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Dornbusch Sticky Price Model Test in Explaining the Exchange Rate Fluctuation of Rupiah to American Dollar

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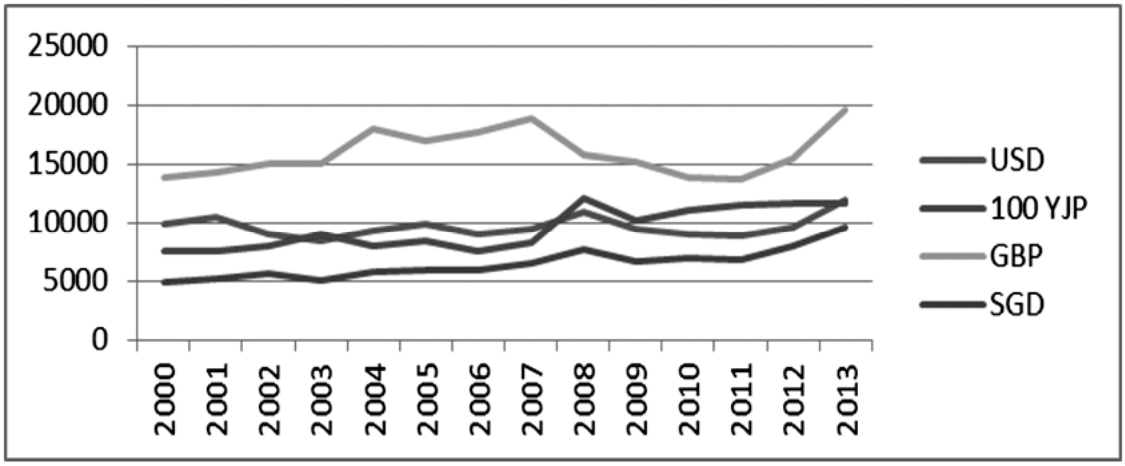
Abstract: The stability of Rupiah exchange rate would influence the stability of Indonesian macro economy. Thus, it is important to manage Rupiah exchange rate stabilitazion. This research aimed to test Dornbusch Sticky Price model in explaining Rupiah exchange rate behaviour. In this research, error correction models (ECM) was used as analysis method to find out the long term and short term connections. The results showed that the value of error correction term (ECT) was significantly positive. From this result, it could be concluded that Rupiah exchange rate moved farther from equilibrium. Even the facts showed the wider gap between daily rate and average volatility of Rupiah exchange rate. In policy maker level, Bank Indonesia, indicated that the policy and strategy of managing Rupiah exchange rate would cause distortion which always lead the exchange rate to disequilibrium position.

Keywords: Rupiah Stability, Dornbusch Sticky Price, Disequilibrium Position, Bank Indonesia, Distortion

JEL code: F310

INTRODUCTION

Asia experienced economic crisis as one of economy events in mid 1997. The economic crisis particularly concerned the exchange rates of countries in Asia that affected the foreign exchange market. It resulted in a very sharp depreciation against the US dollar experienced by the exchange rate of some currencies in Asia. The results of empirical studies conducted by Endy Dwi Tjahyono (1998) regarding the factors that affect the depreciation, showed that economic fundamentals and contagion effect had significant contribution. The model used in the study was Probit Model conducted in eight countries; Malaysia, Indonesia, Philippines, Thailand, Korea, Singapore, Taiwan and Japan. The results show that economic fundamentals and contagion effect are the significant factors encouraging the emergence of currency crisis in a country, through the transmission of speculation.



Graph 1: The Movement of IDR Exchange Rate to USD, YEN, GBP, SGD

The movement of Rupiah against the four currencies, such as the US Dollar, Pound, Yen and Singapore Dollar, can be seen in Graph 1.

The graph 1 showed that there was the same movement in Rupiah against the three currencies in Indonesia's main trading partners, such as the Japanese Yen, the UK's Poundstrerling and Singaporean dollar. It could be concluded that Rupiah exchange rate against the four currencies. It had the same behavior according to the graphic trend.

The impact of the exchange rate crisis was awful for the economy of Indonesia as a consequence of its open economy system. In mid-1997, Rupiah exchange rate against the US dollar was depreciated by 85.46%. Consequently, Indonesian economy was depressed, and this could be seen from a couple of economic indicators. Inflation increased from 6.47% in 1996 to 11.05% in 1997 and increased sharply in 1998 to 77.63%. Economic growth declined from 8.0% in 1996 to 4.7% in 1997 and then became - 13.68% in 1998.

Indonesia Government through the Bank of Indonesia actually has sought to overcome the crisis by conducting monetary policy by intervening dollars in the foreign exchange market in order to keep the exchange rate at the level of band intervention. This was done as a consequence of the use of the exchange rate system of managed exchange rate. The Bank of Indonesia also conducts the policy of expanding the intervention band from 8% to 12% with the purpose to anticipate if Rupiah might move "broader". Thus, the intervention by the Bank of Indonesia was reduced. However, the measures taken previously did not bring satisfactory results. The exchange rate crisis was followed by foreign investor confidence crisis in the Indonesian economy, matured foreign debt crisis, and political instability crisis. As a result, Rupiah was highly fluctuative and still within the range of very low (undervalue) rates . Finally, on August 14, 1997, the Bank of Indonesia removed the intervention band, which meant the system of exchange rate determination became free floating rate. In fact, the policy actually worsened Rupiah fluctuation exchange rate and it was increasingly undervalued.

The shift of the exchange rate system in Indonesia, from managed exchange rate system to free exchange system caused Rupiah position against foreign currencies determined by market mechanisms. Roger D Huang (1981) argues: "... in a floating rate system, the exchange rate is determined directly by market forces, and is liable to fluctuate continually, as dictated by changing market condition". In the

context of the above definition, the exchange rate of Rupiah was freely determined by the strength of the interaction between the demand and supply of foreign exchanges. In addition, in the free exchange rate system, it was assumed that there was no obligation of the Bank of Indonesia to intervene systematically in foreign exchange market. As the result, Rupiah was free to move in response to market forces.

With the free market forces in determining the exchange rate of Rupiah, market behavior was found to be more difficult to be predicted directly. The exchange rates in money market did not only reflect the strength of demand and supply of foreign exchanges to meet underlying transaction. It was also affected by other factors that influenced the expectations of economic agents which were closely related to the element of uncertainty.

The volatility in the form of the weakening of Rupiah's exchange rate up to the figure of 11,850 per 1 US Dollar occurred again in 2008. The turmoil was triggered by the crisis in the United States. The crisis was caused by huge losses in housing market (subprime mortgages) which impacted in the US financial sector. It also had severe consequences for the US economy which slowed economic growth and the purchasing power fell. The US economy worsening influenced Indonesian economy. Indonesia's exports decrease resulted in the deficit of US $ 2.2 billion in the balance of payments, and the indicator of economic growth dropped to 6.1% in 2008 compared to 6.3% in 2007.

The previous description on the exchange rate crisis and the deteriorating Indonesian economy provided the conclusion on the importance of maintaining exchange rate stability to create stability in macro economy. Therefore, a Rupiah exchange rate approach model was required to explain Rupiah behaviour, in order to determine appropriate Rupiah management policy.

According to Rudiger Dornbusch (1980), there are three basic reviews in exchange rate; exchange rate is the relative price of money (monetary approach), the relative price of goods (purchasing power parity approach) and the relative price of bonds (asset markets). Dornbusch modeled the behavior of exchange rate in the short term, known as Dornbusch Sticky Price Model. The assumption of this model is that the variable of price is sticky (difficult to change) in the short term. This is due to a slower good market adjusting to monetary shock rather than money market. Such assumption leads to price rigidities in the short term. In other words, PPP does not apply. In contrary, the Dornbusch model recognizes the applicability of PPP in the long term.

The existence of price rigidity causes overshooting to exchange rate, which is a greater appreciation or depreciation change to exchange rate compared to the level of change required to achieve balance. Therefore, Dornbusch sticky price model is often referred to as the overshooting model.

Dornbusch Model also explains that the depreciation of domestic exchange rate is not only influenced by monetary shock, but also by the liquidity-induced which lowers domestic interest rates. It would lead to capital outflow which subsequently leads to the depreciation of domestic currency. Thus, this model also assumes the application of interest rate parity.

EMPIRICAL GAP OF DORNBUSCH MODELS

Pippenger (2009) found the evidence of overshooting in the literature inspired by the research of Eichenbaum and Evans (1995), as conducted by Scholl and Uhlig (2008), which is "disabled". Eichenbaum

and Evans (1995) claimed that they did not find 'delayed overshooting', as many interpreted broadly. Instead, they show that response function changed gradually to monetary shocks or 'undershooting'. The problem with the impulse response functions was that they described the impulse response for the 'innovation' in the variable instead of the variable itself. The research results indicate that in the absence of intervention, the exchange rate is basically martingales (consistent with FX of market efficiency). It does not seem appropriate to interpret the impulse response function in the literature as a clear evidence of overshooting.

Voss and Willard (2009) examined two types of currency, USD and AUD, by testing the behavior of the AUD to monetary policy. The research found that Australia's new monetary policy increased the expected exchange rate response in Dornbusch model. The exchange rate changed immediately and slowly returned to equilibrium levels. Voss and Willard also found no significant derivation of uncover interest parity (UIP) during the adjustment. Similarly, the US's interest rate changes were not significant to the exchange rate, but they were significant to the derivation of UIP. It was caused by the Australian interest rate that moved in line with the US interest rates. It was also possibly happen because Australia is a small economy country that use an open economy system. In the other hand, the US is a big economy state that use an open economy system.

Heinlein and Krolzig (2012) examined delayed overshooting puzzle for the US Dollar and Pounsterling within the period of 1972 – 2009. The results showed that there was a strong delayed overshooting in Dornbusch model of sticky price and the violation in uncover interest parity. Scholl and Uhli (2008) also investigated delayed overshooting puzzle with the case of the currencies of G7 States out of the United States. The results obtained concluded that the monetary constraction had the currency appreciation for 3 years so that there is a strong evidence of delayed overshooting.

Bjornland (2009) criticized the research results obtained by Scholl and Uhlig (2008). Bjornland argued that Scholl and Uhlig ignored the strong interaction between monetary policy and exchange rate movement. In addition, by using zero retriction in his research, Bjornland found that, after using neutrality restriction in real exchange rate (long run PPP), delayed puzzle will be absent. The study was conducted in four countries, such as Australia, Canada, New Zeland and Sweeden in the period of 1983 – 2004.

Meese and Rogoff (1988) found that the hypothesis in "real shock" in technology as in the theory of real business cycle is consistent in explianing the volatility of exchange rate rather than monetary shock in Dornbusch model.

THE THEORY OF *DORNBUSCH MODEL*

The monetary model of flexible price is an applicable model for long-term period by holding the assumption of PPP. This model will provide invalid conclusions when it is used to analyze the exchange rate for the short and medium term as evidenced by several empirical studies.

In order to be able to analyze short-term exchange rate movements, Dornbusch (1976) established a model known as the model of sticky price monetary (the overshooting model). Dornbusch model is based on the assumption that prices are sticky in the short term, for goods market adjusts more slowly than money market in response to monetary shocks. Slow adjustment in goods market indicates the invalidity of PPP (in the short term). In other words, there is price stickiness (price rigidities) in the short term, but

Dornbusch acknowledged that PPP applies in the long term. When price is assumed to be sticky in the short term, an increase in the nominal money supply leads to an increase in real money supply, and have an impact on the liquidity effect that interest rate initially decline due to the response of the increase in real money supply. In Dornbusch model, the depreciation of domestic exchange rate is not only influenced by monetary shock, but also by the liquidity-induced which lowers domestic interest rates. It would lead to capital outflow and subsequently leads to the depreciation of domestic currency. The exchange rate will overshoot in the short term on the condition of PPP in the long term.

In addition, the rigidity of prices in the short term also carries implications for the exchange rate that experiences overshooting; the exchange rate change (appreciation or depreciation) is greater than the rate of change needed to reach long-term equilibrium so that the adjustment to the new long term is in the direction different from what happened at the beginning. An increase in money supply, for example, directly causes large depreciation in the initial period and then followed by the appreciation of exchange rate throughout the adjustment towards long-term equilibrium.

This model still uses the assumptions in effect on the monetary model of flexible price. The price flexibility does not take place perfectly if the assumption of goods price flexibility is perfect, and substitution between domestic and foreign goods do not substitute perfectly. Prices of goods can adjust to a new equilibrium with a certain lag. In other words, there are adjustment costs arising as a result of defective information received.

The basic nature of sticky price monetary model of Dornbusch can be illustrated in the following ways: Dornbusch argued that assumption of PPP is held only in the long term, named the long-term equilibrium exchange rate. It will be determined by domestic and foreign relative price level in the long term. Meanwhile, the assumption of monetary approach from the representation of one bond in financial markets is maintained. Therefore, the changes in nominal money supply occur because price is stiff and have real effect, especially in exchange rate.

The approach in Dornbusch model is often called Keynesian approach because it uses some assumptions bellow (Tucker, et. al., 1989: 62):

1. Each money supply is endogenous and positively associated with market interest rates.
2. Purchasing power parity is only valid in the long term.
3. Uncover interest rate parity applies in the short term

THE DERIVATION OF DORNBUSCH MODEL

Richard Baille and Patrick McMahon (1994) explain that Dornbusch model can be used to prove an explanation of dynamic adjustment process that occurs in the exchange rate towards a new equilibrium. The idea of this model is built on the concept of sticky prices. As in monetary models, there is an assumption that the structural parameters of domestic and foreign are considered equal and are perfect substitutes

$$(m_t - m_t^*) - (p_t - p_t^*) = (k_t - k_t^*) + \varphi\,(y_t - y_t^*) - \lambda\,(r_t - r_t^*) + \varepsilon_{1t} \quad (1)$$

$$(d_t - d_t^*) = \gamma\,(p_t - p_t^*) - \sigma\,(r_t - r_t^*) - \acute{o}\,(s_t - p_t - p_t^*) \quad (2)$$

$$(p_t - p_t^*) - (p_{t-1} - p_{t-1}^*) = \delta\,(d_t - d_t^*) - \lambda\,(y_t - y_t^*) + \varepsilon_{2t} \quad (3)$$

$$(r_t - r_t^*) = E_t s_{t+1} - s_t + \varepsilon_{3t} \quad (4)$$

Where:

s : spot exchange rate

y : real income

p : price level

m : money supply

r : nominal interest rate

d : domestic demand for good

Note: all in log natural

mark * shows foreign variable.

Equation (1) reflects the balance of standards demand in the form of relative, and equation (2) is a relative request to the goods which depends on relative real income, the difference in interest rates and terms of trade. Equation (3) implies a price adjustment to be proportional to excess demand, and equation (4) is an uncover interest parity condition with white noise disturbance.

To complete the model with the equation specifications:

$$s_t = (p_t - p^*_t) \quad (5)$$

and

$$E_t s_{t+1} - s_t = \alpha (s_t - s_t) \quad (6)$$

Where s_t, p and p * are the equilibtrium of long-term exchange rate and price, so equation (5) indicates PPP in the long term. Equation (6) reflects the expectations of exchange rate in the long term.

From equation (1), (2) and (3), it is obtained:

$$(p_t - p^*_t) = {}_0 + {}_1 (p_t - p^*_t) + {}_2 s_t + {}_t) \quad (7)$$

where

$$\beta_1 = [1 + \partial (\omega + \sigma / \lambda)^{-1}$$
$$\beta_2 = \beta_1 \partial \omega$$
$$\tau = \beta_3 (y_t - y^*_t) + \beta_4 (m_t - m^*_t) + u_t \quad (8)$$

and

$$\beta_3 = \beta_1 \partial (\gamma - 1 - \sigma \phi / \lambda)$$
$$\beta_4 = \beta_1 \partial \sigma / \lambda$$
$$\beta_0 = -\beta_1 \partial \sigma (k - k^*) / \lambda$$
$$u_t = \beta_1 \varepsilon_{2t} - (\beta_1 \partial \sigma / \lambda) / \varepsilon_{1t}$$

The interesting thing about this model is that it gives attention to the long-term equilibrium exchange rate. From equation (1) and (4), the price difference can be written:

From equation (3.6) and (3.9), the variable rates can be derived to:

$$(p_t - p^*_{t)} = - (k - k^*) + (y_t - y^*_t) - (m_t - m^*_t)$$

where

$$u_t = {}_{1t} + {}_{3t}$$

For long-term equilibrium, the change in exchange rate expectation is equal to 0 (zero), so that $(E_t\, s_{t+1} - s_t) = 0$, and from equation (5) and (9), it is obtained:

$$s_t = - (k - k^*) + (y_t - y^*_t) - (m_t - m^*_t) + (E_t\, s_{t+1} - s_t) + u_t$$

By eliminating $E_t\, s_{t+1}$ in equation (4) and (6), then the expected depreciation of exchange rate can be formulated:

$$(r_t - r^*_{t)} = [- (k - k^*) + (y_t - y^*_t) - (m_t - m^*_t) + s_t)] \quad (9)$$

But from equation (1), the difference in interest rates can also be written:

$$(r_t - r^*_t) = 1/ [(k - k^*) + (y_t - y^*_t) - (m_t - m^*_t) + (p_t - p^*_t)] \quad (10)$$

From equation (9), (10) and the elimination $(p_t - p^*_t)$ from equation (7) and (8), so the Dornbusch's Sticky Price is obtained and formulated as follows:

$$s_t = {}_0 + {}_1 (m_t - m^*_{t)} + {}_2 (y_t - y^*_t) - {}_3 (p_{t-1} - p^*_{t-1}) \quad (11)$$

THE TESTING RESULTS OF *DORNBUSCH* MODEL

The Testing of Unit Roots

This test is one analysis form of data behavior used to determine the stationary of data. Therefore the presence of long-term relationship between dependent variable and independent variable are visible. The testing results of unit roots to the variables used in this analysis can be summarized as follows:

Table 1
Unit Root Test of *Dickey Fuller*

Variable	*ADF Value*	*Sig.*	*MacKinnon Critical Value*		
KSPOT	-7.191798	*			
PRICE_AS	-3.916543	**			
PRICE_INDO	-8.100638	*	1%	level	-3.56001
JUB_INDO	-6.127512	*	5%	level	-2.91765
JUB_AS	-7.100069	*	10%	level	-2.59668
GDP_INDO	-5.872468	*			
GDP_AS	-4.121012	*			

From the analysis output, it can be concluded that the variable stationary estimation has different stationary degree. The variable of GDP_AS is stationary on the degree of 0 (zero), whereas the other variables, namely: SKBUNGA_INDO, SK_BUNGA_AS, KSPOT, KFORWARD, PRICE_INDO, PRICE _AS, JUB_INDO, JUB_AS and GDP_INDO are stationary in the first degree. The determination of

significance level is by comparing the value of ADF Test Statistic using MacKinnon Critical Value. The variable is stationary when the value of the ADF test is greater than the Critical Value.

Cointegration Test

This test was conducted to determine the stationary nature of the equations to be estimated, so it can be concluded whether it has a long-term equilibrium or not. Thus, Johansen Cointegration Test was used in this analysis. The processing results showed that the value of Trace Statistic of 65.83 is greater than 5 percent critical value, so it is concluded that the model has a long-term equilibrium.

Classic Assumption Test

Autocorrelation Test

The assumption used in this test is that there is no autocorrelation or serial correlation in its *disturbance term*. In this research, the test used was *Breusch Godfrey Test* (B-G Test).

Table 2
B-G Test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	1.269787	Probability	0.290551
Obs*R-squared	2.825262	Probability	0.243502

The decision determination is if the probability is not significant, the hypothesis stating that there is no autocorrelation in the model is rejected. The calculation results show that the probability value of 0.290551 (insignificant) or there is no autocorrelation in the model (Ho is accepted).

Heteroscedacity Test

This test was conducted using the method of Glejser by regresing the residual absolute value obtained to the independent variable. The data processing results are as follows:

Table 3
Heteroscedacity Test

Dependent Variable: ARES01		
Variable	*t-Statistic*	*Prob.*
D(LGDP)	0.379620	0.7059
D(LJUB)	0.931628	0.3561
D(LPRICE)	1.487000	0.1434
ECT	0.197600	0.8442
R-square	0.096819	
DW stat	1.970891	
F stat	1.050536	

Based on the decision-making on the significance of the dependent variables, heteroscedasticity appears when dependent variables have significant effect on independent. From the data processing results above, it can be seen that each of the dependent variable is not significant to the independent variables, where the level of significance of D (LGDP): 70.59%, D (LJUB): 35.61%, D (LPRICE (-1): 14.34% and D(RISK): 33.24%, so it can be concluded that heteroscedasticity is ignored in the model.

Multicolinearity Test

Multicolinierity is a condition in which there is a correlation of independent variable of each other, so that the variables are not orthogonal (the independent variable with the correlation value with one another equal to zero). To find out the multicolinieritas, a test was conducted by regressing the main model and partial model. Next, R-square count of partial regression was compared with R-square count of the main model.

Table 4
Multicolinearity Test

Variable	*R^2 Value of Partial Model*	*R^2 Value of Main Model*
Dep.Var : LGDP	0.8240	0.9045
Dep.Var : LJUB	0.7920	
Dep.Var : LPRICE	0.1.14	

Based on the above test results, it can be seen that the R-square value of the three partial models and the R-square value of the dependent variables of LGDP = 0.8240; LJUB: 0.7920, LPRICE: 0.1014 and 0.3218 are smaller than the R-square value of the Main Model of 0.9045. This gives the conclusion that the multicollinearity in the model can be ignored.

The Estimation of Error Correction Models in Dornbusch Model

Basically, ECM model is used to find the balance which remains in the long term between the economic variables in a model. If there is an imbalance in the short term, ECM model will correct it in the long term.

Table 5
The Estimation of Dornbusch's ECM Model

Variable	*Coefficient*	*t-Statistic*	*Prob.*
C	4.076573	5.197171	0.0000
LJUB	0.384923	1.733614	0.0902
LGDP	0.646663	6.292837	0.0000
LPRICE	0.550966	5.649099	0.0000
D(LJUB(-1))	-0.094600	-0.470880	0.6401
D(LGDP(-1))	-0.045613	-0.297722	0.7673
D(LPRICE(-1))	0.044959	0.500863	0.6190
ECT	-0.087313	-1.820692	0.0748
R-squared	0.659803		
F-statistic	9.266355		
Prob (F-statistic)	0.000000		

With this mechanism, spurious regression problem can be avoided through the use of fixed variable differences in the model without eliminating long-term information resulting from the use of the data difference alone. Thus, it can be said that ECM model is consistent with the concept of co integration or Granger Representation Theorem.

The data results show that the probability value of ECT : 0.0748 (positive) indicated significant regression in α = 10 %. It means ECM model is valid and the observed variable was cointegrated well. *R-square* value in 0.6598 means 65,98 % from dependent variable variation (LSPOT) can be explained through variation collection of national income variable (LGDP), money circulation (LJUB), and price level (PRICE). In the other hand, F-stat probability value of 0.0000 implied that both independent variable influence dependent variable at the same time.

Short term analysis showed that national income independent variable (LGDP) and price level (LPRICE) had probability value of 0.0000, whereas the money circulation amount variable (LJUB) had probability value of 0,0902. It can be concluded that those three variable were significantly influenced dependent rate variable (LSPOT) in α =10 % value. In contrary, long term analysis showed different result. The three variables in Dornbusch: national income, money circulation amount, and price level, could not explain the behaviour of Rupiah exchange rate to US Dollar.

The regression analysis using error correction model showed positive ECT value of 0.0748. This indicates that the movement of the Rupiah against the US dollar and the average exchange rate volatility has a greater gap. Perry Warjiyo in *Indonesia: stabilizing the exchange rate along its fundamentals* (BIS Papers No 73) shows the data that supports the above findings. The data in graph 4 illustrates the movement of average volatility and USD / IDR Daily Rate, and the greater difference (gap) between them since September 2011. According to Perry, it is due to a massive capital outflow.

Reinheart (2000) explained that the developing countries had high risk of making their exchange value fluctuated freely 'fear of floating' with high deviation standard. If they had good economy, high exchange rate would decrease export competitiveness. However, if they had bad economy, high denomination loan of foreign currency (US Dollar) would cause exchange rate falling they feared . Exchange rate devaluation

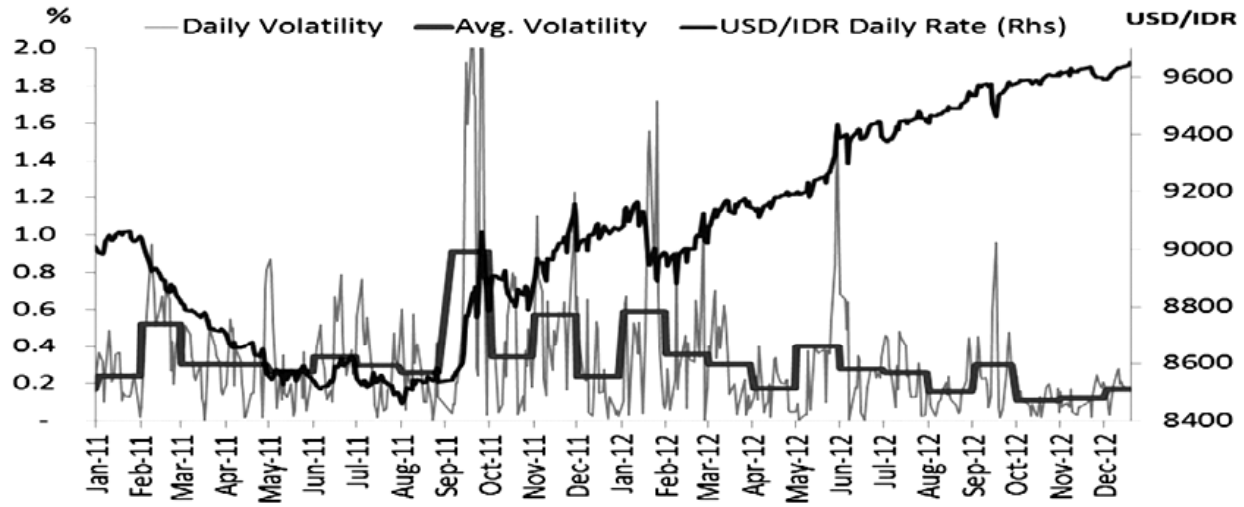


Figure 2: The Development Daily Volatility, Avg. Volatility dan USD/IDR Rate

policy would just cause recession and inflation, not export led growth. That's why Bank Indonesia made some Rupiah exchange rate stabilization policies and strategies, named Peraturan Bank Indonesia (Bank Indonesia Policy) or PBI. Some are PBI No 3/3/2001, PBI No 6/20/PBI/2004 dan PBI No 13/20/PBI/2011. Bank Indonesia also organized direct conduct and indirect supervision of Rupiah exchange rate management.

The research result showed that Bank Indonesia policy and strategy in managing Rupiah exchange rate didn't support its way to equilibrium. In this case, daily rate and average volatility showed bigger gap. The conclusion was conclued based on the research result that showed ECT positive value score. This positive value score showed the fact that the exchange rate wasn't move to equilibrium position.

CONCLUTION

It is concluded that the Dornbusch sticky Price exchange rate model testing was't able to explain Rupiah exchange rate behavior. Thus, this research supported some research conducted by Pippenger (2009) , Heinlein and Krolzig (2010) and Scholl and Uhli (2008) .

The research results also showed that the Rupiah exchange rate management policy that aimed to reach equilibrium, in contrary, moved to disequilibrium. It indicated that Bank Indonesia policies caused distortion. As the result, Rupiah exchange rate deviation standard was high.

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