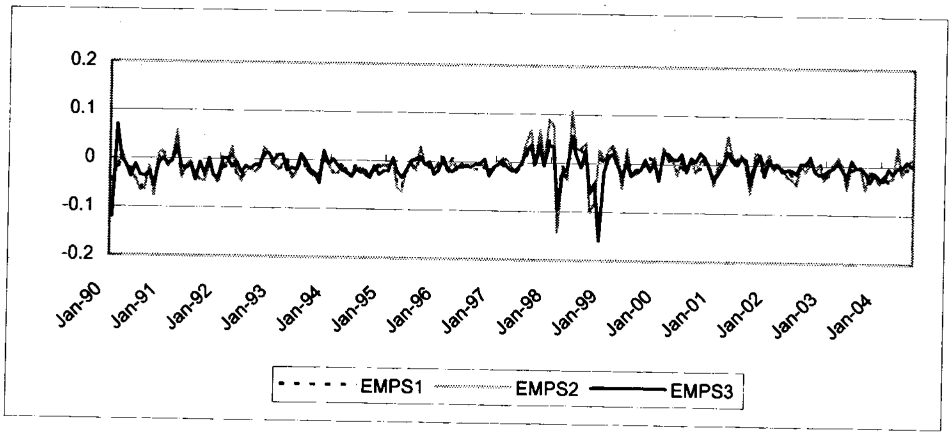

Fig. 6 Calculated exchange market pressure for Singapore

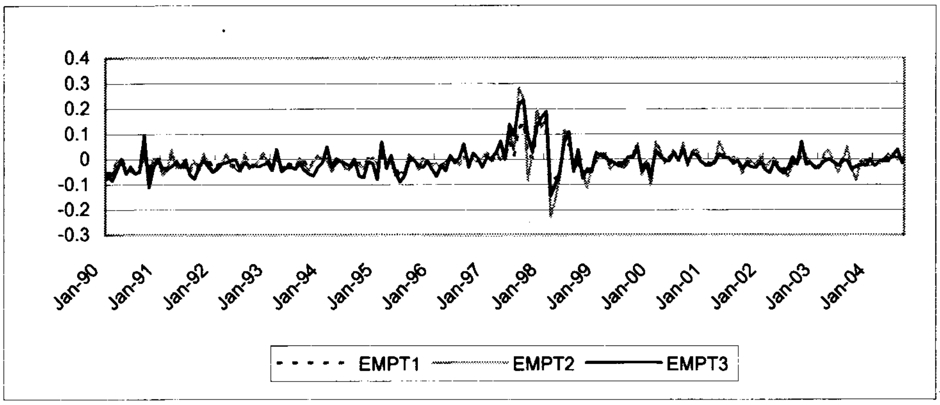

Fig. 7 Calculated exchange market pressure for Thailand

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