



EXCHANGE MARKET PRESSURE IN INDONESIA: A UNIVARIATE MARKOV SWITCHING ANALYSIS

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ABSTRACT

The aim of this paper is to analyze the nature of exchange market pressure in the case of the Indonesian economy. More specifically, this paper aims to answer whether there is non-linearity or multiple equilibria in the EMPI. The paper relies on a univariate Markov Switching autoregressive model. The model estimation also incorporates procedures such as unit root test, diagnostic test and log likelihood ratio test, focusing on the period from January 1990 to September 2008. This paper found that a 2-state Markov switching AR(6) model of EMPI outperforms a linear autoregressive model in explaining the behavior of EMPI. The findings also suggest that the significant regime dependent intercept confirms the existence of a multiple-equilibria condition in the EMPI. The degree of uncertainty of EMPI in a volatile state was found to be much higher than in the stable state and there was also an inertia characteristic. Due to the inertia characteristic in the EMPI, the monetary authority should take into account the role of economic agents' expectations in delivering monetary policy to stabilize the exchange rate following significant market pressure in the economy. This paper contributes by providing empirical evidence on the characteristics of EMPI in the context of the Indonesian economy.

Key Words: Exchange Market Pressure, Currency Crises, Regime Switching, Multiple Equilibria

JEL Classification: F30, F31, F33

INTRODUCTION

Over the last two decades, both developed and developing countries have experienced high volatility in their currency. Even in the 1990s, many countries in Europe, Latin America and Asia encountered a currency crisis. The occurrence of currency crises has motivated intense studies to identify crisis determinants and to develop an appropriate early warning system. Along with discussions on the determinants of crises and early warning systems specific to the context of

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currency crisis studies, some fundamental questions arise, such as whether there are differences in the behavior of macroeconomic variables during the time before the occurrence of speculative attacks compared to other periods, whether the behavior of the economic variables changes after speculative attacks, and if there is any difference in the level of uncertainty experienced by economic agents, before and during the speculative attacks.

Currency crises have been extensively analysed in the literature, with a variety of analytical tools proposed to identify crisis episodes. One of the measures which is most widely adopted to signal the breakup of a crisis is Exchange Market Pressure, EMPI (Bertoli, Gallo, and Ricchiuti, 2006). EMPI is usually related to changes in variables describing internal and external condition of an economy, which are reflected by nominal exchange rate, international reserve holdings and interest rate. These three variables represent the macroeconomic indicators that are mainly affected when the economy is in crisis.

Based on the above questions, this paper analyzes the behavior of EMPI in the context of the Indonesian economy. More specifically, this paper aims to answer whether there is non-linearity or multiple equilibria in the EMPI. A univariate model was employed to answer the question on EMPI behavior for two main reasons. First, the main use of univariate time series analysis is in forecasting and the assessment of structural breaks. Therefore, using a univariate model, this paper can identify properly the existence of multiple equilibria in EMPI due to structural breaks during the study period. Second, univariate time series analysis has proven accurate in predicting future observations. In accordance with the purpose of this paper, the observation of EMPI behavior will also cover the prediction aspect. By employing the univariate model, this paper will predict the value of EMPI based on two endogenous states and compare the value of prediction with the actual value from month to month. However, this paper does not aim to identify the determinants of EMPI which are discussed using the growing crisis model over three generations in a considerable amount of the literature.

This paper analyses the Indonesian economy. The preference for using the Indonesian economy as a case study is motivated by the experience of the crisis in the late 1990s. Despite Indonesia having sound macroeconomic management during 1990s, it suffered the worst effects of the financial crisis in Asia compared to neighboring countries such as Malaysia, Thailand, and the Philippines. At the time of the crisis, in late 1997, Indonesia experienced significant economic contraction. In 1998, real GDP contracted by 13.7%, and the economy reached its lowest point in mid-1999 and real GDP growth for the year was 0.3%. In the same period, inflation reached 77% in 1998, and slowed to 2% in 1999. In terms of exchange rates, the Rupiah, which had been in the range 2,600 Rupiah/USD at the start of August 1997 fell to 11,000 Rupiah/USD by January 1998.

The paper is organized into five different sections. Section 2 reviews the relevant literature on the meaning and concepts of exchange market pressure. The method and the development of the

models are discussed in Section 3 followed by the results in Section 4. Section 5 concludes the paper.

LITERATURE REVIEW

The term exchange market pressure (EMPI) was first used by Girton and Roper (1977). The index is measured as the sum of exchange rate change and change in international reserves, scaled by base money. In the context of a monetary approach to balance of payments, exchange rate and international reserves influence the equilibrium, both in the money market and the foreign exchange market. Girton and Roper (1977) show how excess demand on foreign currency can cause changes in the price of foreign exchange and alter the position of foreign reserves (Jayaraman and Choong, 2008).

Changes in the exchange rate can be regarded as adjustments reflecting monetary disequilibrium, and such conditions must be resolved by either an exchange rate adjustment, or an official intervention, or both simultaneously. When there is speculative pressure on a currency, in the case of a fixed exchange rate regime, the central bank must neutralize the exchange market pressure through foreign exchange intervention. However, in the case of a floating exchange rate regime, speculative pressure is reflected by exchange rate changes. In all, EMPI changes in the nominal exchange rate component show the central bank's passive adjustment to EMPI, while its purchase/sales of foreign assets are its active response (Braga de Macedo, Pereira, and Reis, 2007).

In the context of measurement, a number of researchers have tried to expand the concept of EMPI. For example, Roper and Turnovsky (1980) and Turnovsky (1985) use a small open economy model and the IS-LM framework with perfect capital mobility in developing EMPI measurements (Stavarek, 2007). Further development of the concept involves the use of generalized EMPI, where the EMPI component involves the element of weight, both for changes in nominal exchange rate and international reserves (Weymark, 1995, 1997a, 1997b, 1998). Specifically, Weymark (1995) estimates a parameter which represents the relative weight of exchange rate changes and intervention in the EMPI (Stavarek, 2007). Spolander (1999) includes the partial element sterilized foreign exchange interventions as part of the EMPI in a system of floating exchange rate. Girton and Roper (1977) and the above studies are well known as a model-dependent measure of exchange market pressure. However, Eichengreen, Rose and Wyplosz, (1994, 1995) criticize the aspect of the EMPI measure which depends on a particular model. This is undesirable, because as an operational index, the model-dependent measure has little explanatory power; therefore, they introduced a model-independent or *ad-hoc* EMPI measure. The EMPI is a weighted linear combination of exchange rate changes, foreign reserve changes, and interest rate changes. In contrast to Weymark's model, the weights are calculated from the sample variance of those three variables. A further contribution made by Eichengreen, Rose and Wyplosz (1995) is the inclusion of interest rate as a component element of EMPI. They argue that a high increase in interest rate is a form of

central bank response to speculative attacks, which demonstrates the pressure experienced by the domestic economy.

Following the work of Eichengreen, Rose and Wyplosz (1994), many studies of currency crises using ad-hoc EMPI on the analysis appeared (see for example, Ford, Santoso, and Horsewood, 2007; Kaminsky, Lizondo, and Reinhart, 1998; Kaminsky and Reinhart, 1999; Cerra and Saxena, 2002, Edison, 2003; Fratzscher, 2003; Kumah, 2007). The use of ad-hoc EMPI is considered more representative than using measures of currency depreciation alone, as the use of measures of currency depreciation only captures crisis and speculative attacks that are successful, i.e. those that lead the central bank to abandon the pegged exchange rate with the consequent depreciation of currency (Li, Rajan, and Willet, 2006), whereas the use of ad-hoc EMPI allows the analysis to cover both successful and unsuccessful speculative attacks.

Hence, in the framework of monetary policy, the EMPI measurement becomes very important, for two fundamental reasons. First, EMPI is relevant for the central bank in exchange rate management. The contagion effect in the Asian crises can be regarded as a good reference for the central bank regarding the importance of observing the EMPI of neighboring countries. The EMPI on neighboring countries might indicate how much pressure monetary authorities could expect on their own currency due to contagion (Tatomir, 2009). Second, EMPI can be used to measure the effectiveness of central bank policy in reducing pressure in the economy.

MODEL AND DATA

Ms-Ar Methodology

This study employs a Markov switching autoregressive model. The estimation involves two processes, the data generating process and the regime generating process. The Markov switching autoregressive model (MS-AR) was first developed by Hamilton (1989), who used a two-state mean switch model of order four to analyze the business cycle in America. His model can be summarized as follows:

Equation-1

$$y_t = \mu(s_t) + \left[\sum_{i=1}^4 \alpha_i (y_{t-i} - \mu(s_{t-i})) \right] + u_t$$

$$u_t | s_t \sim NID(0, \sigma^2) \text{ and } s_t = 1, 2$$

Based on Equation 1, changes between regimes occurred in the mean parameter, μ . Krolzig (1997) classifies the above equation as MSM (2)-AR (4). Once the data generating process has been specified in the form of an autoregressive model, an identification of the regime-

generating process is carried out to obtain the value of each parameter in different regimes. In the context of the regime-generating process, it is assumed that s_t as an unobserved state follows a first-order Markov process. This means that the current regime, s_t only depends on the previous regime, s_{t-1} . Hence, the transition of probability can be summarized as follows:

Equation-2

$$P\{s_t = j | s_{t-1} = i, s_{t-2} = k, \dots\} = P\{s_t = j | s_{t-1} = i\} = p_{ij}$$

$$\sum_{j=1}^M p_{ij} = 1 \quad \forall i, j \in \{1, \dots, M\}$$

where p_{ij} is the probability of being in regime j in period t , if regime i occurs in period $t-1$. Markovian transition matrix P can be arranged in a matrix as follows.

Equation-3

$$P^* = \begin{bmatrix} p_{11} & p_{12} & \dots & p_{1M} \\ p_{21} & p_{22} & \dots & p_{2M} \\ \vdots & \vdots & \ddots & \vdots \\ p_{M1} & p_{M2} & \dots & p_{MM} \end{bmatrix}$$

Univariate Model for Empi

This study employs a regime switching univariate model as presented in Equation 4.

Equation-4

$$EMP_t = \alpha_0(s_t) + \sum_{i=1}^p \alpha_i EMP_{t-i} + \varepsilon_t$$

$$\varepsilon_t \sim IID(0, \sigma^2(s_t))$$

Based on Krolzig (1997), Equation 4 can be classified as a Markov switching- Intercept autoregressive heteroscedastic specification (MS-IAH). The above model is used to confirm whether there is non-linearity in EMPI. The autoregressive model will capture whether there is an inertia factor in forming the expectation of economic agents toward the domestic economy condition. Moreover, the heteroscedastic specification for each state will give a reference of the degree of uncertainty in the economy at different states through the value of variances. This study defines two regimes, the stable regime and the volatile regime.

Empi Measures

EMPI was built using the three variables considered to be most affected when pressure on foreign exchange and the money markets increased. Following the work of Eichengreen, Rose, and Wyplosz (1995), EMPI has been developed as a proxy for the currency crisis. The occurrence of a currency crisis is shown by currency depreciation pressure that exceeds its long-term value, depletion of foreign reserves, and changes in domestic interest rate, in response to high pressure in the money and foreign exchange markets. When there is pressure, in terms of significant depreciation of domestic currency, the central bank's response is to use foreign reserves to intervene in foreign exchange markets and to increase the domestic interest rate.

In order to show pressure within the domestic economy, the EMPI was formulized as follows:

Equation-5

$$EMPI_t = \omega_1 \Delta e_{i,t} + \omega_2 \dot{i}_{i,t} - \omega_3 \Delta r_{i,t}$$

where $EMPI_t$ is the speculative pressure index; $e_{i,t}$ is the value of the Rupiah against the US Dollar (Rupiah/Dollar); $\dot{i}_{i,t}$ is the domestic interest rate (this study did not use interest rate changes for reasons argued by Klaassen and Jager, 2006); $r_{i,t}$ is the domestic stock of foreign reserves; ω_i is the weight given to each component of EMPI. Therefore, $EMPI_t$ is a weighted index which measures the depreciation of the Rupiah against the U.S Dollar, increase in domestic interest rates, and the depletion of foreign exchange reserve.

The weight refers to the inverse of the standard deviation of each series over the period 1990-2008. The standard deviation was calculated using the standard formula and not logarithmic form, since logarithmic difference is a poor approximation of rate of change and results in a lower variance in the distribution of the existing sample (Bertoli, Gallo, and Ricchiuti, 2006).

DATA

All data was collected from International Financial Statistics (IFS). The nominal exchange rate (Rupiah/US\$) was collected from the market rate period average (IFS Line AF). The domestic stock of foreign reserves was collected from total reserves minus gold (IFS Line 1L.D) and the interest rate used the call money rate. The analysis uses monthly observations, over the period January 1990 to September 2008.

The first econometric procedure was the stationary test, which tests whether all series were stationary in the levels, $I(0)$. This study employed the DF-GLS test proposed by Elliot, Rothenberg, and Stock (1996). Essentially, this is an augmented Dickey–Fuller test, but the time series is transformed via a generalized least squares (GLS) regression before performing the test. Elliott, Rothenberg, and Stock, and later studies, have shown that this test has significantly greater power than the previous versions of the augmented Dickey–Fuller test. DF-GLS performs the DF-

GLS test for the series of models that include l to k lags of the first differenced, detrended variable, where k can be set by the user or using the method described in Schwert (1989).

The augmented Dickey–Fuller test involves fitting a regression of the form:

Equation-6

$$\Delta y_t = \alpha + \beta y_{t-1} + \delta t + \zeta_1 \Delta y_{t-1} + \dots + \zeta_k \Delta y_{t-k} + u_t$$

and testing the null hypothesis, $H_0 = 0$. The DF-GLS test is performed analogously but on GLS-detrended data. The null hypothesis of the test is that y_t is a random walk, possibly with drift.

RESULTS

Stationary Test

The results of the stationary test on the EMPI showed that the adjusted t-statistic value was -2.588142, which is greater than the 5% critical value, -1.942282, therefore the series is stationary or $I(0)$. Hence, the use of the stationary autoregressive model is justified for the series of EMPI.

Diagnostic Test

Diagnostic tests were first conducted to assess the error properties of the estimated model. A test was also conducted to evaluate regime switching against a linear model. Table 1 shows the results of diagnostic tests for a univariate regime switching model. Based on the results of model simulation, this study used MSIH (2) – AR (6) model specification. The first step in the process of model testing is to ensure the white noise residuals, which are normally distributed, have zero mean, constant variance, and are serially uncorrelated.

In the context of normal distribution, the residual was tested using the normality test developed by Doornik and Hansen (1994), derived from Shenton and Bowman (1977). The test showed that the null hypothesis could not be rejected (normal distribution), which means the residual derived from the MSIH (2) – AR (6) estimation has a normal distribution.

The next diagnostic test was the heteroscedasticity test to the MSIH (2) – AR (6) specification. Using an ARCH test, the results showed that the test did not reject the null hypothesis, which was the homoscedastic residual. The regime-switching model was sufficient to capture the ARCH process, as was evidenced by the ARCH test and the Ljung-Box Q-test for serial correlation in the standardized residuals. Hence, it can be said that there is no evidence of heteroscedasticity in the residuals.

The next procedure was a portmanteau test, which identified whether there was serial correlation between the residuals. This test is similar to the Box-Pierce test, but with a degree of freedom

correction as suggested by Ljung and Box (1978). It is designed as a goodness-of-fit test in stationary, autoregressive moving-average models. The portmanteau test showed that it could not reject the null hypothesis, which means that there was no autocorrelation based on a 36-lag test.

Table-1. Diagnostic test : MSIH (2) – AR (6) specification

	MSIH(2)-AR(6)
No. of observations	219
No. of parameters	12
AIC criterion	74,04
Log-likelihood	49,02
Linearity LR-test [$\text{Chi}^2(4)$]	286,53 [0,00]
Normality test [$\text{Chi}^2(2)$]	4.8741 [0.0874]
ARCH 1-7 test: F(7,193)	1.3050 [0.2498]
Portmanteau(36): $\text{Chi}^2(36)$	37.691 [0.3918]

Regime Characterization

Based on the results of the normality, heteroscedasticity, and serial correlation tests, it can be stated that the estimates can be analyzed based on MSIH (2) – AR (6) specification. One of the most important implications of this specification is the robustness of the regime-switching model. A likelihood ratio (LR) test can be employed to determine which model specification is better. In this study, the LR test was conducted to compare the linear model against the regime-switching model. The null hypothesis of the test was that the appropriate model was the linear specification, while the alternative hypothesis was that the regime-switching model was more representative in explaining the behavior of EMPI. The chi-square value obtained from the test was 286.53 with p value close to zero, which means that the null hypothesis was rejected and it was concluded that the regime-switching specification fitted the data better than the linear autoregressive counterpart. In addition, the AIC statistic also supports the conclusion of the LR test. The AIC statistic, from the MSIH (2) – AR (6) specification was lower than that in the linear AR (6) specification, which indicates a statistical preference for nonlinear models over their linear autoregressive counterparts.

By using the estimates of the MSIH (2) – AR (6) results, the period in the Indonesia economy between 1990 and 2008 can be divided into two regimes, stable and volatile, as indicated in Figure 1 by the dark bar and the unshaded regions. It can be observed that the volatile state has a limited occurrence; as indicated by the dark bars, these periods are concentrated in the middle parts of the sample period, in late 1997, the whole of 1998 and early 1999. These periods coincide with the Asian financial crisis. High pressure periods also happened in early 1990, mid 2001, early 2002, and late 2004. Periods of stable state (indicated by the unshaded regions) dominate the picture, which means that stable states tend to have longer duration than volatile states. Furthermore, the estimation result of endogenous regime by employing a Markov switching AR model shows that the model was able to predict accurately the volatile and stable periods, especially during the late 1990s financial crisis periods.

Figure-1. Regime classification based on smooth probabilities method

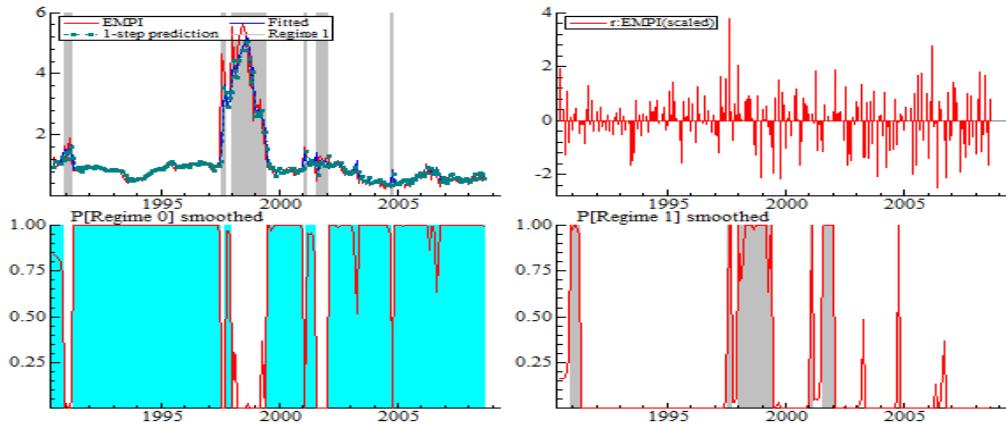


Table 2 presents the empirical results for Markov regime-switching EMPI. When the economy is modeled as having two unobserved regimes or states, stable and volatile, different behavior emerges in each regime. First, this can be considered from the intercept estimates. As the EMPI is modeled with intercept switching, change in EMPI behavior in different regimes can be observed through the intercepts in both stable and volatile states. The estimated regime-dependent intercepts yielded interesting and mostly statistically significant results. The estimates show that the regime dependent intercept is higher in the volatile state (1.37) compared to that of the stable state (0.822), which means that the pressure in the economy as represented by changes in nominal exchange rate, foreign reserves, and interest rate increased in the volatile state.

Table-2. Regression results: MSIH (2) – AR (6) specification

	Coefficient	t-value	t-prob
<i>regime-dependent intercepts</i>			
C(0)	0.822357	5.29	0.000
C(1)	1.36508	8.00	0.000
<i>Autoregressive coefficients</i>			
AR-1	0.667045	4.24	0.000
AR-2	0.130269	1.21	0.227
AR-3	0.0996687	2.10	0.037
AR-4	0.123215	2.74	0.007
AR-5	0.0671650	0.897	0.371
AR-6	-0.159647	-2.12	0.035
$\Sigma(0)$	0.116124	15.0	0.000
$\Sigma(1)$	0.806733	7.55	0.000
$p_{\{0 0\}}$	0.958752	38.7	0.000
$p_{\{0 1\}}$	0.222043	1.43	0.155
<i>Fitting</i>		<i>MSIH(2)-AR(6)</i>	<i>Linear AR(6)</i>
AIC		-0.338070787	0.951824335
Linearity LR-test [$\text{Chi}^2(4)$]			286,53 [0,00]*
p_{ij}	<i>Regime 0,t</i>		<i>Regime 1,t</i>
<i>Regime 0,t+1</i>	0.95875		0.22204
<i>Regime 1,t+1</i>	0.041248		0.77796

The second condition that represents the change of behavior of EMPI is related to the variance of EMPI in both states. Considering the behavior of variance, the coefficients of variance in both volatile and stable states, in general, are significant (referring to both value of $\Sigma(0)$ and $\Sigma(1)$). However, the value of variance coefficient is much higher in the volatile state (0.807) than in the stable state (0.116), which implies that the degree of uncertainty in the volatile state is much higher than that of in the stable state.

Further, autoregressive coefficient estimates indicate that the current value of EMPI was strongly influenced by the EMPI lag. A positive coefficient on the autoregressive term demonstrates that the autoregressive model specification was an appropriate decision for examining the behavior of EMPI. Furthermore, it can be seen that the estimates of coefficient of the EMPI lag are not only positive, but also smaller with more distant lag used in the model. This suggests the existence of inertia, where EMPI in the previous period influenced the expectations of private agents toward EMPI at the current time.

Regime Shift

Estimated transition probabilities are presented in the matrix P below:

Equation-7

$$P = \begin{bmatrix} 0.959 & 0.222 \\ 0.041 & 0.778 \end{bmatrix}$$

The matrix shows that the estimated transition probabilities indicate that none of the regimes are permanent, since all the estimated transition probabilities are below one, except for the early period of the Asian crisis in August-September 1997 and February 2001. For example, there is a 96% probability of staying in the stable state, which is higher than the probability of staying in the volatile state (78%). This means that the stable state is more persistent than the volatile state. Further, the transition probability from stable state towards the volatile state is 4%, which is much smaller than that of volatile towards stable (78%).

Moreover, the estimated ergodic probabilities indicate that Indonesia experienced periods of stability 85% of the time, with an average duration of 26.57 months. The ergodic probability of the volatile state shows that Indonesia experienced volatile periods 15% of the time, with an average duration of 5.50 months. Thus, there were only a few episodes of high exchange market pressure in the Indonesian economy during 1990–2008. In addition, from the regime property of EMPI below, the MSIH (2) - AR (6) model can accurately detect the currency crises in the middle of 1997 (August-September). This is not only indicated by high market pressure but also demonstrated by the high average of probability. Therefore, the inferred probabilities for a volatile state have high informative content regarding the Asian currency crises of 1997.

Table-3. Regime property of EMPI, 1990-2008

	Months	Average of Probability
Regime 0: Stable state		
1990(7) - 1990(11)	5	0.801
1991(5) - 1997(7)	75	0.999
1997(10) - 1997(12)	3	0.958
1999(7) - 2001(1)	19	0.997
2001(3) - 2001(7)	5	0.917
2002(2) - 2004(9)	32	0.980
2004(11) - 2008(9)	47	0.987
<i>Total 186 months (84.93%) with average duration of 26.57 months</i>		
Regime 1: Volatile state		
1990(12) - 1991(4)	5	0.983
1997(8) - 1997(9)	2	1.000
1998(1) - 1999(6)	18	0.939
2001(2) - 2001(2)	1	1.000
2001(8) - 2002(1)	6	0.999
2004(10) - 2004(10)	1	0.999
<i>Total: 33 months (15.07%) with average duration of 5.50 months</i>		

In all, in terms of crisis theories, the behavior of exchange market pressure in Indonesia confirms the characteristic of multiple equilibria as predicted in the second generation of crisis model. It implies that private agents' self-fulfilling expectations could trigger the emergence of crisis, even when the fundamentals (such as unemployment, monetary policy) were sound (Chui, 2002). Some previous studies confirm that fundamental factors such as MI (AbuDalu and Ahmed, 2011; Khattak, Tariq, and Khan, 2012; Ford, Santoso, and Horsewood, 2007), real exchange rate (Ford, Santoso, and Horsewood, 2007), and banking sector vulnerability influence the exchange market pressure. One of the implications of the self-fulfilling multiple equilibria crisis is that it is extremely difficult to predict accurately an impending crisis because of the absence of a tight relationship between fundamentals and crises (Chui, 2002).

Further, the existence of inertia and the ability of the MSIH (2) – AR model to accurately detect currency crises in Indonesia imply that giving attention to the behavior of the EMPI would be beneficial in the identification of crisis periods. Moreover, the above result shows that a simple regime switching autoregressive model can be used as a starting model in developing an effective model to analyze the crisis and its determinants.

CONCLUSION

This paper aimed to analyze the nature of exchange market pressure in the case of the Indonesian economy. The results from the paper confirm the robustness of the regime-switching model of exchange market pressure compared to the linear autoregressive model. This finding underscores the advantages of the regime-switching model in understanding the behavior of exchange market pressure.

The univariate regime switching intercept autoregressive heteroscedastic model estimates have been able to identify significant regime dependent intercept and differences in the variance in both states. Thus, the significant regime dependent intercept confirms the multiple equilibria condition in the economy. Hence, this finding confirms the second generation of crisis models that postulate the existence of multiple equilibria in economies that experience a currency crisis.

The findings also suggest that EMPI are also characterized by higher variance in volatile states compared to that in stable states, as well as the existence of inertia or sluggishness in the exchange market pressure. From a policy perspective, EMP is very relevant for the central bank in exchange rate management. Hence, due to the inertia characteristic in EMPI, the monetary authority should take into account the role of economic agents' expectation in delivering monetary policy to stabilize the exchange rate following significant market pressure in the economy.

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