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Monetary integration in the ASEAN Economic Community challenge: the role of the exchange rate on inflation in Indonesia

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Abstract: The implementation of the *ASEAN Economic Community* (AEC) in 2015 required some form of monetary integration, such as exchange rate management. This paper investigates the role of the exchange rate on the inflation rate in Indonesia. Using the monthly data series from 1970 to 2015, we find that the nominal exchange rate affects the inflation rate at a low transmission speed rate. However, the exchange rate volatility and depreciation threshold may accelerate the speed of the exchange rate's transmission to inflation. Thus, studies with *short-lagged* variables, or studies in different periods may lead to different findings, as shocks and changes in exchange regimes occur regularly in Indonesia. These findings are important as they imply that Indonesia may fail to reach the aims of the AEC if it fails to coordinate its exchange rate policy with the rest of the AEC.

Keywords: exchange rate pass-through; ERPT; exchange rate; inflation; monetary policy; Association of Southeast Asian Nations; ASEAN; ASEAN Economic Community; AEC; Indonesia.

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1 Introduction

The implementation of the *Association of Southeast Asian Nations* (ASEAN) *Economic Community* (AEC) began in 2015 to boost the economic growth of the countries of South-East Asia. By integrating the economy, South-East Asian countries have become the third largest economy in Asia and the seventh largest in the world. However, learning from the experience of the European Union has shown that integrating the economy is not an easy task. The variety of economic levels among countries within South-East Asia creates many challenges. Although not as comprehensive as the European Union regarding economic integration, it is likely that the AEC would require some form of fiscal and monetary integration between member states, which also leads to the necessity to consider the differences of fiscal and monetary management between countries. The pivotal role of the exchange rate to preserve macroeconomic stability has been identified as one of the key policies for coordination among the ASEAN countries (ADBI, 2014; Tan, 2016).

Coordinating exchange rate policies between the ASEAN countries may also be a challenge. Similar to the aforementioned differences among economies within South-East Asia, the arrangement of the exchange rate management also varies across countries. This is reflected in Indonesia – the biggest economy in the ASEAN; on the one hand, it has a *free-float* exchange rate regime with the focus on the short-term interest rate as the anchor of its monetary policy, on the other hand, Singapore – the hub of financial services in the region – focuses its monetary policy on the exchange rate management. These two different exchange rate approaches, ultimately, will require close coordination to achieve the aims of the AEC. For there to be close coordination within an exchange rate policy, one needs to understand the role of the exchange rate in one particular country.

There is a strand of literature that has focussed on the impact of a change in the exchange rate regarding the change in price, also known as ERPT or *exchange rate pass-through* (Goldberg and Knetter, 1997). This hypothesis provides a background to understand the role of the exchange rate in the economy. Recognising the role of the exchange rate will have implications for policymakers, particularly for central banks that conduct their monetary policy based on the *inflation-targeting framework* (ITF) that incorporates a *free-float* exchange rate regime. The role of the exchange rate itself, however, has been acknowledged as a part of central banks' strategy to achieve the inflation target, which then becomes *flexible ITF* (Svensson, 1997). The flexibility of the ITF also needs to address that a strong domestic exchange rate will lead to a low inflation rate (and lower export competitiveness) and, in contrast, a weak domestic exchange rate is expected to boost export performance (and have a higher inflation rate).

Despite wide agreement that the exchange rate effectively affects inflation and there is a host of pertinent studies on ERPT, the findings in this area are still inconclusive. In addition, the study of ERPT in emerging countries – particularly in Indonesia – is still inadequate, due to the unavailability of a dataset. Therefore, it is still unclear if central banks should target the nominal, volatility or percentage threshold depreciation (appreciation) of the exchange rate to achieve the inflation objective. In addition, the central bank would find that intervening in the market to achieve a specific nominal exchange rate would be complex (Kamil, 2008). Thus, this study is driven by an overarching research question: How does the Indonesian exchange rate affect the inflation rate? This will be addressed by answering the following three sub-questions:

1 What impact does a nominal exchange rate have on the inflation rate?

2 What impact does exchange rate volatility have on the inflation rate?

3 Is there a certain percentage of the depreciation (appreciation) threshold of the exchange rate that affects the inflation rate?

This paper has four key contributions: first, we find that the nominal exchange rate significantly affects inflation. However, the velocity of nominal exchange rates transmitted to inflation tends to be slow. Thus, a study with *short-lagged* periods may fail to identify the significant role of the exchange rate. Second, we demonstrate that exchange rate volatility may accelerate the speed of the exchange rate transmitted to inflation. Third, this study exhibits the presence of a percentage threshold effect of the exchange rate that affects the transmission to the inflation rate. Thus, a shock to the exchange rate, which triggers a movement on the exchange rate above a certain threshold, could also accelerate the speed of the exchange rate's transmission to inflation. Fourth, the study implies that the aim of the AEC may be compromised if Indonesia fails to coordinate its exchange rate policy with the rest of the AEC. As the exchange rate is significant to inflation, the *under-value* or *over-value* exchange rate, compared to the AEC member countries, may lead to competitive disadvantages and consequently harm the economy of Indonesia.

The paper is organised as follows. The next section discusses the literature review. The third and fourth sections discuss the data and the methodology used in this paper respectively. The fifth section presents the findings and discussion. The final section concludes.

2 Literature review

The ASEAN community was first established in late 1960. However, the *ASEAN Economic Community* (AEC) was not officially launched until late 2015. According to the ASEAN Secretariat, some aims of the AEC have already been achieved in, among others: "eliminating tariffs and facilitating trade; advancing the services trade liberalisation agenda; and liberalising and facilitating investment" (ASEAN Secretariat, 2015). Despite its achievements, Pelkmans (2016) argues that there is no clear interpretation of some of the AEC concepts, such as *free flow* or *single market*, as there are still barriers to movement and the single market (Jetin, 2016).

Furthermore, the challenges in the AEC also stem from the variation in logistical infrastructures. For example, despite its position as the biggest economy within the AEC, Indonesia has poor logistical infrastructures. In many cases, logistics costs from abroad are much cheaper than the cost from one area to another area within Indonesia. For example, logistics costs from Singapore to Jakarta, Indonesia, are much cheaper than the domestic costs within Indonesia, such as from Jakarta to Makassar, which is the logistics hub for the east Indonesia region. Thus, free trade may encourage firms to establish their bases outside Indonesia, although the ultimate market is in Indonesia. Therefore, both the variation in the rate of inflation and the exchange rate volatility in the AEC member states may also create imbalances in the community, which in turn may harm the aims of the AEC.

Inflation of the goods and services prices in one country has been discussed as one of the major macroeconomic factors that need to be taken into account to maintain sustainable growth. One of the explanations of the cause of inflation can be derived from Samuelson and Solow (1960) who provide two basic theories for the causes of inflation: demand-pull and cost-push. Demand-pull inflation derives from increases in the level of aggregate demand that occurred at or near the point of full capacity utilisation – i.e., at points at which the aggregate supply curve was upward-sloping, rather than flat; cost-push inflation is driven by upward shifts in the aggregate supply curve. These shifts could allow wages and prices to rise even before full employment was reached.

In the context of open-economy, the law of one price is used to explain the theory of prices of tradable goods in different countries. This law states that the same producers will sell one type of goods in different countries at the same price. However, this law implies that the exchange rate will be the same. Moreover, with the current floating currency system adopted by many countries, the movement of the exchange rate needs to be incorporated into the price of the imported goods or ERPT.

ERPT can be defined as the percentage change in domestic currency import price stemming from a percentage change in the exchange rate between the exporting and importing countries (Goldberg and Knetter, 1997). A full or complete ERPT assumes that the percentage of change in the import price will be equal to the percentage of change in the exchange rate. In order to have this relationship, two conditions need to be satisfied: the first is a stable markup of price over cost in a perfect competition industry; the second is a steady marginal cost. Thus, the elasticity of demand for imports in a particular country drives the response of the trade balance to exchange rate changes.

The assumption of full or complete ERPT has driven early studies of ERPT to focus mostly on the impact of the exchange rate on pricing and trade strategies in the literature on the industrial organisation (Aron et al., 2014). The volatility in the exchange rate and persistent trade imbalances has driven a shift in the focus from microeconomic to macroeconomic. Taylor (2000) provides an empirical model of how ERPT is affected by the monetary policy regime. It can be argued that this monetary policy regime also relates to the exchange rate regime of a country. By investigating how different exchange rate regimes in developing and emerging countries connect with the ERPT, Yamada (2013) finds that the *free-float* exchange rate regime tends to lead to higher ERPT.

Despite suggestions in the literature that there is a strong relationship between a *free-float* exchange rate regime and higher ERPT, most countries have recently implemented the *free-float* exchange rate (IMF, 2014). This is partly influenced by the *speculative currency attack* model (Krugman, 1979) which argues that employing a *fixed* exchange rate regime could lead to currency attack if a country suffers from *current account deficit*. Furthermore, the increasing popularity of the ITF as the monetary policy regime has also contributed to this phenomenon (Little and Romano, 2008).

According to Bernanke and Mishkin (1997), inflation targeting is a framework in which a central bank has a numerical target of inflation over a certain period, which becomes the overriding objective. As the ITF requires central banks to target only inflation, the ITF is often associated with the *free-float* exchange rate regime, as foreign exchange intervention could confuse the public and interfere with expectations (Bernanke et al., 1999). However, Yamada (2013) finds that ERPT on ITF countries does not differ significantly in countries implementing a *fixed* exchange rate regime. In addition, Alfaro (2005) demonstrates that a *fixed* exchange rate regime acts as a commitment mechanism, and therefore restrains inflation.

These findings have fuelled the long debate on the role of the exchange rate regime on ERPT, as the assumption is for ITF countries to employ the *free-float* regime. This phenomenon is known as *fear of floating* – where central banks secretly intervene in foreign exchange markets to create a more stable exchange rate (Calvo and Reinhart, 2000). This *fear of floating* is accommodated in the ITF by Svensson (2000) who argues that the exchange rate and the shocks from the rest of the world may play a critical role, due to their importance in conducting monetary policy. *Flexible inflation targeting* – which allows a certain degree of exchange rate stabilisation – indicates low variability in inflation and the output gap. Therefore, a new *flexible* ITF is proposed to allow central banks to manage the exchange rate while implementing the ITF. On the basis of a somewhat different approach, this view was also supported by Aizenman et al. (2011). Extending the *Taylor rule*, they demonstrated that central banks in emerging markets did not follow strict inflation targeting. These central banks – particularly those that come from commodity-based export economies – use interest rates as a response to the exchange rate movement more frequently. In addition, Ghosh et al. (2016) argue that exchange rate intervention can be implemented as complementary to the interest rate policy in an ITF. In the aftermath of the financial crisis 2008, the fear of floating has become a global theme for many central banks. This is partly influenced by the impact of the quantitative easing policy, which is conducted by most of the central banks in the developed countries, namely The Federal Reserve and European Central Bank.

Despite a growing interest in having a *flexible* ITF with exchange rate management in the monetary policy, Ramakrishnan and Vamvakidis (2002) argue that using the exchange rate as an indicator of monetary policy will decrease the value of the significance of other indicators, such as money supply or interest rates. This implies that the central bank should focus on either the exchange rate or non-exchange rate indicators. The use of both the exchange rate and non-exchange rate indicators simultaneously as the anchor of monetary policy, would lead to the decrease of monetary policy effectiveness. Thus, Amato and Gerlach (2002) suggest that the central bank should only consider the exchange rate as a monetary target, if, and only if, the exchange rate is deemed capable of interfering with the achievement of its inflation target. Furthermore, Taylor (1993), in his popular rule, does not suggest the use of the exchange rate in monetary policy. He argues that the central bank, in determining its policy rate, should refer to the rate of inflation and the desired inflation, real interest rates at the equilibrium and the output gap. Even though there are still debates on the *Taylor rule*, the rule is now becoming common practice by many central banks.

Identifying which variable in the exchange rate to include in the target of the central bank is also a subject of interesting discussion. Many studies of the ERPT use the nominal exchange rate to measure the repercussions of the nominal exchange rate on the adjustment of domestic prices (e.g., Aleem and Lahiani, 2014a; Barhoumi, 2006; Campa and González Mínguez, 2006). Another strand of literature in the ERPT uses the volatility of the exchange rate, which is argued to have an impact on domestic prices (e.g., Du Plessis and Reid, 2015). Other studies argue that a threshold of exchange rate movement affects the domestic prices (e.g., Aleem and Lahiani, 2014b). However, Wimanda (2014) did not find any impact of a threshold in the exchange rate on the domestic prices inflation in the case of Indonesia.

Central banks in the South-East Asia region have different approaches in their implementation of monetary policy. These can be observed from the differences in their

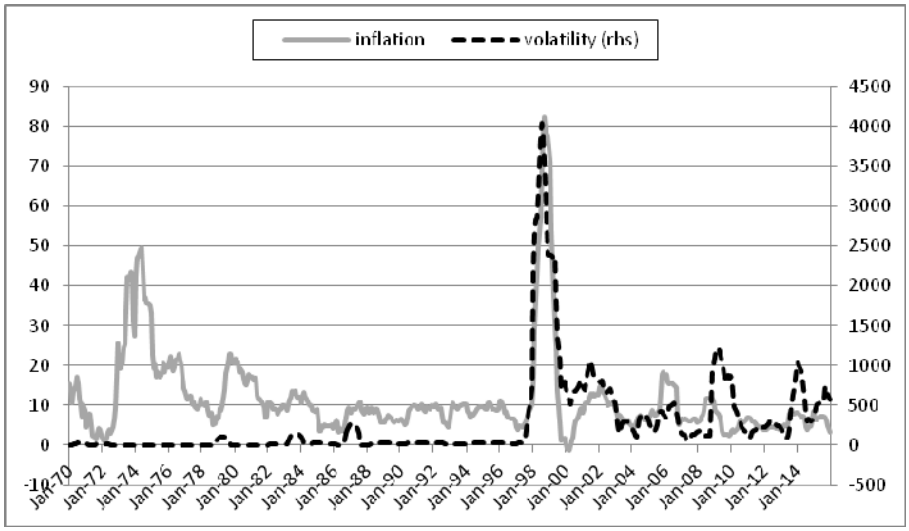
monetary policy anchors, which range from inflation targeting central banks and floating exchange rate regimes such as Indonesia, Thailand and the Philippines, exchange rate anchor with stabilised arrangement such as Singapore and Vietnam, to no explicitly stated nominal anchor and other stabilised arrangement such as Malaysia (IMF, 2014). Therefore, it is interesting to put the exchange rate variable into a uniform monetary framework in the AEC. Moreover, according to Engwerda et al. (2012), a coordinated monetary policy in the ASEAN will benefit all the members; although, this still leaves the question of whether the ASEAN should form a monetary union. In contrast, fiscal policy has a small effect on macroeconomic variables.

3 Data

In this paper, we use the data of the exchange rate of US dollars and Indonesian rupiah (USD/IDR) and the Inflation year-on-year (YoY) of 1970 to 2015. All the variables are in the form of a monthly data series, obtained from the *Thomson Reuters Datastream*. In addition to the previous variables, we add a variable of Volatility, measured as a standard deviation of the last 12-months' exchange rate depreciation.

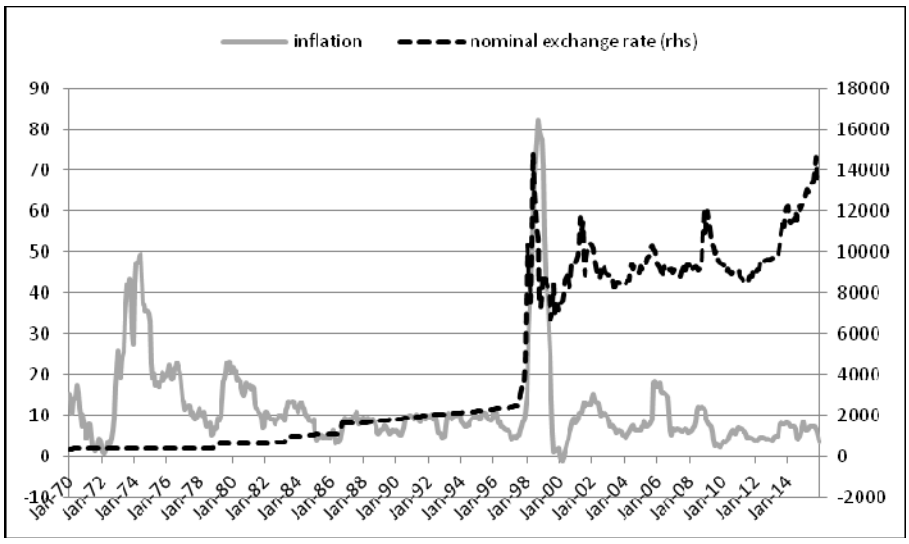
We then put the USD/IDR volatility and the nominal USD/IDR in their relationship to the inflation into a graphical representation. The relationship between USD/IDR volatility and inflation (YoY) is depicted in Figure 1, while the relationship between nominal USD/IDR and inflation (YoY) is represented in Figure 2.

Figure 1 The relationship between IDR/USD volatility and inflation (YoY)



Source: Thomson Reuters Datastream

Figure 2 The relationship between nominal IDR/USD exchange rate and inflation (YoY)



Source: Thomson Reuters Datastream

These graphical representations suggest an interesting contrast. On the one hand, the chart analysis suggests that exchange rate volatility and inflation had a low relationship, prior to the Asian crisis of 1997; whereas there is a stronger relationship post the crisis of 1997. On the other hand, the graphical display suggests that there is no clear relationship between nominal exchange rate and inflation rate.

We also used some dummy variables to identify the depreciation thresholds. We specify DU5 as one if the yearly change of exchange rate is more than 5% and DU10 as one if the yearly change of exchange rate is more than 10%. We specify any exchange rate movement below the threshold as zero.

Furthermore, we also test the impact of exchange rate volatility using another approach. While Indonesia has suffered from many financial crises, the volatility of IDR/USD was relatively stable prior to the Asian crisis of 1997. However, the exchange rate's volatility has dramatically increased in the aftermath of the Asian crisis of 1997. This is partly due to the change in the exchange rate regime from *managed-float* to *free-float*. To address this potential *structural break* in the data series, we put a dummy variable into our model. We use DUB to identify the time prior to and post the Asian crisis of 1997, where we specify DUB as one for the year 1998 and after, while DUB equals zero for 1997 and before.

4 Methodology

In order to answer the question whether the nominal or volatility of the exchange rate affects the inflation rate, we divide our investigations into the following equations:

$$\Delta\pi_t = c + \sum_{i=1}^{k} \Delta\pi_{t-1} + \sum_{i=0}^{k} ER_t + DUB_t + \varepsilon_t \quad (1)$$

$$\Delta\pi_t = c + \sum_{i=1}^{k} \Delta\pi_{t-1} + \sum_{i=0}^{k} Volatility_t + DUB_t + \varepsilon_t \quad (2)$$

where $\Delta\pi_t$ is the inflation rate at time t, $\Delta\pi_{t-i}$ is the inflation lag, $\sum_{i=0}^{k} ER_t$ is the nominal exchange rate of USD/IDR, $Volatility_t$ is the standard deviation of moving the 12-month exchange rate and DUB is the dummy variable which identifies the period post the crisis of 1997.

In our model, as the inflation rate is persistent (Taylor, 2000), we put the *lagged* inflation rates as independent variables. We also put the lagged nominal exchange rates or exchange rate volatility as independent variables, as we assume that the impact of the exchange rate on inflation develops at a slow rate, due to incomplete ERPT (Rogoff, 1996). We employ our model up to 12 *lags*, and evaluate each model with robustness tests.

In addition, as high currency depreciation might have a different impact on inflation (Bussière, 2007), we also investigate the question of whether the threshold of exchange rate depreciation affects the inflation rate as follows:

$$\Delta\pi_t = c + \sum_{i=1}^{k} \Delta\pi_{t-1} + DUx_t + DUB_t + + \varepsilon_t \quad (3)$$

where *DUx* is the dummy variable, which identifies the depreciation threshold exceeding x% (we use 5% and 10% for the testing).

The above equations are then analysed with a *multivariate regression* approach. To avoid spurious regressions and to create the *best linear unbiased estimator* (BLUE), we also conduct the following tests: first, we identify the presence of a *unit-root* using the *augmented Dickey-Fuller* (ADF) test (Elliott et al., 1996).

However, one needs to be thoughtful when interpreting the ADF test, as its capability perishes if there is a *structural break* in the data series (Perron, 1989). Thus, we employ the *Zivot-Andrews* (ZA) test (Zivot and Andrews, 1992) as a comparison to the ADF test in order to identify the presence of a *unit-root*, as we acknowledge the possibility of a *structural break* in our data series. The ZA test is chosen because of its ability to identify the presence of an *unknown structural break*, and because it takes into account the impact of the *structural break* in the *unit-root* test.

Furthermore, we test the robustness of our models by using two approaches. First, we test the presence of *serial correlation* on *residuals*. As the *Durbin-Watson* statistic is sometimes difficult to interpret, we then use the *Breusch-Godfrey serial correlation-LM* test (BG-LM) to identify the presence of *serial correlation* in our *residual*. Second, we exercise the *ARCH-LM* test to assess the presence of *auto regression conditional heteroscedasticity* in our *residual*, where *t* is the *residual*.

Following the *Gauss-Markov* theorem, we conclude that the best models will have the significant *F-statistic*, while the BG-LM and ARCH LM (A-LM) test are not significant. The significant BG-LM and A-LM represent the presence of *serial correlation* and *heteroscedasticity* respectively.

5 Finding and discussion

Our tests indicate that ADF and ZA tests have a similar result for both export and inflation data series. Both tests suggest inflation is *stationary* on *level*. However, the

results for nominal exchange rate and exchange rate volatility are inconclusive. The ADF test suggests that it is stationary on *first difference*, whereas, the ZA test concludes that it is stationary on *level*. According to the ZA test, there is a *structural break* presence on the exchange rate data series in the aftermath of the Indonesian crisis of 1997. Thus, according to the ZA test, the exchange rate data series is *stationary* on *level*. As the ZA test is considered to be more powerful than the ADF (Chaudhuri and Wu, 2003), thus, for the rest of analysis, we assume that both nominal and volatility of the exchange rate are *stationary* on *level*. The result of the *unit-root* test is shown in Table 1.

Table 1 Unit-root test

Variables	*ADF*		*ZA*			
	Level^	*1st diff.*^	*Level*^	*Break*	*1st diff.*^	*Break*
Intercept						
Inflation	–3.94***	–8.22***	–6.08***	1997:8	–9.12***	1998:10
Nominal exchange rate	–0.05	–16.56***	–6.71***	1997:12	–11.11***	1998:7
Volatility of exchange rate	–3.86***	–13.22***	–5.54***	1997:7	–8.18***	1998:7
Trend and intercept						
Inflation	–4.25***	–8.22***	–6.29***	1997:12	–9.19***	1998:10
Nominal exchange rate	–2.74	–16.59***	–6.75***	1997:12	–11.13***	1998:7
Volatility of exchange rate	–4.17***	–13.21***	–6.40***	1997:8	–8.26***	1998:7

Notes: ^ is presented as t-statistic
***, **, and * show that variables are significant at 1, 5, and 10% levels of significance respectively.

Moving on to the model implementation, we investigate equations (1), (2) and (3) using the *level-data* as we find that all variables are *stationary* on *level*. We further find that all nominal, volatility, and depreciation thresholds of the exchange rate have a significant effect on inflation. The summary of the results is shown in Table 2.

Table 2 Summary of the impact of nominal, volatility, and threshold of exchange rate on inflation rate

Variables	*Lag*	*F-stat*	*Adj.* R^2	*DW*	*BG-LM*	*ARCH LM*
Nominal	11	987.07***	0.98	2.01	2.51	1.71
Volatility	4	2017.59***	0.97	2.02	1.15	0.94
Threshold 5%	5	1487.64***	0.97	2.00	2.79	2.65
Threshold 10%	4	1802.00***	0.97	2.01	1.51	2.50

While nominal, volatility and depreciation thresholds of the exchange rate have a significant effect on inflation, we also demonstrate that they have a different speed of transmission.

There are three possible explanations for the low ERPT speed of transmission. First, there is a contract multiplier, which forces producers to stick to plans or strategic complementarities by applying the *countercyclical* mark-ups. Thus, prices become *sticky* (Klenow and Malin, 2010) as enterprises absorb some of the exchange rate impacts on prices.

Second, consumers substitute more expensive imported goods with cheaper local goods. This shifting is often miscalculated when measuring the *consumer price index*, creating a *sticky* inflation rate (Burstein et al., 2003).

Third, the producers always consider other firms' prices when adjusting their price. As the review of the price is only conducted periodically, the price change relies on the persistent changes in the exchange rate (Taylor, 2000).

Our test suggests that the nominal exchange rate could significantly explain the inflation rate after an 11-month accumulation of nominal exchange rate movement. Significant *F-statistic* and non-significant *Breusch-Godfrey serial correlation-LM test* and ARCH-LM statistic, indicate that our model is robust. Surprisingly, despite the ERPT having a low speed of transmission, the adjusted R^2 of 98% indicates that the nominal exchange rate has a significant role in the development of the Indonesian inflation rate.

The low speed of ERPT's transmission indicates the existence of incomplete ERPT (Goldberg and Hellerstein, 2008). This is also in line with Isnowati and Setiawan (2017) who find that there is an incomplete ERPT in Indonesia. As, the exchange rate gradually affects the import prices in Indonesia, thus, research with a *short-lagged* period could easily find a weak relationship between nominal exchange rate and the inflation rate in Indonesia (Lopez-Villavicencio and Mignon, 2016). The regression result of equation (1) at *lag* 11-month is presented in Table 3.

Table 3 Regression results of nominal exchange rate and inflation at lag 11

Variable	*Coefficient*	*Std. error*	*t-statistic*	*Prob.*
C	1.176287	0.203768	5.772669	0
Inflation (–1)	1.378413	0.043552	31.65004	0
Inflation (–2)	–0.603374	0.073489	–8.210423	0
Inflation (–3)	0.279523	0.077133	3.623914	0.0003
Inflation (–4)	–0.055817	0.076545	–0.729199	0.4662
Inflation (–5)	–0.168435	0.076547	–2.200404	0.0282
Inflation (–6)	0.221874	0.075876	2.924161	0.0036
Inflation (–7)	0.047894	0.075802	0.631838	0.5278
Inflation (–8)	–0.27207	0.075394	–3.608661	0.0003
Inflation (–9)	0.241211	0.074971	3.217383	0.0014
Inflation (–10)	–0.177467	0.07105	–2.497778	0.0128
Inflation (–11)	0.041708	0.040103	1.040035	0.2988
Exchange rate	0.000151	0.000173	0.874559	0.3822
Exchange rate (–1)	0.000749	0.000246	3.045348	0.0024
Exchange rate (–2)	–0.000608	0.00025	–2.437335	0.0151

Table 3 Regression results of nominal exchange rate and inflation at lag 11 (continued)

Variable	*Coefficient*	*Std. error*	*t-statistic*	*Prob.*
Exchange rate (–3)	0.000435	0.000246	1.76627	0.0779
Exchange rate (–4)	–0.00012	0.000247	–0.485862	0.6273
Exchange rate (–5)	–0.000516	0.000247	–2.087704	0.0373
Exchange rate (–6)	0.000754	0.000249	3.033068	0.0025
Exchange rate (–7)	–0.000472	0.000247	–1.909524	0.0567
Exchange rate (–8)	–0.000724	0.000249	–2.908309	0.0038
Exchange rate (–9)	0.000125	0.000257	0.485667	0.6274
Exchange rate (–10)	0.000304	0.000255	1.193602	0.2332
Exchange rate (–11)	–0.000441	0.000185	–2.3775	0.0178
DUB	2.704892	0.700629	3.860664	0.0001
Adjusted R^2	0.977691			

Moreover, with the adjusted R^2 of 97%, we show that the volatility of the exchange rate is also significant to the formation of the inflation rate. This finding is robust as it is supported by a significant *F-statistic* and non-significant *Breusch-Godfrey serial correlation-LM* test and ARCH-LM statistic. However, one may assume the volatility of the exchange rate to be more important than the nominal exchange rate, as it has a faster speed of ERPT's transmission to the inflation rate than the nominal exchange rate. Our results show that an accumulated four-month volatility of the exchange rate, significantly explains the inflation rate. The regression result of equation (2) at *lag* four-month is presented in Table 4.

Table 4 Regression results of volatility of exchange rate and inflation at lag 4

Variable	*Coefficient*	*Std. error*	*t-statistic*	*Prob.*
C	0.578026	0.152933	3.779604	0.0002
Inflation (–1)	1.421983	0.04172	34.08382	0
Inflation (–2)	–0.634792	0.07194	–8.823861	0
Inflation (–3)	0.382237	0.070858	5.394417	0
Inflation (–4)	–0.22107	0.039375	–5.614423	0
Volatility	0.001657	0.000911	1.817772	0.0697
Volatility (–1)	0.003975	0.001626	2.444154	0.0148
Volatility (–2)	–0.005404	0.001706	–3.168007	0.0016
Volatility (–3)	0.001496	0.001657	0.902772	0.3671
Volatility (–4)	–0.001087	0.000969	–1.121541	0.2626
DUB	–0.454219	0.227914	–1.992938	0.0468
Adjusted R^2	0.973591			

In addition, our model also suggests that the financial crisis of 1997 (variable DUB) has a significant impact on the relationship between the exchange rate volatility and the inflation rate. This finding is in line with Goeltom (2008) who argues that exchange rate volatility and inflation displayed a weak relationship prior to the financial crisis of 1997, and became stronger in the aftermath of the Asian financial crisis. This is partly due to an adjustment in the exchange rate regime in Indonesia, from a *managed-float* exchange rate prior to the Asian financial crisis, to a *free-float* exchange rate after the crisis. This adjustment created more volatility in the exchange rate. It can be suggested that the role of the exchange rate on the inflation rate during the period of a relatively stable exchange rate is very low. The role of the exchange rate on the inflation rate increases along with a rise in the volatility of the exchange rate.

In order to find out whether the exchange rate has a threshold or not, we employ equation (3) to understand the impact of high depreciation on the relationship between the exchange rate and inflation rate. Interestingly, we find that a 5% depreciation of the exchange rate may accelerate the speed of the exchange rate's transmission to inflation to five months. Moreover, a 10% depreciation of the exchange rate may accelerate further, to only four months of transmission speed rate. We argue that our model is robust, which can be derived from the adjusted R^2 of 97% and supported by a significant *F-statistic* and non-significant *Breusch-Godfrey serial correlation-LM* test and ARCH-LM test.

Our finding differs to Wimanda (2014) who argues that there is no threshold effect on exchange rate depreciation in Indonesia. This difference can be reconciled with the failure to acknowledge the *lagged* effect in previous studies.

Our findings suggest that policymakers should be aware that the exchange rate speed of transmission to inflation could also be influenced by exchange rate volatility and the threshold of exchange rate depreciation. Whilst the nominal exchange rate is expected to have low transmission speed rate, it could go faster if the change of nominal exchange rate were higher. Furthermore, although the change of nominal exchange rate is limited, it could still affect prices if the exchange rate is volatile.

Our findings suggest that the nominal exchange rate has a significant effect on the inflation rate. While the nominal exchange rate has a slow transmission speed rate to inflation, the volatility or the shock on the exchange rate may accelerate the transmission speed. Therefore, it is important for a policymaker to understand the impact of exchange rate volatility and the depreciation threshold on the exchange rate transmission speed rate.

However, it is still not clear how Indonesia manages its exchange rate. Officially, Indonesia adopts a *free-float* exchange rate regime, aligned with the adoption of the ITF; in practice, the Indonesian central bank is also known for having a regular intervention in the exchange market without open announcement (Bank Indonesia, 2015). However, despite its intervention, the Indonesian Rupiah tends to be more volatile compared to prior the financial crisis of 1997. The failure of the intervention to smooth the exchange rate volatility, to some extent, could be blamed on the secrecy of the intervention (Dominguez, 1998; Cashin et al., 2006). Thus, it is important for the central bank to make a clear stance on its exchange rate regime. The regression results of equation (3) with 5% and 10% thresholds at *lag* five-month and four-month respectively are presented in Tables 5 and 6.

Table 5 Regression results of 5% threshold of exchange rate and inflation at lag 5

Variable	*Coefficient*	*Std. error*	*t-statistic*	*Prob.*
C	0.449248	0.162251	2.768852	0.0058
Inflation (–1)	1.494369	0.04321	34.58391	0
Inflation (–2)	–0.66493	0.077339	–8.597648	0
Inflation (–3)	0.352094	0.080875	4.353564	0
Inflation (–4)	–0.17972	0.077084	–2.331465	0.0201
Inflation (–5)	–0.044489	0.04328	–1.027937	0.3044
DU5	0.311067	0.317815	0.978768	0.3281
DU5 (–1)	0.146766	0.401256	0.365766	0.7147
DU5 (–2)	–0.06597	0.39994	–0.16495	0.869
DU5 (–3)	–0.51427	0.396908	–1.295689	0.1956
DU5 (–4)	–0.010152	0.396595	–0.025597	0.9796
DU5 (–5)	0.308546	0.312561	0.987154	0.324
DUB	–0.079046	0.173252	–0.45625	0.6484
Adjusted R^2	0.970303			

Table 6 Regression results of 10% threshold of exchange rate and inflation at lag 4

Variable	*Coefficient*	*Std. error*	*t-statistic*	*Prob.*
C	0.437326	0.143766	3.041933	0.0025
Inflation (–1)	1.493686	0.041897	35.65134	0
Inflation (–2)	–0.662906	0.075338	–8.799039	0
Inflation (–3)	0.368303	0.075799	4.858957	0
Inflation (–4)	–0.240865	0.04214	–5.715822	0
DU10	0.547642	0.367332	1.490863	0.1366
DU10 (–1)	0.332399	0.484345	0.686285	0.4928
DU10 (–2)	–0.611715	0.477846	–1.280151	0.201
DU10 (–3)	–0.207924	0.476224	–0.43661	0.6626
DU10 (–4)	0.262152	0.359648	0.728912	0.4664
DUB	–0.096058	0.173754	–0.552838	0.5806
Adjusted R^2	0.970523			

In addition, the importance of the exchange rate implies that the member states should extend the scope of their collaboration to the coordination of exchange rate policies. For Indonesia, the task is more challenging as it has a more volatile exchange rate compared to the others. Thus, it is important for Indonesia to publicly adopt the *flexible* ITF by considering the exchange rate as one of its monetary objectives. As managing the exchange rate is not an easy task, all member states of the AEC should also help each other to manage the exchange rates; failure to do so may harm the aims of the AEC and may lead to the breakdown of the AEC.

6 Conclusions

The implementation of the AEC in 2015 requires some form of monetary integration between member states. The exchange rate has been identified as one of the key coordinating policies among the central banks within the AEC. However, monetary policies – particularly exchange rate management – among the member states vary. As the biggest economy in the ASEAN, a shock in the Indonesian exchange rate will create imbalances in the region. Therefore, it is important to understand the role of the exchange rate in the formation of inflation in Indonesia, as it will drive the Indonesian monetary policy.

Using the data of the exchange rate and the annual inflation rate (YoY) during the period 1970–2015, we conducted an empirical study to determine the impact of the Indonesian exchange rate on the rate of inflation using *multivariate regression* analyses. We conclude that the persistence of the inflation rate and the probability of high currency depreciation has a different impact on low currency depreciation to inflation.

Our investigations have four key findings: first, we show that a nominal exchange rate influences the inflation rate at a low transmission speed rate. This may explain why previous studies with short *lag* have reached insignificant results. Second, we demonstrate that the exchange rate's transmission speed rate is influenced by the exchange rate volatility. This explains why the impact of the exchange rate on the inflation rate in Indonesia became higher in the aftermath of the Asian financial crisis of 1997, as suggested by Goeltom (2008). Third, unlike Wimanda (2014), we show that there is a threshold effect of the exchange rate. Thus, a shock to the exchange rate could also accelerate the speed of the exchange rate's transmission to inflation. Four, as the findings suggest that the exchange rate has an important role in the Indonesian inflation, thus failure to coordinate the exchange rate to the AEC may harm the Indonesian economy, as it may create competitive disadvantages.

While our findings suggest that the exchange rate has a significant effect on the inflation rate, it is still not clear how Indonesia manages its exchange rate. Despite its official stance on the adoption of ITF, Indonesia is also known to secretly intervene in the exchange market. However, this intervention has failed to smooth the exchange rate volatility; this is partly due to the secrecy of the intervention (Dominguez, 1998; Cashin et al., 2006). Thus, it is important for the central bank to make a clear stance on its exchange rate regime.

Furthermore, the significant role of the exchange rate on the inflation rate suggests that it is important for member states of the AEC to extend the scope of its cooperation with the exchange rate coordination. In particular, as the biggest economy in the AEC, Indonesia has a challenging task in managing the exchange rate, as shown by a more volatile exchange rate compared to the other member states. Therefore, it is important for Indonesia to publicly adopt the *flexible* ITF by considering the exchange rate as one of its monetary objectives. In addition, all member states of the AEC should help each other to manage the exchange rates. Failure to do so may harm the aims of the AEC and lead to the breakdown of the AEC.

In this study, we assume that the exchange rate has a linear relationship with the inflation rate in Indonesia. It would be interesting to examine the presence of a nonlinearity relationship between the exchange rate and the inflation rate. We leave this puzzle for future research to solve.

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