Exchange Rate Pass-Through into Domestic Prices

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ABSTRACT

The exchange rate is a important policy variable in determines trade flows, capital flows, inflation, and the international reserves in a given economy. Economists have devoted considerable empirical attention to various questions surrounding exchange rates. One area of interest has been the exchange rate pass through (ERPT) into import price have been debated for long time. In this dissertation consist of three independent research papers that study regarding the exchange rate pass through. In particular, this dissertation tries to extend the literature through advanced methodologies. In order to overcome the limitation of past studies, the threshold models is employed and new threshold variable is used. The first paper is to examine the exchange rate pass through into Korean import. After the currency crisis in 1997-1998, many countries started to change their exchange rate regime. Korea had switched her exchange rate regime to floating with the inflation targeting framework. However, it is difficult to maintain inflation target while achieving the exchange rate target. Therefore, in order to achieve the exchange rate stability, Korean authorities tend to intervene the foreign exchange market. This raise a question that would these intervention in foreign exchange market affect the level of exchange rate pass through? However, past studies are limited. This might due to the limitation of the data. In Korea, there is a unique tool using to sterilize the money supply after the intervention known as monetary stabilization bonds (MSBs). This bond is use to control the excessive short term liquidity. The monetary stabilization bonds is chose as the threshold variable in this paper. Past studies show that the spread of this bond can be serve as a signal of financial crisis. In contrast with past studies, the contract currency based Nominal Effective Exchange Rate (NEER) is used in this paper. Unlike the conventional NEER, contract currency based NEER is invoice currency shares weighted. This help to the capture the effect of third currency using the invoicing. According to Bank of Korea, Korean import consists of

large share of third currency in invoicing. Almost 80 % of the import are invoicing in U.S. Dollar. Results revealed that the exchange rate pass through are different across the industries and different during the foreign exchange rate intervention period. Exchange rate is expected to be more volatility during intervention period, exporters have tendency to pass through effect of the exchange rate movement. Overall, Korea has high level of exchange rate pass through. Significant of the exchange rate pass through in short run reflects the important of foreign currency used as invoicing currency. The second paper is examining the level of exchange rate pass through into Malaysian import during depreciation and appreciation period. After July of 2005, Malaysia had change from fix exchange rate regime to manage float regime. This had led to a greater fluctuation in exchange rate. In this paper, the asymmetric effects that raise from the exchange rate appreciation and depreciation is taking into consideration. Based on the previous empirical studies, the exporters are expected to behave differently during the appreciation and depreciation period. To capture this effect, the Nonlinear Autoregressive Distributed Lag (NARDL) model is used in this paper. Based on the model, the asymmetric variable is decomposed into partial sum by using threshold. NARDL model allows to examine the effect of asymmetric variable in both long run and short run. The results show that most of the commodities have cointegrating relationship among the variables. Long run pass through exists for most of the commodities. The exchange rate pass through is different across the commodities. However, the asymmetric test show that only a commodity exhibit the asymmetric effect in the exchange rate pass through. This implies the position of Malaysia as a price taker. This also explained the less responsiveness of Malaysia import price to the sharp depreciation in Malaysian Ringgit since September 2015. The third paper is to examine the exchange rate pass through using threshold model. The threshold variable used in this study is the level of exchange rate volatility. After the change of the exchange rate regime, Central Bank of Malaysia, Bank Negara Malaysia (BNM) tend to intervene the foreign exchange

market. The intention to intervene in the foreign exchange rate is to contain the excessive exchange rate volatility. However, there are studies show that the foreign intervention tend to increase the exchange rate volatility in the short run. For the case of Malaysia, the central bank of Malaysia intervened foreign exchange market to counter strong portfolio inflows against the US dollar that sharply increased international reserves, from USD 83.5 billion in January 2007 to USD 125.8 billion in June 2008, a rise of just over 50%. However, the onset of the global financial crisis caused a sudden reversal of portfolio investment, exerting a significant downward pull on the ringgit. This lead to a greater exchange rate volatility. As argued by previous study the performance of the Malaysian import is important in order to further generate Malaysia's economy. There are studies show that the demand of Malaysian imports is affected by the exchange rate volatility. Hence, it is important to understand the relationship between the exchange rate volatility and the exchange rate pass through in Malaysian import. The results show that significant pass through in low exchange rate volatility. However, there are two commodities where the exchange rate pass through is in negative and both commodities are the main imported commodities. In overall, the exchange rate pass through is different across the industries and commodities. Lack of evidence in the asymmetric effect of exchange appreciation and depreciation in Malaysia import reveal the position of Malaysia as a price taker. The results help to explain the less responsiveness of Malaysian import to the sharp decline of exchange rate.

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Introduction

The exchange rate is a critical policy variable in determines trade flows, capital flows, inflation, and the international reserves in each economy. Moreover, a degree of exchange rate stability is essential for ongoing economic growth and economic stability. Over the past decade, economists have devoted considerable empirical attention to various questions surrounding exchange rates and international trade flows. One area of interest has been the exchange rate pass through (ERPT) into import have been debated for long time.

After the financial crisis in 1997-1998, Korea had switched their exchange rate regime to flexible exchange rate regime along with inflation targeting framework. However, this change had led Korean won become highly volatile and sharp depreciation. This can be explained by great number of banks' external debt and liquidity mismatch. The high demand of foreign exchange hedging has cause high banks' external debts. Importers in Korea try to acquire the foreign currency in the spot market. However, due to the short of foreign currency, banks try to overcome this by borrow foreign currency or creating short foreign exchange swap positions. In exchange, the foreign bank received the Korean won by investing in domestic bonds. This have led to high external debt for Korean banks. Due to this, Korean won have become highly vulnerable.

Therefore, in order to contain excessive exchange rate volatility, the Korean authorities tend to intervene in the foreign exchange market. There are two administrative bodies involved in Korean foreign exchange intervention which are Ministry of Strategy and Finance (MOSF) and the Bank of Korea (BOK). MOSF in charge of maintain the stability of the foreign exchange market and foreign exchange policy. While BOK responsible for manages the foreign reserve.

Past empirical studies show the intervention of the central bank could lead to raise of nonlinearity in the exchange rate movement. The central bank tends to change the direction of the exchange rate movement to avoid sharp depreciation or appreciation of exchange rate . However, few studies pointed out that intervention in foreign exchange market may have the exchange rate high tendency to become more volatile. With this ambiguous effect of intervention, it is necessary to understand the effect of foreign exchange intervention on exchange rate pass through. The analysis of central bank intervention is limited, this may because of the limitation of the data and unclear timing and magnitude of the intervention.

Most of the past empirical studies are employed conventional linear model in the analysis. However, the conventional models are only allowed for linear specifications, it may not be able to capture the exchange rate dynamics precisely. Hence, in this Ph.D. dissertation, the first paper is focus on the exchange rate pass through into Korean Import by incorporating with the central bank intervention. To overcome the drawback, the first paper employed the threshold autoregressive (TAR) model.

In Korea, the foreign exchange market is often intervened through signalling channel, where the authorities will give warning to the market participate so that they can reconsider the movement of the foreign exchange market. This will change the expectation of market participants regarding the future movement of foreign exchange. Beside than signalling channel, direct intervene in spot market are used. After the intervention, the domestic money supply will be sterilized through the issuance or withdrawal of Monetary Stabilization Bonds. This bond is a unique tool used by the Korean authorities to sterilize the money supply. Therefore, this bond can be used an ideal threshold variable in the TAR model. The results reveal that the ERPT is different not only across the industries but also during foreign exchange intervention period. During the intervention period, the exchange rate tends to be more volatile, exporters might protect themselves by choosing to pass through the exchange rate fluctuation to the importers. Understanding the ERPT behaviour is important in considering the impact of exchange rate movement in Korean import.

Beside Korea, after the Asian financial crisis, Malaysia had changed from a flexible exchange rate regime to a fixed regime to reduce volatility. Under these arrangements, the exchange rate of the Ringgit (RM) was pegged against the United States Dollar (USD) at RM 3.80 per USD. However, in July 2005, the central bank of Malaysia, Bank Negara Malaysia (BNM) had abandoned the fixed exchange rate regime and returned to a floating exchange rate regime. This shift provides empirical economists with a rare and valuable 'natural experiment'.

Importers and exporters tend to behave differently during the exchange rate appreciation and depreciation period. Less studies are done on the differences in the exchange rate pass through between the appreciation and depreciation period, especially for the case of developing countries. Therefore, second paper is analysing the exchange rate pass through into domestic price for Malaysia. By considering the asymmetric effects arise from the exchange rate movements, the Nonlinear Autoregressive Distributed Lag (NARDL) model is used in the analysis. One of the advantages of this model is allowing to test the asymmetric effects in both long run and short run. The results show that the overall pass through to import price is high and mainly contributed by the industries that are heavily depend on the import of raw material which mean high share of import. Almost all the commodities in Malaysia show symmetric in ERPT behaviour, however, there is a commodity where exhibit asymmetric in ERPT coefficient. This might due to Malaysia as a price taker. This help in explaining the less responsiveness of Malaysian Import price to the large depreciation in Malaysia Ringgit (MYR) since September of 2015.

After considering the asymmetric effects of exchange rate during appreciation and depreciation period. Third research paper is to examine the effect of exchange rate volatility on level of ERPT into Malaysian Import. The threshold autoregressive (TAR) model is employed to analyse a possible nonlinear of ERPT dur to the different in the level of exchange rate volatility. From the results, we found out that significant ERPT only occur in the low exchange rate volatility. This implies that high exchange rate volatility can be related to low ERPT. This can be able to be explained by the study done by Corsetti et al. (2007) which may be due to price discrimination. The ERPT coefficient are expecting to be high, however, due to the presence of the distribution services, the impact of the nominal exchange rate movement on price is reduced.

Table 1.1 provide an overview of the three research papers.

Table 1.1: Overview of three research papers

Research Paper	First	Second	Third
Method	Threshold Autoregressive (TAR) model	Nonlinear Autoregressive Distributed Lag (NARDL) model	Threshold Autoregressive (TAR) model
Country	Korea	Malaysia	Malaysia
Sample period	2000M1 -2017M3	2011M1-2017M7	2008M1-2017M7
Variables	-Won-Based Import Price Index, -Contract Currency Based Import Price Index, -Industrial Production Index (IPI), -Producer Price Index (PPI), -Consumer Price Index (CPI) -Monetary Stabilisation Bonds (MSBs). -Nominal Effective Exchange Rate (NEER) -Real Effective Exchange Rate (REER)	- Import Unit Value index, -Industrial Production Index (IPI), -Producer Price Index (PPI), -Consumer Price Index (CPI),) -Nominal Effective Exchange Rate (NEER) -Real Effective Exchange Rate (REER) -Bilateral Exchange Rate	- Import Unit Value index, -Industrial Production Index (IPI), -Producer Price Index (PPI), -Consumer Price Index (CPI) -Nominal Effective Exchange Rate (NEER) -Real Effective Exchange Rate (REER) -Bilateral Exchange Rate

Results	-Overall pass through to import price is high. -The ERPT is different not only across the industries but also during foreign exchange intervention period.	-Overall pass through to import price is high -There is no asymmetric between depreciation and appreciation period in both long run and short run.	-Significant ERPT only occur in the low exchange rate volatility. This implies that high exchange rate volatility can be related to low ERPT.

Exchange Rate Intervention and It Implication on Exchange Rate Pass-Through: Case of Korea

2.1. Introduction

The exchange rate pass through (ERPT) into import price have been debated for long time. The degree of pass- through to import price is an important parameter in conduct of monetary policy. The incomplete pass through is commonly found in previous studies (Goldberg and Knetter, 1997; Choudhri and Hakura, 2015). The complete exchange rate pass through refer to the exchange rate change is completely transmitted into import price. Most of the ERPT studies had focused on developed countries (Bailliu and Fujii, 2004; Campa and Goldberg, 2005; Choudhri, Faruqee and Hakura, 2005).

After the financial crisis of 1997-1998, Korea had officially adopted flexible exchange rate regime with inflation targeting arrangement (Cavoli and Rajan, 2007). Kang and Wang (2003) had analysed the effect of ERPT into import prices and consumer prices for countries such as Japan, Singapore, Korea and Thailand using a VAR framework for period 1991-2001. Authors found out that the flexible exchange rate regimes had contributed to the high ERPT into import prices and consumer prices in Korea.

While, Ito et al. (2005) found out that the ERPT into import price in Korea in statistically insignificant. These authors examined the ERPT into import prices and consumer prices for eight East Asian countries over the sample period of 1986-2004. Ghosh and Rajan (2007) had examined the ERPT into import prices and consumer prices in Korea and Thailand for period of 1980-2006. Authors were used different bilateral nominal exchange rate and nominal effective exchange rates (NEER) in their study. The authors found partial ERPT into import prices for Korea case.

Most past empirical studies had employed linear models in the analysis. There is possibility that the model used might not able to capture the effect og exchange rate dynamics correctly. Nonlinearity in the nominal exchange rate could be due to the transaction cost (Micheal et al., 1997), diversity of opinion amongst market practitioners (Kilian and Taylor, 2003), and intervention of central bank (Suardi, 2007). The presence of transactions costs in the exchange rate determination model imply a nonlinear adjustment process toward purchasing power parity (PPP) (Micheal et al., 1997). The intervention of central bank are effective in changing the direction of exchange rate movement (Suardi, 2007). There are limited application of the nonlinear models in the analysis of central bank intervention in the past studies. This could be due to the limitation of the data and there is no clear timing or magnitude of the intervention.

In this paper, we are focusing on the analysis of the ERPT into import prices incorporating with the case of central bank intervention in Korea. In Korea, One of the methods of intervention in the foreign exchange rate market is through the signalling channel. The Bank of Korea will give warning to the market participants regarding the recent movements of the foreign exchange market (Ryoo et al. 2013). This will change the expectations about the future exchange rates of market participants.

After the intervention of the foreign exchange market, the domestic money supply will be fully sterilized through issuance or withdrawal of Monetary Stabilization Bonds (MSBs). MSBs is the major sterilization instrument after the foreign exchange intervention in Korea.

Therefore, MSBs can be a good proxy to represent the central bank intervention in Korea. Figure 2.1 shows the Monetary Stabilization Bonds issued and Nominal Korean Won vis-à-vis US Dollar. Based on Figure 2.1, the movement of nominal exchange rate of Korean Won and MSBs issued are follow closely to each other. We can observe clearly large amount MSBs issued around 2008 to 2010 and in the same period there are great fluctuation of nominal exchange rate.

To overcome the drawback of the previous studies, this paper employed threshold autoregressive (TAR) model to analysis a possible nonlinear of ERPT in Korean Import. MSBs is used as the threshold variable in this study as it is a good proxy to represent the central bank intervention in Korea. In contrast to previous studies, this paper uses the contract currency-based NEER that first proposed by Ceglowski (2010) and then further developed by Shimizu and Sato (2015). Based on the data from Bank of Korea, Korean imports consist of large amount of third currency invoicing which mainly invoicing in U.S. Dollar (USD). Contract Currency Based NEER can better reflect the ERPT of Korea import rather than conventional NEER. The conventional NEER is basically trade weighted NEER, which cannot reflect the role of the third currency invoiced in Korean Import. One of the main advantages of using the contract currency based NEER is that it is an industry-specific NEER which can reflect the degree of exchange rate risk faced by importers across different industries.

The estimation results show that the ERPT to Korean import is relatively high. In short run, we found significant ERPT into import price for all industries. These results are consistent with the previous studies. The results imply that the exporter firms have higher tendency to choose foreign currency in invoicing. In the long run, the ERPT is relatively high and significant for all the industries. Based on the equality test results, there are several industries exhibit the significant different in the level of ERPT. The results show the ERPT tend to be high during intervention period which mean the exchange rate is highly volatile.

The reminder of this paper is organized as follows. Section 2 describes the foreign exchange market intervention. Section 3 explain the data and methodology. Section 4 present the results of estimation and discussion. Section 5 is the conclusion.

2.2. Foreign exchange market intervention

In order to achieve exchange rate market stabilization in Korea, the foreign exchange market intervention had been used as a main instrument. Korea had changed to a flexible exchange rate regime since December 1997 after the Asian financial crisis. With this shift of exchange rate regime, the inflation targeting framework was chosen as Korea's monetary policy. Due to the difficulty in achieving the inflation rate target and exchange rate target simultaneously, the major focus for Korea is to attain foreign exchange market stabilization through alleviating excess short-term exchange rate volatility.

The main objective of foreign exchange rate intervention in Korea is to stabilize the foreign exchange market by mitigate short term exchange rate volatility. Besides that, it also acts to acquire foreign reserves. The Korean won is vulnerable due to Korea's high degree of capital market openness and the large amount of banks' external debt (Ryoo et al., 2013). There are two administrative bodies involved in Korea exchange rate intervention which are the Ministry of Strategy and Finance (MOSF) and the Bank of Korea (BOK).

There are two often used intervention tools which are signalling intervention and direct intervention in the spot market (Rhee and Lee, 2004). Signalling intervention is used to give speculative forces a warning regarding the authorities' intention to exchange rate movement. Spot market intervention is used when the authorities aim for alleviating excess short-term exchange rate volatility. After the foreign exchange intervention, the domestic money supply is sterilized by the Bank of Korea. The main sterilization instrument is through issuance and withdrawal of MSBs. The MSBs is a unique policy tool used by Korean government to control excess liquidity. Study done by Kim and Kim (2012) shows that the MSBs spread can serve as a signal for a financial crisis. After 1997 financial crisis, MSBs act as important foreign currency reserves management tool. By considering above point, MSBs can be used as a good proxy to indicate the foreign exchange intervention in Korea.

2.3. Data and Methodology

2.3.1 Data

The data collected are monthly data from January 2000 to March 2017 including industries breakdown Won-Based Import Price Index, Contract Currency Based Import Price Index, Industrial Production Index (IPI), Producer Price Index (PPI), Consumer Price Index (CPI) and Monetary Stabilisation Bonds (MSBs). The data are collected from the Bank of Korea. Nominal Effective Exchange Rate and Real Effective Exchange Rate are collected from Bank of International Settlement (BIS).

2.3.2 Contract Currency Based NEER

In contrast with previous studies, the contract currency based NEER is employed in this study. The contract currency based NEER was first proposed by Ceglowski (2010) and then further extended by Shimizu and Sato (2015). Conventional NEER are constructed by using trade weighted average bilateral nominal exchange rate. However, the contract currency based NEER is invoice currency shares weighted average bilateral nominal exchange rate. Based on the Bank of Korea, Korean imports consist of large amount of third currency invoicing which mainly invoicing in U.S. Dollar (USD). The contract currency based NEER can be constructed by using two type of import price indices published by the BOK. These two types of import price indices include Won-Based import price index and contract currency-based import price index.

Below shows the derivative of the contract currency based NEER. For simplicity, assume that there are only four currencies used in Korean imports: Korean Won, USD, Euro and Japanese Yen. The contract currency-based import price index, IMP^{con} and Won-Based import price index, IMP^{won} can be expressed as following:

$$IMP^{con} = (P_{won})^{p} (P_{usd})^{q} (P_{euro})^{r} (P_{jpy})^{s} \quad (2.1)$$

$$IMP^{won} = (P_{won})^{p} (P_{usd} \cdot E_{won/usd})^{q} (P_{euro} \cdot E_{won/euro})^{r} (P_{jpy} \cdot E_{won/euro})^{s} \quad (2.2)$$

where P_{won} denote the price of import in Korean Won, P_{usd} denote the price of import in USD, P_{euro} denote the price of import in Euro and P_{jpy} denote the price of import in Japanese Yen. p,q,r and s denote the share of the currency invoice in the import. $E_{i/j}$ denote the bilateral exchange rate i vis-à-vis j.

BOK gather the information on the price of imported goods in the contract currencies. BOK will construct import price index on a contract currency basis. The domestic currency units are then computed by using the contract currency prices with the monthly average exchange rates. By dividing equation (2.1) and equation (2.2), we can obtain following formula of the contract currency based NEER:

$$NEER_{jt}^{con} = \frac{IMP_{jt}^{won}}{IMP_{jt}^{con}} = (E_{won/usd})^{q}(E_{won/euro})^{r}(E_{won/euro})^{s} \tag{2.3}$$

with refer to above discussion, the four contract currencies, can be further generalized into more contract currencies. With refer to the Figure 2.2, around 80% of Korean imports were invoice in USD.

2.3.3 Marginal Cost

Following Campa and Goldberg (2005), the foreign production, MC_t can be obtain by:

$$MC_t = \frac{NEER_t}{REER_t} \cdot CPI_t \tag{2.4}$$

where $NEER_t$, $REER_t$ and CPI_t are the nominal effective exchange rate, real effective exchange rate and consumer price index at time t respectively.

2.3.4 Empirical model

In this study, threshold autoregression (TAR) model is employed. To estimate the threshold, this study employed the conventional ERPT model proposed by Goldberg and Knetter (1997).

$$\ln P_t = \alpha_0 + \alpha_1 \ln X_t + \alpha_2 \ln ER_t + \alpha_3 \ln Z_t + \varepsilon_t \tag{2.5}$$

where P_t is the price for the goods, X is the independent variables and ER is the exchange rate. Z_t is the control variables in the model. ε_t is the error term.

The first difference specification of the equation (2.5) is used. Such kind of specification is used in previous studies (Ceglowski, 2010). Equation (2.5) can be extended into the threshold model, the model is given by following equation:

$$\Delta IMP_{jt} = \begin{cases} c_1 + \sum_{i=0}^{q} \alpha_{1i} \Delta NEER_{jt-i} + \sum_{i=0}^{r} \beta_{1i} \Delta mc_{t-i} + \sum_{i=0}^{s} \phi_{1i} \Delta ipi_{t-i} + \varepsilon_t, \ \ if \ \ MSB_{t-i} < \omega \\ c_2 + \sum_{i=0}^{q} \alpha_{2i} \Delta NEER_{jt-i} + \sum_{i=0}^{r} \beta_{2i} \Delta mc_{t-i} + \sum_{i=0}^{s} \phi_{2i} \Delta ipi_{t-i} + \varepsilon_t, \ \ if \ \ MSB_{t-i} > \omega \end{cases} \tag{2.6}$$

where IMP_{it} is the Won-Based import price index of industry j at time t, $NEER_{jt}$ is the contract currency based nominal effective exchange rate of industry j. An increase in $NEER$ denotes the depreciation of the Korean Won. mc_t denotes the marginal cost. ipi_t denotes the industrial production index. ε_t denotes the error term. MSB_t is the amount of Monetary Stabilization Bonds issued. ω is a threshold selected from MSB_t. If MSB_t exceeds the threshold level, ω it is denote there is foreign exchange intervention; otherwise, it is considered as no foreign exchange intervention. The maximum lag length for all variable are set as three and six. All variables are natural log transformed variables.

The short run ERPT coefficient is given by α_{10} and α_{20}, while the long run ERPT coefficient is given by $\sum_{i=0}^{q}\alpha_{1i}$ and $\sum_{i=0}^{q}\alpha_{2i}$. The equality test is conducted to examine the significance different between $\sum_{i=0}^{q}\alpha_{1i}$ and $\sum_{i=0}^{q}\alpha_{2i}$. The equality test is conducted by using Wald test and the null hypothesis is given as H_0: $\sum_{i=0}^{q}\alpha_{1i} = \sum_{i=0}^{q}\alpha_{2i}$.

2.4. Empirical Results

The import price index, *IMP* are divided into 13 categorise based on industry breakdown which include (i) all, (ii) manufacturing products, (iii) food products and beverages, (iv) Fiber products and leather products, (v) wood and paper products, (vi) chemical products, (vii) non-metallic mineral products, (viii) basic metal products, (ix) metal products, (x) general machinery. (xi) electrical and electronic equipment, (xii) transport equipment, and (xiii) other manufacturing products.

Before proceeding into the threshold regression, the unit root test was employed to check the stationarity of the data. The unit root test employed in this paper is Augmented Dickey-Fuller (ADF) test. The results of ADF suggest that all variables are stationary at first different and non-stationary at level. For the threshold regression, two regimes are defined, regime 1 denotes no foreign exchange intervention while regime 2 denotes there is foreign exchange intervention.

2.4.1 Import Price Index

The threshold regression estimation results are presented in Table 2.1 and Table 2.2. The results show that the Korean import ERPT in the short run are found to be high and statistically significant for all industries. While for the long run ERPT, all the industries exhibit the significant incomplete ERPT in Korean Import. The level of ERPT is high in overall. The estimated results for lag=3 and lag=6 are almost similar. These finding are consistent with the past empirical research on Korean Import (Kang and Wang, 2003; Ghosh and Rajan, 2007). As discussed by Gopinath et al. (2010), the short run ERPT are related to the choice of the invoicing currency use in the import. While for the long run ERPT are more likely to be affected by firms' pricing behaviour and other macroeconomics variables. As show in Figure 2.2, the share of foreign currencies is large for overall Korean import, therefore, ERPT is significant for all industries.

For results of the long run model with lag=3 and lag=6, the ERPT level is high in overall. The level of ERPT is higher for regime 2 for both the long run model with lag=3 and lag=6. This indicate that the central bank intervention does have significant effect on the ERPT level. During foreign exchange intervention, the exchange rate is expected to be more volatility, which mean that the exchange rate risk is higher. The exporters tend to have higher pass through into Korean import to protect themselves. In other words, as Korean importers are price taker, the exporters pass through the exchange rate risk to the Korean importers rather than sharing the exchange rate risk. The results become more significant with the long run model with lag=6.

With refer the results of the equality test, six out of thirteen industries show significant different in the level of ERPT between regime 1 and regime 2. This confirmed that exporter firms tend to act differently during central bank intervention across the industries. From result of equality test for lag=6, the ERPT tend to be relative higher during central bank intervention. Two implications can be draw from these results. First, foreign exchange intervention has significant effect on the level of ERPT. Second, the conventional model is not able to explain the ERPT when considering the foreign exchange intervention. The foreign exchange intervention will give raise of nonlinearity in the ERPT. The results show significant different ERPT when considering the nonlinearity raise due to the foreign exchange intervention.

In order to get better understanding of Korean ERPT, the import price is replaced by the industry breakdown Producer price index. The result for producer price index is presented in table 2.2. Based on the result, the ERPT into producer price are more likely to be small. These results are consistent with the past research where ERPT into producer price are often relatively small or insignificant.

2.5. Conclusion

This paper investigates the exchange rate pass-through into import price and producer price in Korea. In contrast with previous studies, this paper consider the possibility of nonlinearity in ERPT when there is foreign exchange intervention. The MSBs is selected as the proxy of foreign exchange intervention in Korea and use as the threshold variable. Beside that, the contract currency based NEER is employed in this paper. Differ from conventional NEER, contract currency based NEER is currency invoice share weighted average which reflect the role of the third currency invoiced in Korean Import.

The results show that the overall pass through to import price is relatively high. In short run, we found significant ERPT into import price for all industries. These results are consistent with the previous studies. This implies that the exporter firm have higher tendency to choose foreign currency invoicing. In the long run, the ERPT is relatively high and significant for all the industries. Based on the equality test results, there are several industries exhibit the nonlinearities in the ERPT. The results show that the level of ERPT tend to be high during intervention period which mean the exchange rate is highly volatile.

The results reveal that the ERPT is different across the industries and also different during foreign exchange intervention period. During the intervention period, the exchange rate tends to be more volatile, exporters might protect themselves by choosing higher pass through to the importers. The conventional model might not be enough to explain the ERPT behaviour. Understanding the ERPT behaviour is important in considering the impact of exchange rate movement in Korean import.

References

Bailliu, J, and Fujii, E. 2004. Exchange rate pass-through and the inflation environment in industrialized countries: an empirical investigation. *Working Papers 2004-21,* Bank of Canada

Campa, J. M. and Goldberg, L. S. 2005. Exchange rate pass-through into import prices. *The Review of Economics and Statistics*. 87 (4): 679–690

Cavoli, T., and Rajan, R.S., 2007. Inflation Targeting Arrangements in Asia: Exploring the Role of the Exchange Rate. *Briefing Notes in Economics. No. 74.*

Ceglowski, J. 2010 Has Pass-Through to Export Prices Risen? Evidence for Japan. *Journal of the Japanese and International Economies*. 24:86-98

Choudhri, E. U., Faruqee, H. and Hakura, D. S. 2005. Explaining the exchange rate pass-through in different prices. *Journal of International Economics.* 65 (2): 349–374

Choudhri, E. U., and Hakura, D. S. 2015. The exchange rate pass-through to import and export prices: The role of nominal rigidities and currency choice. *Journal of International Money and Finance.* 51: 1-25

Ghosh, A., and Rajan, R. S. 2009 Exchange rate pass-through in Korea and Thailand: Trends and determinants *Japan and the World Economy* 21:55-70

Goldberg, P. K, and Knetter, M. M. 1997 Goods prices and exchange rates: what have we learned? *Journal of Economic Literature* 35(3):1243-1272

Gopinath, G., Itskhoki, O., and Rigobon R., 2010 Currency choice and exchange rate pass-through *American Economic Review* 100 (1):304-336

Ito, T., Sasaki, Y. N. and Sato, K. 2005 G Pass-Through of Exchange Rate Changes and Macroeconomic Shocks to Domestic Inflation in East Asian Countries. *RIETI Discussion Paper Series 05-E-020*

Kang, S., and Wang, Y., 2003. Fear of Floating: Exchange Rate Pass-through in East Asia. *Working Paper No. 03-06. Korea Institute of Economic Policy.*

Kilian, L., and Taylor, M., 2003. The monetary stabilization bond spread as a signal for financial crisis *Journal of International Economics* 60: 85–107.

Kim, J., and Kim, Y., 2012. Why is it so Difficult to Beat the Random Walk Forecast of Exchange Rates? *Journal of International Economics* 60: 85–107.

Michael, P., Nobay, A.R., and Peel, D.A., 1997. Transactions Costs and Nonlinear Adjustment in Real Exchange Rates: An Empirical Investigation. *Journal of Political Economy* 105: 862–879

Rhee, G. and Lee E. 2004. *Foreign Exchange Intervention and Foreign Exchange Market Development in Korea. BIS Paper no 24.*

Ryoo S., Kwon T. and Lee, H. 2013. A chapter in *Market volatility and foreign exchange intervention in EMEs: what has changed? Bank for International Settlements 73:* 205-213

Shimizu, J., and Sato, K. 2015 Abenomics, Yen depreciation, trade deficit and export competitiveness. *RIETI Discussion Paper Series 15-E-020*

Suardi, S. 2008. Central Bank Intervention, Threshold Effects and Asymmetric Volatility: Evidence from the Japanese Yen–us Dollar Foreign Exchange Market *Economic Modelling 25:628-642.*

Table 2.1 Threshold regression estimation results for Won-based import price index

Industry	Short Run Lag=3		Long Run Lag=3		
	Regime 1	Regime 2	Regime 1	Regime 2	Remark
All	0.563*	0.407*	0.407*	0.063	-1.364
Manufacturing products	0.522*	0.706*	0.364**	0.554*	1.116
Food products & beverages	1.036*	0.614*	1.026*	0.563*	-1.704***
Fiber products & leather products	0.812*	0.917*	0.647*	0.829*	0.936
Wood & paper products	0.551*	0.790*	-0.024	0.399*	-1.703***
Chemical products	0.732*	0.619*	0.484*	0.262	1.057***
Non-metallic mineral products	0.860*	0.438*	0.862*	0.435**	1.856
Basic metal products	0.422*	0.435*	0.358	-0.003	1.330
Metal products	0.927*	0.695*	0.924*	0.609*	2.445**
General machinery	0.779*	0.870*	0.839*	0.949*	-0.960
Electrical & electronic equipment	0.592*	0.871*	0.498*	0.843*	-2.019**
Transport equipment	0.793*	0.846*	0.827*	0.959*	-1.240
Other manufacturing products	0.564*	0.860*	0.566*	0.822*	-1.664**

Note: (a) asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively. (b)Remark report the t-statistic of equality test

Table 2.2 Threshold regression estimation results for Won-based import price index

Industry	Long Run Lag=6 Regime 1	 Regime 2	 Remark
All	0.129	0.679*	-1.774***
Manufacturing products	0.529*	0.906*	-2.308**
Food products & beverages	0.644*	1.813*	-2.660*
Fiber products & leather products	0.563**	1.011**	-1.647
Wood & paper products	0.436	0.437	-0.003
Chemical products	0.527*	0.780*	-1.052
Non-metallic mineral products	1.056*	0.989**	0.154
Basic metal products	-0.027	0.093	-0.335
Metal products	0.972*	1.020*	-0.200
General machinery	0.916*	0.970*	-0.340
Electrical & electronic equipment	0.353	0.864*	-1.969***
Transport equipment	0.865*	0.939*	-0.522
Other manufacturing products	0.804*	0.790*	0.062

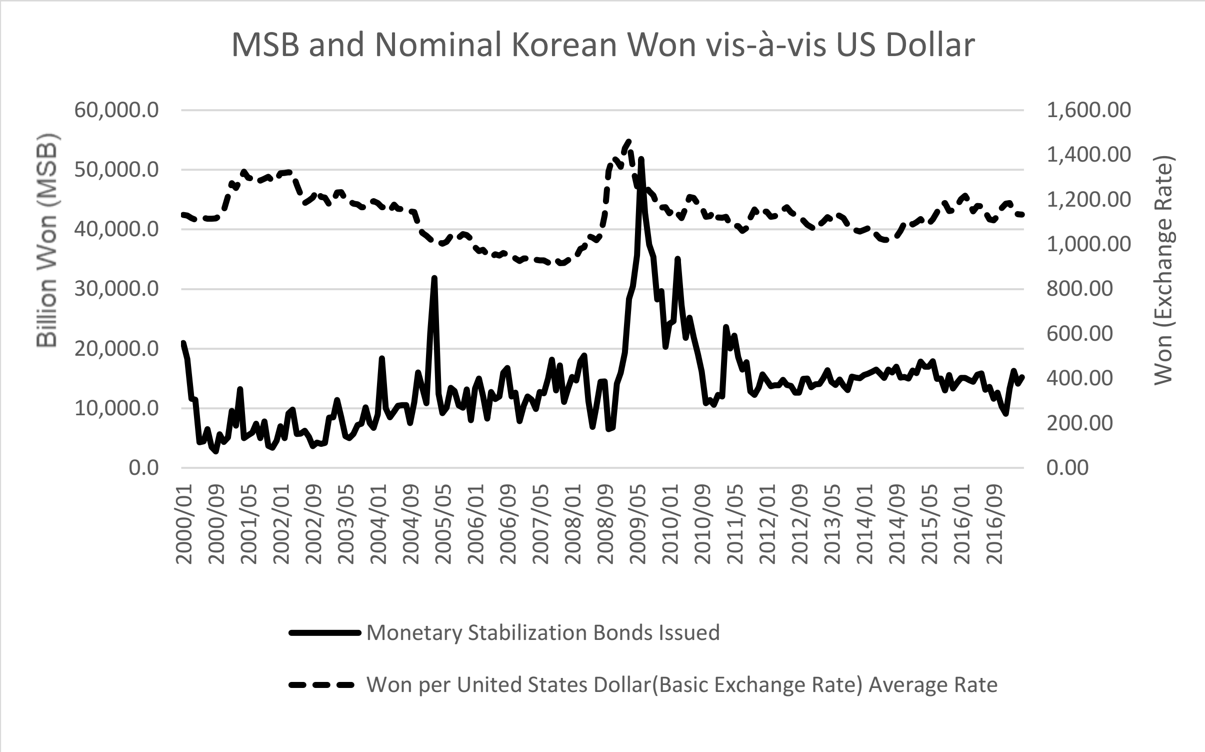
Note: (a) asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively. (b)Remark report the t-statistic of equality test

Table 2.3 Threshold regression estimation results for Producer Price Index

Industry	Short Run Lag=3		Long Run Lag=3		
	Regime 1	Regime 2	Regime 1	Regime 2	Remark
All	0.022	0.037	0.034	-0.031	-1.039
Manufacturing products	0.030	0.105**	0.045	0.062	0.190
Food products & beverages	0.016	0.033	0.099*	-0.026	-1.679***
Fiber products & leather products	0.046***	0.108	-0.002	0.135*	2.374*
Wood & paper products	0.027	0.069	0.085**	0.085	0.009
Chemical products	0.041	0.114	-0.036	-0.060	0.142
Non-metallic mineral products	0.108***	0.162*	0.055	0.204*	-1.378
Basic metal products	-0.081	0.356*	-0.041	0.368	-1.654***
Metal products	-0.192*	0.039***	-0.042	0.111*	-1.473
General machinery	-0.062**	0.017	0.018	0.070*	-1.209
Electrical & electronic equipment	0.156**	0.224*	0.051	0.162	-0.828
Transport equipment	0.004	-0.004	0.019	-0.017	0.751
Other manufacturing products	0.019		0.090***		

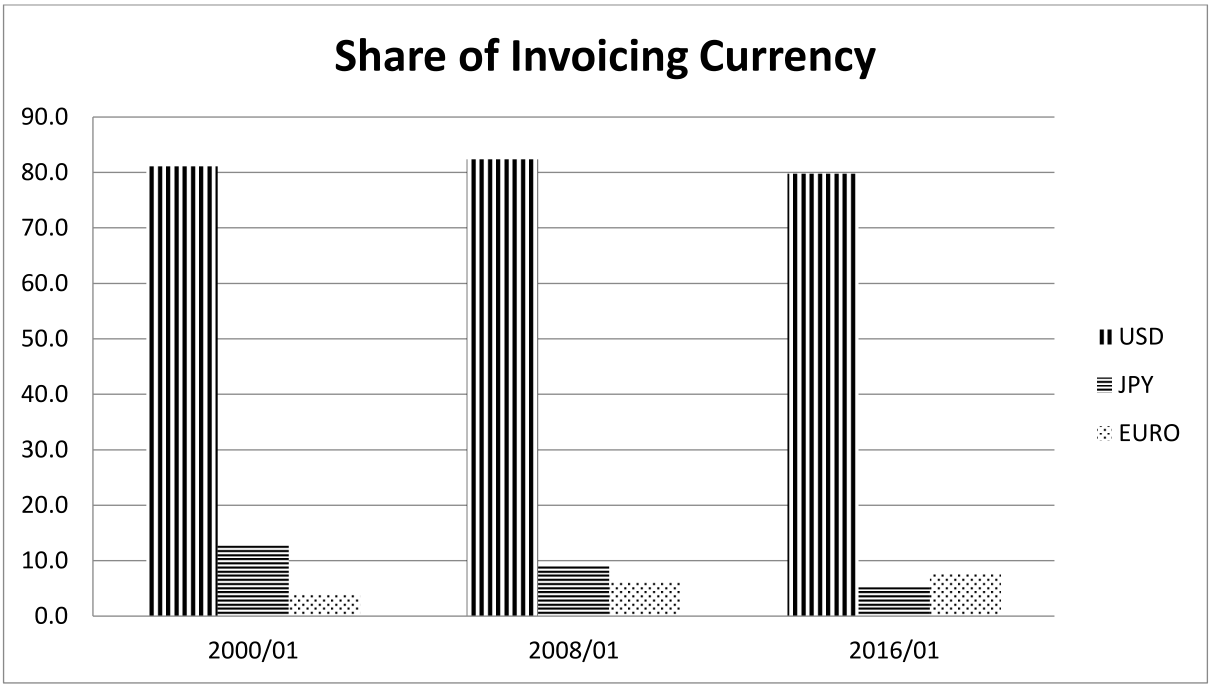
Note: (a) asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively. (b)Remark report the t-statistic of equality test

Figure 2.1 Monetary Stabilization Bonds issued and Nominal Korean Won vis-à-vis US Dollar



Source: Bank of Korea

Figure 2.2 Share of invoicing currency



Source: Bank of Korea

Appendix:2.1 Threshold regression estimation results for Won-based import price index lag=3

	All		Manufacturing Products	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	-0.0167*	0.0076	-0.0042	-0.0079*
Δ $NEER_t$	0.5634*	0.4066*	0.5218*	0.7057*
Δ $NEER_{t-1}$	-0.1226***	0.0052	-0.0965	-0.0842**
Δ $NEER_{t-2}$	0.0467	-0.3584	0.0388	-0.0295
Δ $NEER_{t-3}$	-0.0806	0.0098	-0.0999	-0.0380
Δ MC_t	7.5877*	-0.0366	8.8336*	3.2178*
Δ MC_{t-1}	-0.0533	0.9720	-5.2742*	1.0825**
Δ MC_{t-2}	1.1755	0.7622	4.8874*	0.5862
Δ MC_{t-3}	0.2466	1.0907	-3.0494***	-0.0397
Δ IPI_t	0.1259	-0.3604	0.0615	0.0018
Δ IPI_{t-1}	0.0290	-0.4339	-0.2827**	-0.0923
Δ IPI_{t-2}	0.1681	-0.3491	-0.1618	-0.1304**
Δ IPI_{t-3}	0.0607	-0.2140	-0.3737*	-0.0813
Sample Size	207		207	
R^2	0.6063		0.8083	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

	Food Products & Beverages		Fiber Products & Leather Products	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	0.0145***	-0.0099*	0.0041	-0.0021
Δ $NEER_t$	1.0358*	0.6138*	0.8118*	0.9169*
Δ $NEER_{t-1}$	-0.3210**	0.0026	-0.2471***	-0.0414
Δ $NEER_{t-2}$	0.6294*	-0.0285	-0.0028	0.0048
Δ $NEER_{t-3}$	-0.3181	-0.0249	0.0853	-0.0513
Δ MC_t	0.4995	2.3170*	4.8231**	1.3550**
Δ MC_{t-1}	-2.1168	0.3781	-3.3339***	0.2366
Δ MC_{t-2}	0.4086	0.7645	6.2438*	-0.2418
Δ MC_{t-3}	-3.7666	2.6076*	-6.4733**	0.6030
Δ IPI_t	0.8056*	0.1096	0.3985*	-0.0202
Δ IPI_{t-1}	0.3538	0.1644***	-0.5994*	-0.0403
Δ IPI_{t-2}	0.0669	0.1732***	-0.3479*	-0.0191
Δ IPI_{t-3}	-0.7144*	0.0587	-0.5126*	0.0343
Sample Size	207		207	
R^2	0.6332		0.8018	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

	Wood & Paper Products		Chemical Products	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	-0.0227*	-0.0042***	-0.0125*	0.0094**
Δ $NEER_t$	0.5511*	0.7898*	0.7318*	0.6189*
Δ $NEER_{t-1}$	-0.3185**	-0.0724	-0.1524*	-0.0373
Δ $NEER_{t-2}$	-0.0795	-0.2186*	-0.0504	-0.0986
Δ $NEER_{t-3}$	-0.1768	-0.0998	-0.0450	-0.2206**
Δ MC_t	-3.0094	0.4761	5.1089*	0.9974
Δ MC_{t-1}	3.1761	0.8066	1.3859**	3.5164**
Δ MC_{t-2}	-3.4369	0.8595	1.2669***	0.0446
Δ MC_{t-3}	7.7342**	0.7971	0.4842	-3.6036**
Δ IPI_t	-0.0461	0.0763	0.0636	-0.2609***
Δ IPI_{t-1}	0.4612	0.0640	-0.0984	-0.6321*
Δ IPI_{t-2}	0.6675*	0.0770	-0.0594	-0.4407**
Δ IPI_{t-3}	0.8896*	0.1054	-0.0734	-0.0601
Sample Size	207		207	
R^2	0.6985		0.7318	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

	Non-Metallic Mineral Products		Basic Metal Products	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	-0.0056**	-0.0103***	-0.0094	0.4351*
Δ $NEER_t$	0.8602*	0.4381*	0.4224*	-0.0827*
Δ $NEER_{t-1}$	0.0074	0.1639	-0.2334	-0.0591
Δ $NEER_{t-2}$	-0.0562	-0.1615	0.4182*	-0.2966*
Δ $NEER_{t-3}$	0.0508	-0.0057	-0.2488**	4.0647*
Δ MC_t	0.5953	1.6081	9.0810*	0.8371
Δ MC_{t-1}	0.6567	3.6884**	-0.1848	1.7097
Δ MC_{t-2}	0.2162	3.0117**	2.8577	0.4411
Δ MC_{t-3}	0.0003	-1.2791	1.0568	-0.0557
Δ IPI_t	0.0385	-0.0626	0.0069	-0.2407
Δ IPI_{t-1}	-0.0155	-0.0889	-0.1586	-0.2333
Δ IPI_{t-2}	-0.0268	-0.2483	0.1205	-0.1251
Δ IPI_{t-3}	0.0954	-0.5428*	-0.1229	0.4351
Sample Size	207		207	
R^2	0.6677		0.5010	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

	Basic Metal		General Machinery	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	0.0005	0.0151*	-0.0011	0.0002
Δ $NEER_t$	0.9274*	0.6954*	0.7786*	0.8695*
Δ $NEER_{t-1}$	0.0180	-0.1471**	0.1282*	0.0692
Δ $NEER_{t-2}$	-0.0113	0.1364***	-0.0197	0.0834
Δ $NEER_{t-3}$	-0.0106	-0.0761	-0.0478	-0.0729
Δ MC_t	0.5380	-5.1882*	0.4113	0.5293
Δ MC_{t-1}	-0.1009	-2.6974***	-0.7856	-1.2017
Δ MC_{t-2}	0.4051	3.0675***	1.6179*	-1.2513
Δ MC_{t-3}	-0.5168	3.2728**	-0.4298	3.2628*
Δ IPI_t	0.0248	-0.2255	-0.0411	0.1185
Δ IPI_{t-1}	-0.0851	-0.3643**	-0.1681**	0.1804***
Δ IPI_{t-2}	-0.0121	-0.6039*	-0.0337	-0.1231
Δ IPI_{t-3}	0.0022	-0.2653*	-0.0191	-0.1276***
Sample Size	207		207	
R^2	0.8807		0.8716	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

	Electrical & Electronic Equipment		Transport Equipment	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	-0.5399	-3.0460*	-0.0003	-0.0006
Δ $NEER_t$	6.4015*	25.9021*	0.7927*	0.8464*
Δ $NEER_{t-1}$	-0.2094	1.5081	0.0995**	0.0424
Δ $NEER_{t-2}$	0.1307	-0.8403	-0.0197	0.1706*
Δ $NEER_{t-3}$	-1.0702	-1.4288	-0.0455	-0.1003**
Δ MC_t	3.5510*	-0.4449	0.4993	0.8730
Δ MC_{t-1}	-3.8472*	-0.6114	-0.5392	-0.3570
Δ MC_{t-2}	3.8999*	0.0965	0.8901**	-2.1841*
Δ MC_{t-3}	-2.4180**	1.8335***	-0.4201	2.8440*
Δ IPI_t	-0.3069	-0.8904	-0.0595	0.1755*
Δ IPI_{t-1}	-3.0607*	-0.8002	-0.1468*	0.1812**
Δ IPI_{t-2}	-2.9200*	-1.1109	-0.0743	-0.0016
Δ IPI_{t-3}	-4.4526*	-0.7877	-0.0480	-0.0763
Sample Size	207		207	
R^2	0.8682		0.8658	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

	Other Manufacturing Products	
	Regime 1	Regime 2
Constant	0.0029	-0.0023
Δ $NEER_t$	0.5637*	0.8603*
Δ $NEER_{t-1}$	-0.0369	-0.0130
Δ $NEER_{t-2}$	0.0228	0.0605
Δ $NEER_{t-3}$	0.0165	-0.0861***
Δ MC_t	2.4050**	-0.4170
Δ MC_{t-1}	-1.9967**	0.9147***
Δ MC_{t-2}	2.1293**	0.1974
Δ MC_{t-3}	-0.7550	0.0766
Δ IPI_t	-0.0805	0.0744
Δ IPI_{t-1}	-0.2483**	0.0181
Δ IPI_{t-2}	-0.1457	0.0264
Δ IPI_{t-3}	-0.1264	-0.0133
Sample Size	207	
R^2	0.7681	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

Appendix:2.2 Threshold regression estimation results for Won-based import price index lag=6

	All		Manufacturing Products	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	0.0176**	-0.0158*	-0.0050**	-0.0114*
Δ $NEER_t$	0.6578*	0.5257*	0.7423*	0.6068*
Δ $NEER_{t-1}$	-0.3353*	0.0443	-0.1230**	0.0175
Δ $NEER_{t-2}$	-0.1273	0.0566	0.0848***	0.0010
Δ $NEER_{t-3}$	0.1266	-0.0645	-0.0864	-0.0410
Δ $NEER_{t-4}$	-0.1321	0.2732*	0.0246	0.1947*
Δ $NEER_{t-5}$	0.0180	-0.0725	-0.0413	0.0474
Δ $NEER_{t-6}$	-0.0785	-0.0835	-0.0724	0.0792
Δ MC_t	5.8690*	7.1450*	4.1038*	2.3548
Δ MC_{t-1}	-0.7038	0.7990	0.4733	0.2132
Δ MC_{t-2}	2.6447	0.4145	1.2416**	0.0832
Δ MC_{t-3}	-3.2230***	-0.0047	-0.4464	0.6751
Δ MC_{t-4}	1.2423	-0.6519	0.6024	-0.2431
Δ MC_{t-5}	-2.1192	-0.6149	-1.0531**	1.1963
Δ MC_{t-6}	-5.9258**	-0.4627	-1.2186	-0.4148
Δ IPI_t	-0.0637	0.0629	0.0195	0.0274
Δ IPI_{t-1}	-0.3358	0.1045	-0.1358**	-0.0134
Δ IPI_{t-2}	-0.3946***	0.2269***	-0.0402	0.0540
Δ IPI_{t-3}	-0.4964**	0.2823**	-0.1388***	0.2979*
Δ IPI_{t-4}	-0.5751*	0.3842*	-0.0616	0.5108*
Δ IPI_{t-5}	-0.5060*	0.2831**	-0.0242	0.4069*
Δ IPI_{t-6}	-0.2179	0.1388	0.0249	0.1593**
Sample Size	207		207	
R^2	0.6737		0.8521	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

	Food Products & Beverages		Fiber Products & Leather Products	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	-0.0096*	-0.0412*	0.0218**	-0.0009
Δ $NEER_t$	0.7189*	0.3864	0.8352*	0.9382*
Δ $NEER_{t-1}$	-0.0045	0.0265	-0.1534	0.0027
Δ $NEER_{t-2}$	0.0736	0.1093	-0.0178	0.0320
Δ $NEER_{t-3}$	-0.1316***	0.4288***	-0.0444	-0.0411
Δ $NEER_{t-4}$	0.0653	0.1513	0.2674**	0.0553
Δ $NEER_{t-5}$	-0.0100	0.5158**	0.0367	0.0368
Δ $NEER_{t-6}$	-0.0673	0.1953	-0.3604*	-0.0124
Δ MC_t	0.8301	0.8559	3.2912	1.5145**
Δ MC_{t-1}	0.5502	-8.7578**	-4.7088**	0.6798
Δ MC_{t-2}	0.7595	-0.8678	9.2383*	0.2572
Δ MC_{t-3}	2.2306**	3.6547	-6.1428**	1.3081**
Δ MC_{t-4}	-0.2192	10.8489*	-7.2065**	-0.4049
Δ MC_{t-5}	0.4500	0.9565	-2.1114	-0.7763
Δ MC_{t-6}	0.7408	3.4115	-0.0846	-1.3762**
Δ IPI_t	0.0663	1.1943*	0.2455	-0.0381
Δ IPI_{t-1}	0.0614	1.8690*	-0.6640*	-0.0781
Δ IPI_{t-2}	0.1572	1.8103*	-0.4317**	-0.0257
Δ IPI_{t-3}	0.1924***	0.9372**	-0.8743*	0.0903
Δ IPI_{t-4}	0.2034***	0.9596*	-0.0890	0.0537
Δ IPI_{t-5}	0.1720	0.5895***	-0.1567	-0.0032
Δ IPI_{t-6}	0.0488	0.2566	-0.1718	-0.0384
Sample Size	207		207	
R^2	0.6848		0.8395	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

	Wood & Paper Products		Chemical Products	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	-0.0606**	-0.0040	-0.0049	-0.0098*
Δ $NEER_t$	0.5549*	0.7878*	0.8102*	0.5016*
Δ $NEER_{t-1}$	-0.4010***	-0.0663	-0.2125*	0.0088
Δ $NEER_{t-2}$	0.0763	-0.1551**	0.0050	-0.0757
Δ $NEER_{t-3}$	0.3474	-0.1437**	-0.0148	-0.0721
Δ $NEER_{t-4}$	-0.3841**	0.1141***	-0.0259	0.1347***
Δ $NEER_{t-5}$	0.2453	-0.0873	0.0789	0.1814**
Δ $NEER_{t-6}$	-0.0034	-0.0130	-0.1136	0.1017
Δ MC_t	-1.2541	0.3860	4.8609*	2.0173***
Δ MC_{t-1}	-0.1771	0.7169	2.0953*	1.3242
Δ MC_{t-2}	-1.1871	0.7860	0.9337	0.7629
Δ MC_{t-3}	0.5839	0.8450	0.5241	-1.0307
Δ MC_{t-4}	13.2273*	-0.6738	0.1927	-0.3281
Δ MC_{t-5}	-0.5337	-0.1813	-2.0583**	1.5219
Δ MC_{t-6}	2.6156	-0.3708	-1.1591	-0.5647
Δ IPI_t	0.7261**	0.1399***	0.0099	0.1199
Δ IPI_{t-1}	1.1259**	0.1461	-0.1798***	-0.1834
Δ IPI_{t-2}	1.4932*	0.1389	-0.1240	-0.0781
Δ IPI_{t-3}	1.5376*	0.2062***	-0.2044***	0.2845***
Δ IPI_{t-4}	1.0747**	0.2055**	-0.1535	0.4637*
Δ IPI_{t-5}	0.8832**	0.2524*	-0.0058	0.4258*
Δ IPI_{t-6}	0.6744**	0.0796	0.0278	0.1483
Sample Size	207		207	
R^2	0.7534		0.7793	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

	Non-Metallic Mineral Products		Basic Metal Products	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	-0.0066**	-0.0169	-0.0150***	-0.0111*
Δ $NEER_t$	0.7833*	0.4690	0.3908*	0.4206*
Δ $NEER_{t-1}$	0.0438	0.1718	-0.2113	-0.0034
Δ $NEER_{t-2}$	0.0590	0.0149	0.4046*	0.0192
Δ $NEER_{t-3}$	0.0164	0.2904	-0.1378	-0.2678*
Δ $NEER_{t-4}$	0.0616	-0.1006	-0.1755	0.0355
Δ $NEER_{t-5}$	0.0855	0.3287	-0.1119	0.0094
Δ $NEER_{t-6}$	0.0061	-0.1855	-0.1862	-0.1208
Δ MC_t	0.1483	-3.1177	10.3309*	4.5017*
Δ MC_{t-1}	-0.1373	7.6156**	-0.5272	0.9856
Δ MC_{t-2}	0.8288	3.6286	3.3723***	0.7941
Δ MC_{t-3}	0.3158	-0.1017	-0.4440	-0.4201
Δ MC_{t-4}	0.7172	-5.2686***	3.6677	-0.2912
Δ MC_{t-5}	0.4218	-2.6603	-2.4395	0.5170
Δ MC_{t-6}	-0.1458	4.1535	1.1684	-1.6882
Δ IPI_t	-0.1380	0.4743	0.1405	0.0063
Δ IPI_{t-1}	-0.1214	0.2981	-0.0456	-0.1568
Δ IPI_{t-2}	-0.0541	0.0316	0.1844	-0.0452
Δ IPI_{t-3}	0.1120	-0.2248	-0.2145	0.1927
Δ IPI_{t-4}	0.1035	1.0803*	0.0000	0.5022*
Δ IPI_{t-5}	0.1020	0.5447	0.2075	0.3646**
Δ IPI_{t-6}	0.0989	0.1083	0.0926	0.1608
Sample Size	207		207	
R^2	0.7123		0.5901	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

	Metal Products		General Machinery	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	0.0005	-0.0046	-0.0026	-0.0027
Δ $NEER_t$	0.9285*	0.7595*	0.7579*	0.8141*
Δ $NEER_{t-1}$	0.0234	-0.2253**	0.1647*	0.0820
Δ $NEER_{t-2}$	-0.0011	0.1618	-0.0276	0.0746
Δ $NEER_{t-3}$	0.0016	-0.0768	-0.0586	-0.0886
Δ $NEER_{t-4}$	0.0042	0.2361*	0.1056**	0.0808
Δ $NEER_{t-5}$	0.0400	-0.0094	-0.0452	0.0202
Δ $NEER_{t-6}$	-0.0245	0.1743**	0.0192	-0.0133
Δ MC_t	0.3484	-1.7847	0.2806	0.9187
Δ MC_{t-1}	-0.0484	-5.6441**	-1.0193**	-1.7749***
Δ MC_{t-2}	0.4779	2.6437	1.8593*	-1.6878***
Δ MC_{t-3}	-0.3481	0.3600	-0.2033	3.2492**
Δ MC_{t-4}	0.1431	1.3242	-0.2208	1.3598
Δ MC_{t-5}	0.1851	1.3333	0.4827	1.1232
Δ MC_{t-6}	-0.8761	4.8381**	-0.1880	-0.0045
Δ IPI_t	0.0084	-0.0894	-0.0538	0.1735***
Δ IPI_{t-1}	-0.0912	0.1331	-0.1539**	0.2511***
Δ IPI_{t-2}	-0.0001	0.0362	0.0113	-0.0392
Δ IPI_{t-3}	0.0438	0.4269	0.0791	-0.0406
Δ IPI_{t-4}	0.0827	0.4499**	0.1070	-0.0640
Δ IPI_{t-5}	0.1224***	0.2479	0.0562	-0.1195
Δ IPI_{t-6}	0.0251	0.0696	-0.0413	-0.1674***
Sample Size	207		207	
R^2	0.8965		0.8938	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

	Electrical & Electronic Equipment		Transport Equipment	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	-0.0057	-0.0031***	-0.0015	-0.0010
Δ $NEER_t$	0.5702*	0.8736*	0.7888*	0.8151*
Δ $NEER_{t-1}$	-0.1492	0.0822**	0.1188*	0.0870
Δ $NEER_{t-2}$	0.0335	-0.0136	-0.0374	0.1369*
Δ $NEER_{t-3}$	-0.1813***	-0.0855**	-0.0588	-0.1060***
Δ $NEER_{t-4}$	0.1107	0.0751***	0.0997**	-0.0057
Δ $NEER_{t-5}$	-0.0474	-0.0533	-0.0210	0.0433
Δ $NEER_{t-6}$	0.0168	-0.0140	-0.0246	-0.0319
Δ MC_t	5.1934*	0.0496	0.4199	1.1885
Δ MC_{t-1}	-4.4891*	-0.2241	-0.9241**	-0.2901
Δ MC_{t-2}	3.9038**	0.1641	1.3623*	-1.9159**
Δ MC_{t-3}	-3.0855	1.1538**	-0.1962	3.0386*
Δ MC_{t-4}	-1.0334	-0.1614	-0.0173	0.4399
Δ MC_{t-5}	0.4982	-0.2373	0.3277	-0.2560
Δ MC_{t-6}	2.2896	-0.7221	-0.5527	0.2269
Δ IPI_t	-0.1130	-0.0533	-0.0820**	0.1955**
Δ IPI_{t-1}	-0.4652*	-0.0559	-0.1436*	0.1425
Δ IPI_{t-2}	-0.4428*	-0.0858	-0.0177	-0.0682
Δ IPI_{t-3}	-0.6470*	-0.0590	0.0420	-0.1303
Δ IPI_{t-4}	-0.1176	-0.0509	0.1153**	-0.1153
Δ IPI_{t-5}	-0.1598	-0.0227	0.0576	-0.1377***
Δ IPI_{t-6}	0.0964	-0.0439	-0.0102	-0.1807*
Sample Size	207		207	
R^2	0.8891		0.8892	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

	Other Manufacturing Products	
	Regime 1	Regime 2
Constant	-0.0047**	-0.0029
Δ $NEER_t$	0.6867*	0.9571*
Δ $NEER_{t-1}$	-0.0165	-0.0229
Δ $NEER_{t-2}$	0.0880	0.1237
Δ $NEER_{t-3}$	-0.0671	-0.1249
Δ $NEER_{t-4}$	0.1028***	0.0041
Δ $NEER_{t-5}$	-0.0089	-0.0171
Δ $NEER_{t-6}$	0.0190	-0.1301
Δ MC_t	-0.5567	1.4446***
Δ MC_{t-1}	-0.3792	0.9645
Δ MC_{t-2}	1.6710*	-1.3392
Δ MC_{t-3}	0.2916	-0.3163
Δ MC_{t-4}	0.5491	-0.2836
Δ MC_{t-5}	0.1197	0.8935
Δ MC_{t-6}	0.0056	0.2478
Δ IPI_t	0.0508	0.1044
Δ IPI_{t-1}	-0.0349	0.1194
Δ IPI_{t-2}	0.1256***	0.0846
Δ IPI_{t-3}	0.1552**	0.0331
Δ IPI_{t-4}	0.2414*	-0.1212
Δ IPI_{t-5}	0.1579**	-0.1985**
Δ IPI_{t-6}	-0.0132	-0.1096
Sample Size	207	
R^2	0.7984	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

Appendix:2.3 Threshold regression estimation results for Producer Price Index lag=3

	All		Manufacturing Products	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	-0.0042*	0.0055*	-0.0087*	0.0036***
Δ $NEER_t$	0.0224	0.0374	0.0298	0.1053**
Δ $NEER_{t-1}$	-0.0188	-0.0124	-0.0128	0.0286
Δ $NEER_{t-2}$	0.0159	0.0295	0.0238	-0.0086
Δ $NEER_{t-3}$	0.0148	-0.0854*	0.0037	-0.0630
Δ MC_t	1.6153*	-1.1000	2.6577*	-0.3141
Δ MC_{t-1}	0.8941*	-0.0397	1.3031*	1.6284***
Δ MC_{t-2}	0.0966	1.2804*	0.4812***	-0.8746
Δ MC_{t-3}	0.2255	-0.4912	0.5186***	0.6089
Δ IPI_t	0.0423**	-0.0608	0.0671**	-0.0540
Δ IPI_{t-1}	0.0303	-0.2128*	0.0268	-0.0980
Δ IPI_{t-2}	0.0118	-0.1435*	0.0301	-0.0764
Δ IPI_{t-3}	0.0184	-0.0467	0.0069	-0.0338
Sample Size	207		207	
R^2	0.5766		0.5800	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

	Food Products & Beverages		Fiber Products & Leather Products	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	-0.0012	0.0048*	-0.0003	-0.0001
Δ $NEER_t$	0.0165	0.0331	0.0465***	0.1078*
Δ $NEER_{t-1}$	0.0558*	0.0158	-0.0448	0.0332
Δ $NEER_{t-2}$	0.0423**	-0.0661***	0.0078	-0.0175
Δ $NEER_{t-3}$	-0.0160	-0.0092	-0.0115	0.0115
Δ MC_t	0.4576**	-0.6203	0.2958	0.3828
Δ MC_{t-1}	0.4630**	-2.4235*	0.4927	0.2997
Δ MC_{t-2}	0.5312**	0.5138	0.4897	0.0812
Δ MC_{t-3}	0.4565***	2.8024*	-0.5336***	0.2460
Δ IPI_t	-0.0011	0.0661	0.0053	-0.0091
Δ IPI_{t-1}	0.0131	-0.0050	-0.0797**	0.0065
Δ IPI_{t-2}	0.0267	-0.1089**	-0.0836**	0.0239
Δ IPI_{t-3}	0.0643*	-0.1221*	-0.0785**	0.0230
Sample Size	207		207	
R^2	0.3909		0.3581	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

	Wood & Paper Products		Chemical Products	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	-0.0020**	0.0020	-0.0137*	0.0018
Δ $NEER_t$	0.0266	0.0688	0.0414	0.1137
Δ $NEER_{t-1}$	0.0276	-0.0204	-0.0604	-0.1031
Δ $NEER_{t-2}$	0.0403***	0.0872***	-0.0285	0.0530
Δ $NEER_{t-3}$	-0.0091	-0.0510	0.0112	-0.1239***
Δ MC_t	0.4345	-1.7234	4.4506*	2.0749
Δ MC_{t-1}	0.5309***	-0.4255	3.4998*	4.2552*
Δ MC_{t-2}	0.2627	3.3616*	0.5722	-1.5996
Δ MC_{t-3}	0.4300	0.2523	0.0391	-3.2191*
Δ IPI_t	-0.0084	0.1807**	0.0619	-0.0558
Δ IPI_{t-1}	0.0086	0.0412	-0.0366	-0.0783
Δ IPI_{t-2}	0.0225	-0.0366	0.0057	-0.1182
Δ IPI_{t-3}	-0.0271	0.0225	-0.0048	-0.0418
Sample Size	207		207	
R^2	0.3378		0.5709	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

	Non-Metallic Mineral Products		Basic Metal Products	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	0.0025	-0.0010	-0.0089*	0.0124
Δ $NEER_t$	0.1080***	0.1615*	-0.0812	0.3562*
Δ $NEER_{t-1}$	0.0029	0.0198	-0.0106	0.0168
Δ $NEER_{t-2}$	0.0006	0.0042	0.0990	0.3392*
Δ $NEER_{t-3}$	-0.0564	0.0180	-0.0485	-0.3438*
Δ MC_t	2.7141*	0.0265	2.6270*	-6.5131**
Δ MC_{t-1}	-3.1005*	0.2452	2.1072*	0.9655
Δ MC_{t-2}	4.0300*	0.2143	-0.4900	3.8161**
Δ MC_{t-3}	-1.5249	0.3433	2.0712*	2.4837
Δ IPI_t	-0.0080	-0.0623**	0.0941	-0.1479
Δ IPI_{t-1}	-0.1674***	-0.0355	0.1172	-0.4285
Δ IPI_{t-2}	-0.1025	-0.0082	0.0225	-0.2175
Δ IPI_{t-3}	-0.1726***	0.0100	0.0598	0.0251
Sample Size	207		207	
R^2	0.4871		0.3912	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

	Basic Metal		General Machinery	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	-0.0070**	-0.0031**	-0.0037*	0.0000
Δ $NEER_t$	-0.1922*	0.0387***	-0.0619**	0.0171***
Δ $NEER_{t-1}$	-0.0449	0.0329	0.0173	0.0192***
Δ $NEER_{t-2}$	0.1274**	0.0428***	-0.0012	0.0180***
Δ $NEER_{t-3}$	0.0678	-0.0031	0.0634*	0.0155
Δ MC_t	3.2050*	0.2014	0.8664*	-0.0295
Δ MC_{t-1}	2.1770*	0.8348**	0.1090	0.2215
Δ MC_{t-2}	1.8659**	1.1202*	1.4928*	-0.1345
Δ MC_{t-3}	-0.0153	0.5319	0.4290	0.4308*
Δ IPI_t	0.0066	-0.0585	0.0458***	0.0110
Δ IPI_{t-1}	-0.0622	-0.0394	0.0243	0.0197
Δ IPI_{t-2}	-0.1080	-0.0333	0.0187	-0.0161
Δ IPI_{t-3}	-0.0431	-0.0673	-0.0030	-0.0148
Sample Size	207		207	
R^2	0.4169		0.4137	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

	Electrical & Electronic Equipment		Transport Equipment	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	-0.0162*	-0.0038*	-0.0026*	0.0010**
Δ $NEER_t$	0.1564**	0.2242*	0.0036	-0.0036
Δ $NEER_{t-1}$	0.0936	-0.0078	0.0406	-0.0052
Δ $NEER_{t-2}$	0.0067	-0.0435***	0.0029	-0.0150
Δ $NEER_{t-3}$	-0.2057*	-0.0113	-0.0282	0.0066
Δ MC_t	0.9354	0.0023	0.4648	-0.1177
Δ MC_{t-1}	0.4796	0.1146	-0.1274	0.1985
Δ MC_{t-2}	1.6547	-0.1859	1.0032*	-0.0861
Δ MC_{t-3}	-0.7597	0.1377	0.1078	0.1224
Δ IPI_t	0.0746	0.0783**	0.0214	-0.0206
Δ IPI_{t-1}	0.1061	0.0945**	-0.0218	0.0053
Δ IPI_{t-2}	0.0882	0.0201	0.0566***	0.0027
Δ IPI_{t-3}	0.1578	-0.0174	0.0009	-0.0085
Sample Size	207		207	
R^2	0.5118		0.1781	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

	Other Manufacturing Products
Constant	0.0015**
Δ $NEER_t$	0.0188
Δ $NEER_{t-1}$	0.0169
Δ $NEER_{t-2}$	0.0472***
Δ $NEER_{t-3}$	0.0070
Δ MC_t	0.2018
Δ MC_{t-1}	-0.1990
Δ MC_{t-2}	0.1122
Δ MC_{t-3}	-0.0598
Δ IPI_t	0.0205
Δ IPI_{t-1}	-0.0207
Δ IPI_{t-2}	-0.0475
Δ IPI_{t-3}	-0.0476**
Sample Size	207
R^2	0.0767

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively.

Exchange rate pass-through to domestic prices in Malaysia

3.1. Introduction

The exchange rate pass through (ERPT) to import have been debated for long time. The degree of pass- through to import price is an important parameter in conduct of monetary policy as the import price affect the domestic inflation rate. The incomplete pass through is commonly found in previous studies (Goldberg and Knetter, 1997; Choudhri and Hakura, 2015). The complete pass through refer to the exchange rate movement is completely transmitted into import price. Most of the ERPT studies had focused on developed countries (Bailliu and Fujii, 2004; Campa and Goldberg, 2005; Choudhri, Faruqee and Hakura, 2005). Less studies were done for developing countries (Frankel, Parsley and Wei, 2012; Barhoumi, 2006). Studies done by Devereux and Yetman (2010) and Ca'Zorzi, Hahn and Sánchez (2007) shows that developing economies tend to experience high pass-through, while developed economies experience low exchange rate pass through. Few studies had supported that high inflation rate is one of the reasons for the high exchange rate pass through (Devereux and Yetman, 2010; Cheikh and Louhichi, 2016).

The possibility of asymmetric in ERPT may due to the imperfect competition where firms can absorb the exchange rate change by adjusting their mark-ups (Knetter 1993). The producers can behave differently during exchange rate appreciation and depreciation period. During appreciation period, producers can reduce their profit by conducting pricing to market (PTM) which helps to maintain importer’s demand. While during the depreciation period, the producers can reduce their export price to increase the importer demand. Hence, this lead to different in the magnitude of ERPT during appreciation and depreciation period.

Less empirical studies are done on the difference in ERPT between the currency appreciation and depreciation period (Pollard and Coughlin, 2004; Frankel et al., 2012; Bussière, 2013; Nguyen and Sato, 2017). Pollard and Coughlin (2004) had analysed asymmetries and nonlinearities in the ERPT. The results show the size of the asymmetry change across industries and the evidence of asymmetry might not show in the aggregate results. The study done by Frankel et al. (2012) shows strong evidence of asymmetries between the appreciation and depreciation period for developing countries andthis was explained by the presence of downward wage rigidity.

Bussière (2013) reveal that it is easier for exporters to mark up their price rather than decrease it as the export prices are usually downward rigid. This implies that the depreciation of exporter currency has greater effect than appreciation on import prices. Asian countries have changed their exchange rate regimes over recent decade from managed floating to floating based on the classification of the de facto exchange rate arrangement. Countries such as Malaysia, Thailand and Singapore have changed their exchange rate regime from managed floating with no pre-determined path to floating.

Malaysia has undergone the major structural transformation from a commodity-based economy to an industrial-based economy. The manufacturing sector has steadily growth since the transformation of the Malaysian economy. However, Malaysia is highly depending in import certain raw material that used for domestic production. Hence, large change in exchange rate generated greater change in production cost. After July of 2005, Malaysia had adopted managed float exchange rate regime. Such changes lead to a greater fluctuation in exchange rate. Figure 3.1 show the index of the nominal exchange rate of Malaysia Ringgit (MYR) vis-à-vis US Dollar (USD) against the Malaysia Import Price from January 2008 to July 2017.

MYR appreciated substantially from January 2009 to September 2011. During these period, we observed that there is an increase in the import price. However, during depreciation period, the import prices seem to be stable. Soon and Baharumshah (2017) found that depreciation of MYR lead to significant increase in the domestic prices.

This paper focuses on analysing the ERPT into domestic price for Malaysia. By considering the possible asymmetric effect of exchange rate on ERPT in Malaysia Import due to the appreciation and depreciation period. As mentioned in past studies, the level of ERPT can be affected by the appreciation and depreciation period of exchange rate. The Nonlinear Autoregressive Distributed Lag (NARDL) model proposed by Shin et al. (2014) is employed. This model allows to test both short run and long run asymmetry effects. The specification for the depreciation and appreciation period of exchange rate is based on Pollard and Coughlin (2004). A positive change in the home currency exchange rate (E_t), $\Delta \ln E_t > 0$, is considered to be the depreciation period, while a negative change ($\Delta \ln E_t < 0$) is included in the appreciation period. Through the analysis, overall there is still high ERPT into import price and low ERPT into consumer price.

The reminder of this paper is organized as follows. Section 2 describes the data. Section 3 explain the methodology. Section 4 present the results of estimation and discussion. Section 5 conclusion.

3.2 Data

The data collected are monthly data from January 2011 to July 2017 including Import Unit Value index, Industrial Production Index, Producer Price Index, Consumer Price Index, Nominal exchange rate MYR vis-à-vis USD, The data collected from the Department of Statistics Malaysia. Nominal Effective Exchange Rate and Real Effective Exchange Rate are collected from Bank of International Settlement (BIS). Domestic Price include Import Unit Value, Producer Price Index and Consumer Price Index. The Import Unit Value Index are based on commodity breakdown which include (i) all, (ii)food, (iii)beverages and tobacco, (iv)crude materials, , (v)chemicals, (vi)manufactured goods, (vii)machinery and transport equipment, and (viii)miscellaneous manufactured articles. Data are seasonally adjusted. To avoid the effect of the global financial crisis happened in 2008, the sample period is selected to start from January 2011.

3.3 Empirical Model

This study employed the conventional ERPT model proposed by Goldberg and Knetter (1997).

$$\ln P_t = \alpha_0 + \alpha_1 \ln X_t + \alpha_2 \ln ER_t + \alpha_3 \ln Z_t + \varepsilon_t \tag{3.1}$$

where P_t is the price for the goods, X is the independent variables and ER is the exchange rate. Z_t is the control variables in the model. ε_t is the error term.

3.3.1 ARDL Model

The conventional Autoregressive Distributed Lag (ARDL) model proposed by Pesaran et. al., (2001). The main advantage of this model is this model applicable for variables that are integrated in different level which are I(0) and I(1).

Equation (3.1) can be extended to the ARDL model. The model is given by following equation:

$$\Delta \ln IM_t = \alpha_0 + \alpha_1 \ln IM_{t-1} + \alpha_2 \ln ER_{t-1} + \alpha_3 \ln MC_{t-1} + \alpha_4 \ln IPI_{t-1}$$

$$+ \sum_{i=1}^{p} \beta_1 \Delta \ln IM_{t-i} + \sum_{i=0}^{q} \beta_2 \Delta \ln ER_{t-i} + \sum_{i=0}^{s} \beta_3 \Delta \ln MC_{t-1} + \sum_{i=0}^{v} \beta_4 \Delta \ln IPI_{t-1} + \varepsilon_t \qquad (3.2)$$

where IM_t is the import unit value index at time t, ER are bilateral exchange rate USD vis-à-vis MYR. An increase in bilateral exchange rate denotes the depreciation of the local currency. IPI_t is the industrial production index at time t. MC_t is the foreign marginal cost at time t. ε_t is the error term.

The ARDL model allow for differ lag order among the variables. The optimal lag length is determined by the Akaike Information Criteria. The bound-F-test and bound-t test are conducted to test the long run relationship between the variables. The null hypothesis of no cointegration (H_0: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$) is tested against the alternative hypothesis. Pesaran et al. (2001) proposed that applying the standard F-statistic with new critical values that they tabulate.

3.3.2 NARDL Model

Conventional ARDL model only allows for examine linear relationship. In order to examine the asymmetric effects, the NARDL model is employed. Shin et.al. (2014) further extended the ARDL model into Nonlinear Autoregressive Distributed Lag (NARDL) model by allowing the asymmetry variables inside the model. This can be done by decompose the possible asymmetric variables into partial sums by using threshold. In this paper, the asymmetric variable is the exchange rate and the threshold specification of the depreciation and appreciation period of exchange rate is based on Pollard and Coughlin (2004). A positive change in the home currency exchange rate (E_t), $\Delta \ln E_t > 0$, is considered to be the depreciation period, while a negative change ($\Delta \ln E_t < 0$) is to be the appreciation period.

$$ER_t^+ = \sum_{i=1}^{t} ER_i^+ = \sum_{i=1}^{t} \max(\Delta ER_i, 0) \qquad ER_t^- = \sum_{i=1}^{t} ER_i^- = \sum_{i=1}^{t} \min(\Delta ER_i, 0) \qquad (3.3)$$

Equation (3.2) can be extended to the (NARDL) model. The model is given by following equation:

$$\Delta \ln IM_{jt} = \alpha_0 + \alpha_{1j} \ln IM_{j,t-1} + \alpha_2 \ln ER_{t-1}^+ + \alpha_3 \ln ER_{t-1}^- + \alpha_4 \ln MC_{t-1} + \alpha_5 \ln IPI_{t-1}$$

$$+ \sum_{i=1}^{p} \beta_{1j} \Delta \ln IM_{j,t-i} + \sum_{i=0}^{q} \beta_2 \Delta \ln ER_{t-i}^+ + \sum_{i=0}^{r} \beta_3 \Delta \ln ER_{t-1}^- + \sum_{i=0}^{s} \beta_4 \Delta \ln MC_{t-1} + \sum_{i=0}^{v} \beta_5 \Delta \ln IPI_{t-1}$$

$$+ \varepsilon_t \qquad (3.4)$$

ER^+ capture the effect of ERPT during depreciation period while ER^- capture the effect of ERPT during appreciation period. The selection of lag length is based on the Akaike Information Criteria. As similar to conventional ARDL model, the bound-F-test and bound-t test are conducted to test the long run relationship between the variables. The null hypothesis of no cointegration (H_0: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0$) is tested against the alternative hypothesis. The number of regressors, *k* for long run relationship is not clear as due to the variables ER^+ and ER^-. The number of regressors should lie between three and four. As suggested by Shin et. Al. (2014), lower *k* should be used because it provides better evidence for the result. Thus, in this paper, *k=3* is selected.

Following Campa and Goldberg (2005), the foreign production, MC_t can be obtain by:

$$MC_t = \frac{NEER_t}{REER_t} \cdot CPI_t \tag{3.5}$$

where $NEER_t$, $REER_t$ and CPI_t are the nominal effective exchange rate, real effective exchange rate and consumer price index at time t respectively.

An Asymmetry test is performed by using Wald tests to check the significant different between depreciation period and appreciation period. The null hypothesis of long run Asymmetry test is given as $H_0 : -\alpha_2 / \alpha_1 = -\alpha_3 / \alpha_1$. While for the short run Asymmetry test is given as $H_0 : \beta_{2i}^{+} = \beta_{2i}^{-}$ for i=0,…,T.

3.4 Empirical Results

The Import Unit Value Index, IM are break into 8 categorise based on commodity breakdown which include (i) all, (ii)food, (iii)beverages and tobacco, (iv)crude materials, , (v)chemicals, (vi)manufactured goods, (vii)machinery and transport equipment, and (viii)miscellaneous manufactured articles..

Before proceeding into the NARDL Bound Test, the unit root test was employed to check the stationarity of the data. The unit root test employed in this paper is Augmented Dickey-Fuller (ADF) test. Based on the result, all variables are stationary at first difference.

Therefore, it is suitable to choose NARDL model to test the long run relationship as this model allows variables to be stationary at both level and first different.

Based on the Pollard and Coughlin (2004) specification, the depreciation and apperception of exchange rate is presented in Figure 3.2. From Figure 3.2, we can observe that the fluctuation of exchange rate is greater since July of 2015. This is due to the political scandal and the decline of the crude oil price. The central bank of Malaysia, Bank Negara Malaysia (BNM) had been intervening in the exchange rate market to maintain the stability of the currency. However, the effects seem to be weak.

The result of NARDL estimation and Asymmetric test are presented in table 2. The main objective in this paper is to examine the degree of ERPT in Malaysia Import and the possible different level of ERPT occurs during depreciation and appreciation periods. Overall, there is high exchange rate pass through into import price in long run. Based on the results, almost all commodities show strong evidence for cointegration relationship. However, there are two commodities cannot find a long run relationship which are food and machinery and transportation equipment. As Malaysia had transformed her economic structure from a commodity-based economy to an industrial-based economy. Malaysia is depending heavily on importing the raw materials. Commodities such as machinery and transport equipment, beverages and tobacco have high ERPT compare to other commodities. This is due to the high import demand for these goods. Malaysian tend to buy imported vehicles rather than local produced vehicles Beside that, parts of the vehicle are mainly imported. The lead to high level of ERPT.

Based on the asymmetric test results, the pricing behaviour of the exporter seem to be similar during the depreciation and appreciation period. Based on the results, almost all of the cases are show no asymmetric between the depreciation and appreciation period. This reflect that Malaysia as a price taker could not conduct different pricing strategies in different period. Exporters does not require to absorb the exchange rate risk raise because of the fluctuation of exchange rate. This is because most of the imports are invoicing in foreign currency. During depreciation period, Malaysian importers require to pay high price to exporter due to the depreciation of the MYR. Malaysian Importer can pay lower price to exporter due to the appreciation of MYR. Only the crude materials show significant different level of ERPT between depreciation and appreciation period. The crude materials including crude oil where Malaysia has producing crude oil itself. This might lead to change in the demand of crude oil during appreciation and depreciation period. Therefore, this commodity show significant different in the level of ERPT. Besides that, this result proved that using conventional ARDL model is not enough to identify the asymmetric ERPT in the long run.

In order to have better understand, the import unit value index is replaced by PPI and CPI. The estimation results show the low pass through into the producer price and no pass through into the consumer price. This result is consistent with the past studies. There is no asymmetric between depreciation and appreciation period in both long run and short run. This implied that the importers in Malaysia tend to keep their benefits from currency appreciation as a higher profit by not reducing the domestic prices and pass-through the increase in import price to consumer by raising the domestic price during depreciation period. Soon and Baharumshah (2017) found that depreciation of MYR lead to significant increase in the domestic prices.

3.5 Conclusion

This paper investigates the exchange rate pass-through into domestic prices for Malaysia. In contrast with previous studies, this paper considers the possibility of asymmetric effects in ERPT during depreciation and appreciation period. By taking into consideration of this, the Nonlinear Autoregressive Distributed Lag (NARDL) model was employed. Based on the unit root test results, all are variables are stationary in first difference.

In the long run, the estimated results revealed the existence of cointegrating relationship for most of the commodities. The results show that the overall pass through into import price is high and mainly contributed by the industries that has large share of import for the raw material. Almost all the commodities in Malaysia show symmetric in ERPT behaviour, however, there is one commodity where exhibit asymmetric in ERPT coefficient. This is due to Malaysian importers as a price taker. The results helped in explaining the less responsiveness of Malaysian Import price to the large depreciation in Ringgit Malaysia since September of 2015. One important point draw from this paper is that using conventional ARDL model is not sufficient to identify the asymmetric ERPT in the long run. The main policy implication draw from this paper is the policy makers should be caution in forming monetary policy, the prices and other nominal variable are reacting differently across regimes and industries.

References

Bailliu, J, and Fujii, E. 2004. Exchange rate pass-through and the inflation environment in industrialized countries: an empirical investigation. *Working Papers 2004-21,* Bank of Canada

Barhoumi, K., 2006. Differences in long run exchange rate pass-through into import prices in developing countries: an empirical investigation. *Economic Modelling*. 23: 926–951

Bussière, M. 2013. Exchange rate pass through to trade prices: the role of nonlinearities and asymmetries. *Oxford Bulletin of Economics and Statistics* 75(5): 731-758

Campa, J. M. and Goldberg, L. S. 2005. Exchange rate pass-through into import prices. *The Review of Economics and Statistics*. 87 (4): 679–690

Cheikh, N. B. and Louhichi, W. 2016. Revisiting the role of inflation environment in exchange rate pass-through: A panel threshold approach *Economic Modelling.* 52: 233-238

Choudhri, E. U., Faruqee, H. and Hakura, D. S. 2005. Explaining the exchange rate pass-through in different prices. *Journal of International Economics.* 65 (2): 349–374

Choudhri, E. U., and Hakura, D. S. 2015. The exchange rate pass-through to import and export prices: The role of nominal rigidities and currency choice. *Journal of International Money and Finance.* 51: 1-25

Ca'Zorzi, M. and Hahn, E. and Sánchez, M., 2007 Exchange Rate Pass-Through in Emerging Markets (March 2007). *ECB Working Paper No. 739*.

Devereux, M. B. and Yetman, J. 2010. Price adjustment and exchange rate pass-through. *Journal of International Money and Finance.* 29:181-200

Frankel, J. A., Parsley, D. and Wei S. 2012. Slow Passthrough Around the World: A New Import for Developing Countries? *Open Economies Review* 23: 213-251

Goldberg, P. K, and Knetter, M. M. 1997 Goods prices and exchange rates: what have we learned? *Journal of Economic Literature* 35(3):1243-1272

Knetter, M. M. 1993 International comparison of price-to-market behavior *American Economic Review,* 83(3):473-486

Nguyen, T. A, and Sato, K. 2017 Firms' predicted exchange rates and nonlinearities in pricing-to-market. *Asian Meeting of Econometric Society, Hong Kong.*

Pesaran, H.M., Shin, Y. and Smith, R.J. (2001), "Bounds Testing Approaches to the Analysis of Level Relationships", *Journal of Applied Econometrics*, Vol. 16, 289-326.

Pollard, P. S. and Coughlin, C. C. 2004. Size matters: asymmetric exchange rate pass-through at the industry level. *University of Nottingham Research Paper* (2004/13)

Shin, Y., Yu, B., and Greenwood-Nimmo, M.J., 2014. Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In; Horrace W.C, Sickles R.C. (eds). *Festschrift in honor of Peter Schmidt,* Springer, New York.

Soon, S. and Baharumshah, A. Z. 2017. Exchange rate pass-through into domestic prices: evidence from a nonlinear perspective. *Economic Bulletin* 37(2): 1160-1167

Table 3.1: NARDL estimation results (Short run)

Commodity	Cointegration Test	Short Run ERPT		
	F-Test	SR^+	SR^-	Asymmetry
All	4.29***	0.215**	0.215**	0.246
Food	1.276	0.155	0.145	2.217**
Beverages and tobacco	4.366**	0.182	0.185	-1.541
Crude materials, inedible	6.208*	-0.069	-0.075	2.240**
Chemicals	5.373**	0.449*	0.452*	-1.014
Manufactured goods	4.142***	0.175	0.173	0.456
Machinery and transport equipment	2.439	0.203	0.203	-0.103
Miscellaneous manufactured articles	2.462	0.114	0.113	0.227
PPI	7.371*	0.243**	0.242**	0.588
CPI	2.802	-0.021	-0.021	0.272

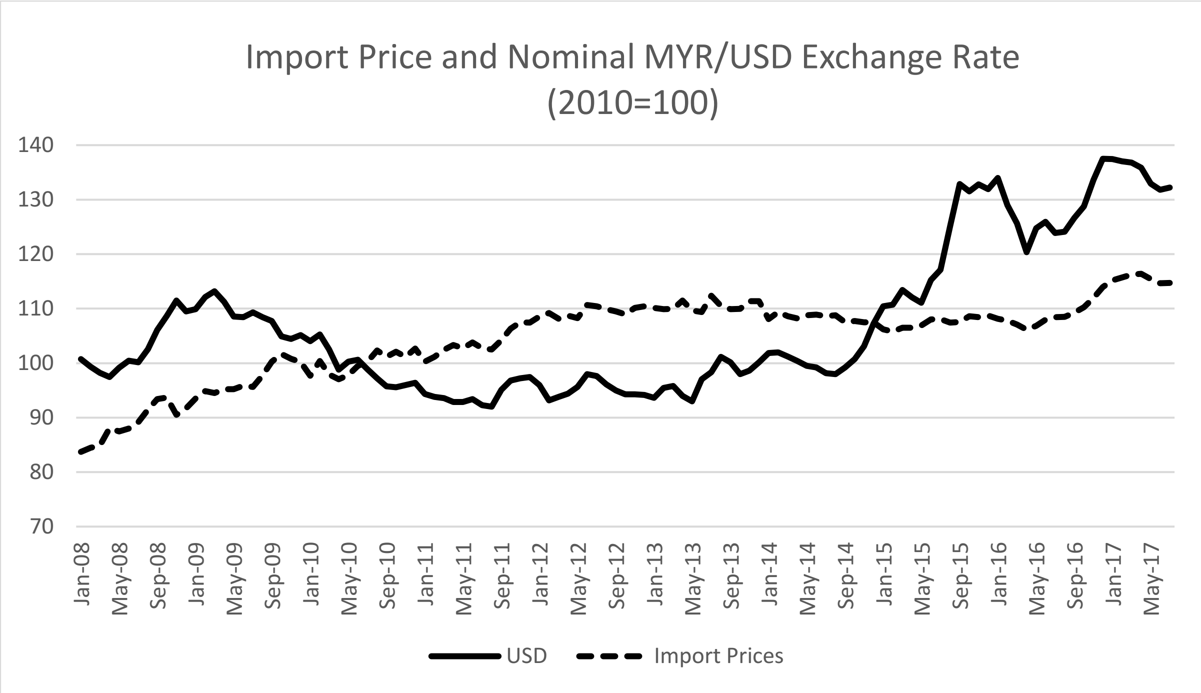
Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively. The significance level of cointegration test is based on F bound test for $k=3$. (b) The SR^+ and SR^- coefficient denote the exchange rate pass through behaviour in the exchange rate depreciation and appreciation periods for short run respectively. (c) t-statistic are reported for asymmetric test for both long run and short run coefficients.

Table 3.2: NARDL estimation results (long Run)

Commodity	Long Run ERPT		
	LR^+	LR^-	Asymmetry
All	0.977**	0.841**	1.499
Food	0.076	0.252	-1.271
Beverages and tobacco	0.410*	0.394*	0.371
Crude materials, inedible	0.402**	0.179	2.409**
Chemicals	0.266	0.520	-1.308
Manufactured goods	0.347**	0.360**	-0.244
Machinery and transport equipment	0.810**	0.742**	1.174
Miscellaneous manufactured articles	1.430	1.464	-0.359
PPI	0.372**	0.461**	-1.193
CPI	0.065	0.070	-0.165

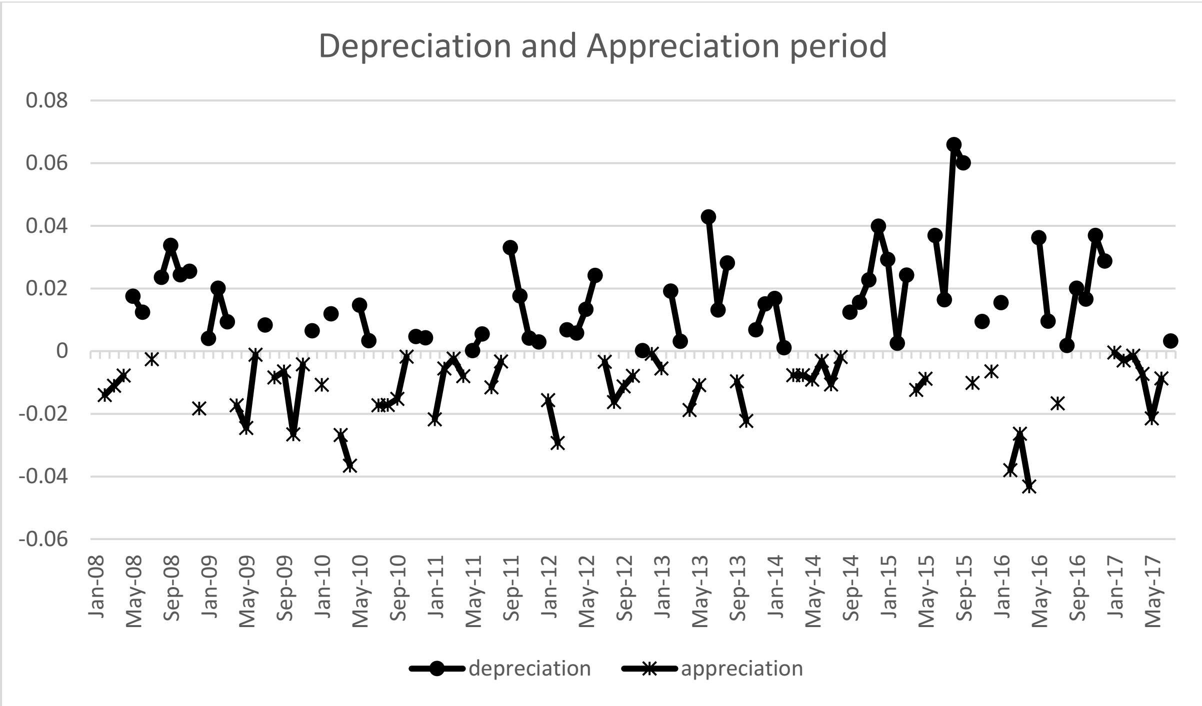
Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively. (b) The LR^+ and LR^- coefficient denote the exchange rate pass through behaviour in the exchange rate depreciation and appreciation periods for long run respectively. (c) t-statistic are reported for asymmetric test for both long run and short run coefficients.

Figure 3.1 Import Price and Nominal Malaysia Ringgit vis-à-vis US Dollar



Source: Department of Statistics Malaysia

Figure 3.2 Depreciation and appreciation period of exchange rate



Appendix:3.1 NARDL estimation results

	All	Food	Beverages and tobacco
Constant	0.5608	4.2245	-1.5504
IM_{t-1}	-0.1119**	0.3667	-0.3981*
ER^{+}_{t-1}	0.1093*	-0.0279	0.1630*
ER^{-}_{t-1}	0.0941*	-0.0922	0.1570*
MC_{t-1}	0.1685	-1.7727	1.5389**
IPI_{t-1}	-0.2030	0.5154	-0.8472*
ΔIM_{t-1}	-0.2194	-0.3633	-0.0183
ΔIM_{t-2}		-0.3103	0.2643***
ΔIM_{t-3}		-0.4877	0.0869
ΔER^{+}_{t}	0.2152**	0.1546	0.1823
ΔER^{+}_{t-1}	-0.0616	-0.1506	-0.1172
ΔER^{+}_{t-2}	-0.0551	-0.1440	-0.0675
ΔER^{+}_{t-3}	-0.1891**	0.4119***	-0.2281**
ΔER^{-}_{t}	0.2148**	0.1453	0.1854
ΔER^{-}_{t-1}	-0.0461	-0.0933	-0.1020
ΔER^{-}_{t-2}	-0.0375	-0.0889	-0.0514
ΔER^{-}_{t-3}	-0.1729***	0.4654**	-0.2106**
ΔMC_{t}	0.1198	0.0591	0.1314
ΔMC_{t-1}		3.4070**	-1.3891
ΔMC_{t-2}		-0.7846	-1.0333**
ΔMC_{t-3}		0.3496	-0.5021
ΔIPI_{t}	0.1754**	0.0533	0.0985
ΔIPI_{t-1}	0.3656**	-0.1096	0.7931*
ΔIPI_{t-2}	0.3938*	0.2002	0.6420*
ΔIPI_{t-3}	0.5791*	0.4646	0.6329*
R^2	0.6260	0.8284	0.8139
F_{PSS}	4.290***	1.276	4.366**

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively. (b) The F_{PSS} is the F-statistics and the significance level of cointegration test is based on F bound test for $k=3$. (c) The maximum lag length is 12 and the selection of lag length is based on Akaike Information Criteria (AIC). (d) Due to limited space, the maximum lag length reported in the table is lag=3.

	Crude material, Inedible	Chemicals	Manufactured goods
Constant	1.1497	3.0877*	-1.9316
IM_{t-1}	-0.2474**	-0.0967***	-0.3309*
ER^{+}_{t-1}	0.0993**	0.0257	0.1148**
ER^{-}_{t-1}	0.0443	0.0503	0.1190**
MC_{t-1}	-0.0045	-0.7614***	1.6016**
IPI_{t-1}	-0.0175	0.1864	-0.8824**
ΔIM_{t-1}	0.2188	-0.0404	0.3062**
ΔIM_{t-2}	0.4257**		0.2284
ΔIM_{t-3}	0.2814		0.4096*
ΔER^{+}_{t}	-0.0691	0.4487*	0.1746
ΔER^{+}_{t-1}	0.1697		0.1904
ΔER^{+}_{t-2}	-0.1466		-0.2500***
ΔER^{+}_{t-3}	-0.1674		-0.1228
ΔER^{-}_{t}	-0.0752	0.4516*	0.1733
ΔER^{-}_{t-1}	0.2143	-0.0109	0.1951
ΔER^{-}_{t-2}	-0.0944	-0.0096	-0.2411**
ΔER^{-}_{t-3}	-0.1202	-0.0100	-0.1157
ΔMC_{t}	0.1229	-0.0559	0.1765
ΔMC_{t-1}	-1.7451	0.1650	0.3689
ΔMC_{t-2}	0.3856	-1.2703	-0.8783
ΔMC_{t-3}	0.0900	1.1264	-2.9964**
ΔIPI_{t}	0.3323**	0.2044	0.0314
ΔIPI_{t-1}	0.4895*	0.2011	0.8663*
ΔIPI_{t-2}	0.2722***	0.1737	0.8308*
ΔIPI_{t-3}		0.4166**	0.5205**
R^2	0.8915	0.6444	0.8559
F_{PSS}	6.208*	5.373**	4.142***

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively. (b) The F_{PSS} is the F-statistics and the significance level of cointegration test is based on F bound test for *k=3*. (c) The maximum lag length is 12 and the selection of lag length is based on Akaike Information Criteria (AIC). (d) Due to limited space, the maximum lag length reported in the table is lag=3.

	Machinery and transport equipment	Miscellaneous manufactured articles	PPI
Constant	0.4394	1.2193	-0.6697
IM_{t-1}	-0.1487**	-0.0909***	-0.2216*
ER^{+}_{t-1}	0.1203**	0.1299***	0.0825**
ER^{-}_{t-1}	0.1104**	0.1331***	0.1021**
MC_{t-1}	0.2645	0.0936	0.7624**
IPI_{t-1}	-0.2371	-0.2959	-0.4242**
ΔIM_{t-1}	-0.2103***	0.0210	0.0426
ΔIM_{t-2}			-0.2144
ΔIM_{t-3}			0.2330
ΔER^{+}_{t}	0.2032***	0.1137	0.2430**
ΔER^{+}_{t-1}	-0.1449		0.1526
ΔER^{+}_{t-2}	0.0420		-0.1510
ΔER^{+}_{t-3}	-0.3008**		-0.0468
ΔER^{-}_{t}	0.2029***	0.1126	0.2419**
ΔER^{-}_{t-1}	-0.1369		0.1378
ΔER^{-}_{t-2}	0.0534		-0.1645***
ΔER^{-}_{t-3}	-0.2879**		-0.0635
ΔMC_{t}	0.0636	-0.1160	0.0892
ΔMC_{t-1}	-2.1706**		2.0625**
ΔMC_{t-2}	-0.0024		1.8654**
ΔMC_{t-3}	1.3882		0.6422
ΔIPI_{t}	0.2814**	0.4650**	0.0226
ΔIPI_{t-1}	0.3110	0.5483	0.3415**
ΔIPI_{t-2}	0.2075	0.4553	0.3005
ΔIPI_{t-3}	0.4667***	0.5152	0.2861
R^2	0.6536	0.2652	0.8480
$F_{PSS2.439}$	2.439	2.462	7.371*

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively. (b) The F_{PSS} is the F-statistics and the significance level of cointegration test is based on F bound test for $k=3$. (c) The maximum lag length is 12 and the selection of lag length is based on Akaike Information Criteria (AIC). (d) Due to limited space, the maximum lag length reported in the table is lag=3.

	CPI
Constant	-0.2132
IM_{t-1}	-0.1899
ER^{+}_{t-1}	0.0124
ER^{-}_{t-1}	0.0132
MC_{t-1}	0.1867
IPI_{t-1}	0.0448
ΔIM_{t-1}	0.3094***
ΔIM_{t-2}	-0.1146
ΔIM_{t-3}	-0.1830
ΔER^{+}_{t}	-0.0212
ΔER^{+}_{t-1}	0.0851**
ΔER^{+}_{t-2}	0.0534
ΔER^{+}_{t-3}	-0.0193
ΔER^{-}_{t}	-0.0214
ΔER^{-}_{t-1}	0.0822
ΔER^{-}_{t-2}	0.0527**
ΔER^{-}_{t-3}	-0.0203
ΔMC_{t}	0.0284
ΔMC_{t-1}	0.7981**
ΔMC_{t-2}	0.2185
ΔMC_{t-3}	0.4053
ΔIPI_{t}	-0.0186
ΔIPI_{t-1}	-0.0506
ΔIPI_{t-2}	-0.0742
ΔIPI_{t-3}	-0.0877
R^2	0.7796
$F_{PSS2.439}$	2.802

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively. (b) The F_{PSS} is the F-statistics and the significance level of cointegration test is based on F bound test for *k=3*. (c) The maximum lag length is 12 and the selection of lag length is based on Akaike Information Criteria (AIC). (d) Due to limited space, the maximum lag length reported in the table is lag=3.

Exchange rate volatility and it implication on exchange rate pass-through: Case of Malaysia

4.1 Introduction

The exchange rate is a critical policy variable in determines trade flows, capital flows, inflation, and the international reserves in a given economy. Moreover, a degree of exchange rate stability is essential for ongoing economic growth and economic stability. Over the past decade, economists have devoted considerable empirical attention to various questions surrounding exchange rates and international trade flows. One area of interest has been the exchange rate pass through (ERPT) into import have been debated for long time. The degree of pass- through to import price is an important parameter in reforming the monetary policy as the import price affect the domestic inflation rate.

According to An (2006), the exchange rate movement transmit into domestics through imported consumption goods, imported intermediate goods and finally the domestic goods priced in foreign currency. The incomplete pass through is commonly found in previous studies (Goldberg and Knetter, 1997; Choudhri and Hakura, 2015). In the context of ERPT, the incomplete pass through refers to the exchange rate fluctuation is partially transmitted into import price.

Most of the ERPT studies have focused on developed countries (Bailliu and Fujii, 2004; Campa and Goldberg, 2005; Choudhri, Faruqee and Hakura, 2005). Only few studies were done for developing countries (Frankel, Parsley and Wei, 2012; Barhoumi, 2006). Studies done by Devereux and Yetman (2010) and Ca'Zorzi, Hahn and Sánchez (2007) show that developing economies tend to experience high pass-through, while developed economies experience low exchange rate pass through. Few studies supported that high inflation rate is one of the reasons for the high exchange rate pass through (Devereux and Yetman, 2010; Cheikh and Louhichi, 2016).

Malaysia had undergone the major structural transformation from a commodity-based economy to an industrial-based economy. After the Asian financial crisis 1997, Malaysia had changed from a manage float exchange rate regime to a fixed exchange regime to maintain the stability of exchange rate. Under these arrangements, the exchange rate of the Malaysian Ringgit (MYR) was pegged against the United States Dollar (USD) at 3.80MYR per USD.

However, after July of 2005, Malaysia had adopted managed float exchange rate regime. In this regime, the Malaysian Ringgit is referenced against a basket comprising the currencies of the country's major trade partners and is allowed to move according to market forces. Such changes lead to a greater fluctuation in exchange rate. The fluctuation of the exchange rate had raised the concern on macroeconomic and financial stability. In the earlier stage of the new regime, the central bank of Malaysia, Bank Negara Malaysia (BNM) tend to intervene the foreign exchange market in order to maintain the stability of the MYR. Besides that, the intention of intervention is to boost the confident level of the market participants that the MYR would remain stable under new regime.

Figure 4.1 shows the index of the nominal exchange rate of Malaysia Ringgit (MYR) vis-à-vis US Dollar (USD) against the Malaysia Import Price from January 2008 to July 2017. MYR appreciated substantially from January 2009 to September 2011. During this period, we observed that there is increase in the import price. However, during depreciation period, the import prices are relatively stable. This might due to Malaysia as a price taker. Soon and Baharumshah (2017) found that depreciation of Malaysian Ringgit (MYR) lead to significant increase in the domestic prices.

Suardi (2008) mentioned that the presence of asymmetric volatility exchange rate might due to the central bank intervention. Foreign exchange intervention tends to increase the exchange rate volatility in the short run (Baillie and Osterberg, 1997; Beine et al., 2002). The central bank of Malaysia had intervened the foreign exchange market, this may lead to an increase in the exchange rate volatility. The central bank of Malaysia intervened foreign exchange market to counter strong portfolio inflows against the US dollar that sharply increased international reserves, from USD 83.5 billion in January 2007 to USD 125.8 billion in June 2008, a rise of 50 percent in the international reserves. However, the onset of the global financial crisis caused a sudden reversal of portfolio investment, exerting a significant downward pull on the ringgit. These intervention had led to a greater volatility in exchange rate.

Nassem et al. (2009) argued that the performance of the Malaysian import is crucial in determines its export policy in order to furtherer generate Malaysia’s economy development. Past studies show that the demand of Malaysian import is affected by the exchange rate volatility (Naseem et al. 2009; Wong et al, 2012; Soleymani and Chua, 2014; Soleymani et al., 2017). As Malaysian importers are price taker, importer might need to absorb the risk of exchange rate. Hence, importer may reduce their import demand. However, foreign exporter can readjust their price level in order to maintain the level of demand. Based on the pervious studies, the level of exchange rate volatility seem to affect the level of ERPT into import prices.

Hence, it is important to understand the relationship between the exchange rate volatility and the level of ERPT in Malaysian import.

This paper focuses on analysing the ERPT into domestic price for Malaysia. By considering the possible effect of different level of exchange rate volatility on ERPT in Malaysia Import. As mentioned in past studies, the ERPT behaviour may be affected by the level of exchange rate volatility. This paper employs a threshold autoregressive (TAR) model to analysis a possible nonlinear of ERPT in Malaysian Import due to different in the level of exchange rate volatility.

The reminder of this paper is organized as follows. Section 2 describes the data. Section 3 explain the methodology. Section 4 present the results of estimation and discussion. Section 5 conclusion.

4.2 Data

The data collected are monthly data from January 2008 to July 2017 including Import Unit Value index, Industrial Production Index, Producer Price Index, Consumer Price Index, Nominal exchange rate MYR vis-à-vis USD, The data collected from the Department of Statistics Malaysia. Nominal Effective Exchange Rate and Real Effective Exchange Rate are collected from Bank of International Settlement (BIS). Domestic Price include Import Unit Value, Producer Price Index and Consumer Price Index. The Import Unit Value Index are based on commodity breakdown which include (i) all, (ii)food, (iii)beverages and tobacco, (iv)animal and vegetable oils and fats, (v)chemicals, (vi)manufactured goods, and (vii)machinery and transport equipment. Data are seasonally adjusted.

4.3 Methodology

In this study, threshold autoregression (TAR) model is employed. To estimate the threshold, this study employed the conventional ERPT model proposed by Goldberg and Knetter (1997).

$$\ln P_t = \alpha_0 + \alpha_1 \ln X_t + \alpha_2 \ln ER_t + \alpha_3 \ln Z_t + \varepsilon_t \tag{4.1}$$

where P_t is the price for the goods, X is the independent variables and ER is the exchange rate. Z_t is the control variables in the model. ε_t is the error term.

The first difference specification of the equation (4.1) is used. Such kind of specification is used in previous studies (Ceglowski, 2010). Equation (4.1) can be extended to the threshold model, the model is given by following equation:

$$\Delta IM_{jt} = \begin{cases} c_1 + \sum_{i=0}^{q} \alpha_{1i} \Delta NEER_{t-i} + \sum_{i=0}^{r} \beta_{1i} \Delta mc_{t-i} + \sum_{i=0}^{s} \phi_{1i} \Delta ipi_{t-i} + \varepsilon_t, & if \quad E_{t-i} < \omega \\ c_2 + \sum_{i=0}^{q} \alpha_{2i} \Delta NEER_{t-i} + \sum_{i=0}^{r} \beta_{2i} \Delta mc_{t-i} + \sum_{i=0}^{s} \phi_{2i} \Delta ipi_{t-i} + \varepsilon_t, & if \quad E_{t-i} > \omega \end{cases} \tag{4.2}$$

where IM_{it} is the import unit value of commodity j at time t, $NEER_t$ is the nominal effective exchange rate. An increase in $NEER$ denotes the depreciation of the Malaysian Ringgit. mc_t denotes the marginal cost. ipi_t denotes the industrial production index. ε_t denotes the error term. E_t is the exchange rate volatility. ω is a threshold selected from E_t. If E_t exceeds the threshold level, ω it is denotes there is high volatility period; otherwise, it is considered as low exchange rate volatility period. Due to the limited number of observations, the maximum lag length for all variable are set as three. All variables are natural log transformed variables. The exchange rate volatility in this paper is compute by taking the standard deviation of bilateral Nominal exchange rate MYR vis-à-vis USD over a month. This measure of exchange rate volatility is widely using in the literature.

The short run ERPT coefficient is given by α_{10} and α_{20}, while the long run ERPT coefficient is given by $\sum_{i=0}^{q}\alpha_{1i}$ and $\sum_{i=0}^{q}\alpha_{2i}$. The equality test is conducted to examine the significance different between $\sum_{i=0}^{q}\alpha_{1i}$ and $\sum_{i=0}^{q}\alpha_{2i}$.

Following Campa and Goldberg (2005), the foreign production, MC_t can be obtain by:

$$MC_t = \frac{NEER_t}{REER_t} \cdot CPI_t \tag{4.3}$$

where $NEER_t$, $REER_t$ and CPI_t are the nominal effective exchange rate, real effective exchange rate and consumer price index at time t respectively.

4.4 Empirical Results

The Import Unit Value Index, IM are break into 7 categorise based on commodity breakdown which include (i) all, (ii)food, (iii)beverages and tobacco, (iv)animal and vegetable oils and fats, (v)chemicals, (vi)manufactured goods, and (vii)machinery and transport equipment, Before proceeding into the threshold regression, the unit root test was employed to check the stationarity of the data. The unit root test employed in this paper is Augmented Dickey-Fuller (ADF) test. The result of Unit root test is presented in Table 4.1. Based on the result, all variables are stationary at first difference. The threshold variable exchange rate volatility is divided into two regimes. Regime 1 refer to low level of exchange rate volatility. While Regime 2 refers to high volatility of exchange rate.

The results of threshold regression estimation are presented in Table 4.2. The main objective in this paper is to examine the ERPT into domestic price for Malaysia by considering the possible effect of different level of exchange rate volatility. From the results, we found out that for significant ERPT only occur in the low exchange rate volatility in both long run and short run. This implies that high exchange rate volatility can be related to low ERPT. During high exchange rate volatility, the importers tend to reduce their import demand in order to reduce the risk from the exchange rate fluctuation. While, the exporters may readjust their level of price in order to maintain the level of demand. The overall small pass through can be explained by weak expenditure-switching effect of exchange rate changes. The fluctuation of nominal exchange rate may not have much substitution effect between good produced internationally and produced locally (Devereux and Engel, 2002)

Besides, this might be can be explained by the study done by Corsetti et al. (2007). This may be due to price discrimination. The ERPT coefficient are expecting to be high, however, due to the presence of the distribution services, the impact of the nominal exchange rate movement on price is reduced. The negative ERPT for commodities such as chemicals and machinery and transport equipment may because of these commodities have large import shares.

4.5 Conclusion

This paper investigates the exchange rate pass-through into domestic prices for Malaysia. In contrast with previous studies, this paper focuses on the effect of exchange rate volatility on ERPT. By taking into consideration of this, the threshold autoregression model was employed. Based on the unit root test results, all variables are stationary in first difference.

The ERPT level is found to be differently across the commodities. Besides, from the results, we found out that for significant ERPT only occur in the low exchange rate volatility in both long run and short run. This implies that high exchange rate volatility can be related to low ERPT. The policy maker should be caution when deal with the exchange rate volatility. The central bank should strengthen the managed float regime as it is important in maintain the level of stability of exchange rate.

References

An, L. 2006. Exchange rate pass-through : Evidence based on vector autoregression with sign restrictions. *Munich Personal RePEc. Archive.*

Baillie, R.T.,and Osterberg, W.P., 1997. Why do central banks intervene? *Journal of International Money and Finance* 16, 909–919.

Bailliu, J, and Fujii, E. 2004. Exchange rate pass-through and the inflation environment in industrialized countries: an empirical investigation. *Working Papers 2004-21,* Bank of Canada

Barhoumi, K., 2006. Differences in long run exchange rate pass-through into import prices in developing countries: an empirical investigation. *Economic Modelling*. 23: 926–951

Beine, M., Bénassy-Quéré, A., and Lecourt, C., 2002. Central bank intervention and foreign exchange rates: new evidence from FIGARCH estimations. *Journal of International Money and Finance* 2: 115–144.

Campa, J. M. and Goldberg, L. S. 2005. Exchange rate pass-through into import prices. *The Review of Economics and Statistics.* 87 (4): 679–690

Ceglowski, J. 2010 Has Pass-Through to Export Prices Risen? Evidence for Japan. *Journal of the Japanese and International Economies*. 24:86-98

Cheikh, N. B. and Louhichi, W. 2016. Revisiting the role of inflation environment in exchange rate pass-through: A panel threshold approach *Economic Modelling.* 52: 233-238

Choudhri, E. U., Faruqee, H. and Hakura, D. S. 2005. Explaining the exchange rate pass-through in different prices. *Journal of International Economics.* 65 (2): 349–374

Choudhri, E. U., and Hakura, D. S. 2015. The exchange rate pass-through to import and export prices: The role of nominal rigidities and currency choice. *Journal of International Money and Finance.* 51: 1-25

Ca'Zorzi, M. and Hahn, E. and Sánchez, M., 2007 Exchange Rate Pass-Through in Emerging Markets (March 2007). *ECB Working Paper No. 739*.

Devereux, M. B. and Engel, C. 2002. Exchange rate pass-through, exchange rate volatility, and exchange rate disconnect. *Journal of Monetary Economics.* 49:913-940

Devereux, M. B. and Yetman, J. 2010. Price adjustment and exchange rate pass-through. *Journal of International Money and Finance.* 29:181-200

Goldberg, P. K, and Knetter, M. M. 1997 Goods prices and exchange rates: what have we learned? *Journal of Economic Literature* 35(3):1243-1272

Nassem, N. A. M., Tan, H. B., and Hamizah, M.S., 2009. Exchange Rate Misalignment, Volatility and Import Flows in Malaysia. *International Journal of Economics and Management* 3(1): 130–150

Soon, S. and Baharumshah, A. Z. 2017. Exchange rate pass-through into domestic prices: evidence from a nonlinear perspective. *Economic Bulletin* 37(2): 1160-1167

Soleymani, A. and Chua S. Y. 2014. Effect of exchange rate volatility on industry trade flow between Malaysia and China. T*he Journal of International Trade and Economic Development* 23:626-655.

Soleymani, A., Chua S. Y. and Hamat A. F. C. 2017. Exchange rate volatility and ASEAN-4's trade flow is there a third country effect? *International Economics and Economic Policy* 14(1):91-117.

Suardi, S. 2008. Central Bank Intervention, Threshold Effects and Asymmetric Volatility: Evidence from the Japanese Yen–us Dollar Foreign Exchange Market *Economic Modelling* 25:628-642.

Wong, Y. S., Ho, C. M. and Dollery, B. 2012. Impact of exchange rate volatility on import flows: the case of Malaysia and the United States. Applied Financial Economics 22:2027-2034.

Table 4.1 Result of ADF Unit Root Test

	Level	First Difference		Level	First Difference
All	-2.7711	-10.6528*	Chemicals	-2.7282	-9.0570*
Food	-2.2793	-9.3997*	Manufactured goods	-2.3615	-11.0275*
Beverages and tobacco	-1.8062	-3.3733***	Machinery and transport equipment	-3.0486	-11.2094*
Animal and vegetable oils and fats	-3.0929	-9.6448*	Miscellaneous manufactured articles	-1.6196	-11.5044*
CPI	-0.8731	-10.6058*	IPI	0.5908	-9.8640*
MC	-1.3419	-11.2686*	PPI	-2.9193	-3.9995*
USD	-1.3944	-7.4444*	NEER	-0.6568	-8.0809*

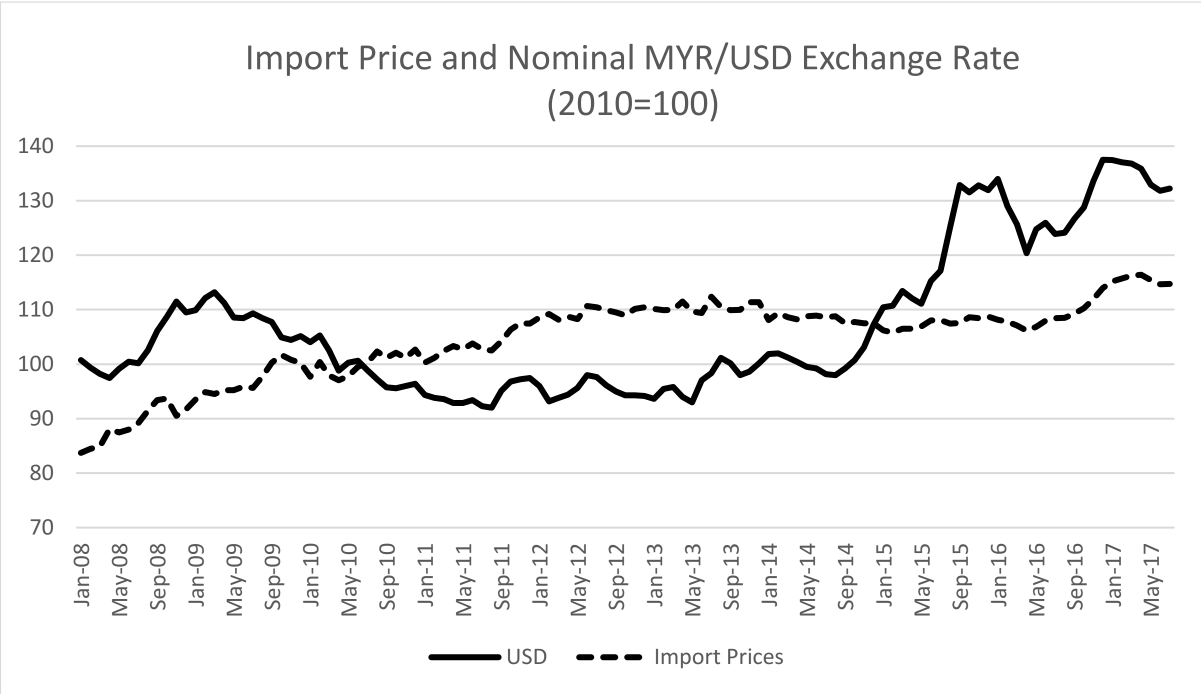
Note: asterisk* and *** denote significance level of 1% and 10% respectively

Table 4.2 Threshold regression estimation results

Industry	Short Run Lag=3 Regime 1	 Regime 2	Long Run Lag=3 Regime 1	 Regime 2
All	0.0668	-0.0471	0.2942***	-0.1323
Food	0.1724	0.0441	0.2978***	0.0162
Beverages and tobacco	0.2061	0.0041	0.2440	-0.0921
Animal and vegetable oils and fats	0.6432***	-0.7023	1.3720**	-0.8991
Chemicals	-1.0568**	0.1701	-0.2736	0.1864
Manufactured goods	0.3192**	0.0458	0.3420	-0.0040
Machinery and transport equipment	-0.5066**	-0.0087	-0.4896	-0.0143
PPI	-0.0962	0.0971	0.2449	0.2596

Note: (a) asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively. (b)Remark report the t-statistic of equality test

Figure 4.1 Import Price and Nominal Malaysia Ringgit vis-à-vis US Dollar



Source: Department of Statistics Malaysia

Appendix:4.1 Threshold regression estimation results for lag=3

	All		Food	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	0.0011	0.0003	-0.0008	0.0041**
Δ $NEER_t$	0.0668	-0.0471	0.1724	0.0441
Δ $NEER_{t-1}$	0.2199**	0.1672***	-0.2217***	0.2544**
Δ $NEER_{t-2}$	0.0136	-0.1566	0.3124*	-0.0727
Δ $NEER_{t-3}$	-0.0060	-0.0957	0.0347	-0.2097***
Δ MC_t	0.1154	0.4852	0.0588	-0.2127**
Δ MC_{t-1}	-0.1915**	1.2999	1.2719**	-0.1442
Δ MC_{t-2}	0.2068*	1.6488	0.1860**	-0.5967
Δ MC_{t-3}	0.0633	-0.0201	0.2244**	0.5493
Δ IPI_t	0.0461	-0.3950*	0.0358	-0.2220**
Δ IPI_{t-1}	-0.0862	-0.0306	0.0780	-0.1813
Δ IPI_{t-2}	0.0224	0.1730	0.0238	-0.1427
Δ IPI_{t-3}	0.1107***	0.0459	0.0665	-0.0175
Sample Size	111		111	
R^2	0.4169		0.4292	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively. (b) The maximum lag length is 3.

	Beverages and tobacco		Animal and vegetable oils and fats	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	0.0038**	0.0002	0.0014	0.0403
Δ $NEER_t$	0.2061	0.0041	0.6432***	-0.7023
Δ $NEER_{t-1}$	0.0394	-0.0537	0.2870	-0.6288
Δ $NEER_{t-2}$	0.1579	-0.1009	0.2845	-0.2895
Δ $NEER_{t-3}$	-0.1594	0.0584	0.1573	0.7215
Δ MC_t	1.5059*	-0.1040	-0.1757	32.3593**
Δ MC_{t-1}	0.0796	-0.9191	-0.1284	-38.8057*
Δ MC_{t-2}	-0.8220	-0.1124	-0.1767	-18.2474**
Δ MC_{t-3}	-0.1917**	1.3911**	-0.1715	21.5973
Δ IPI_t	0.0352	-0.0785	0.0301	1.2232
Δ IPI_{t-1}	0.0273	-0.0900	-0.0147	0.3958
Δ IPI_{t-2}	0.0576	-0.1530***	0.0040	-1.4306
Δ IPI_{t-3}	-0.0293	-0.0910	0.0916	-0.1729
Sample Size	111		111	
R^2	0.2944		0.2838	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively. (b) The maximum lag length is 3.

	Chemicals		Manufactured goods	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	-0.0146**	-0.0003	-0.0004	0.0047
Δ $NEER_t$	-1.0568**	0.1701	0.3192**	0.0458
Δ $NEER_{t-1}$	0.3055	0.1155	0.1688	0.0277
Δ $NEER_{t-2}$	0.4006	-0.0965	-0.1330	0.0961
Δ $NEER_{t-3}$	0.0772	-0.0027	-0.0131	-0.1736
Δ MC_t	1.4739	0.0590	0.9860	0.1852
Δ MC_{t-1}	0.1573	0.7913	-0.0948	1.0197
Δ MC_{t-2}	-1.6960	-0.1523	0.0294	2.6543
Δ MC_{t-3}	5.9846**	0.1149	-0.2102***	-1.0310
Δ IPI_t	0.1545	-0.1347	-0.0744	-0.0912
Δ IPI_{t-1}	0.2237	-0.1137	0.0096	-1.0412*
Δ IPI_{t-2}	-0.2825	0.2853*	0.0192	-0.6496*
Δ IPI_{t-3}	0.0949	0.2027**	-0.1052	-0.5873**
Sample Size	111		111	
R^2	0.3880		0.4129	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively. (b) The maximum lag length is 3.

	Machinery and transport equipment		PPI	
	Regime 1	Regime 2	Regime 1	Regime 2
Constant	0.0115*	-0.0001	0.0018	-0.0198*
Δ $NEER_t$	-0.5066**	-0.0087	-0.0962	0.0971
Δ $NEER_{t-1}$	-0.1245	0.1685	0.1263	0.1556
Δ $NEER_{t-2}$	-0.1325	-0.0838	0.0062	-0.2039
Δ $NEER_{t-3}$	0.2740	-0.0903	0.2086	0.2108
Δ MC_t	-1.4013	0.3093**	-0.0318	1.7618
Δ MC_{t-1}	-0.1103	-0.3298	-0.0135	6.8441*
Δ MC_{t-2}	0.3032**	0.4389	0.0180	-5.8756*
Δ MC_{t-3}	0.3106***	-0.4031	0.0789	7.6165*
Δ IPI_t	-0.3876*	0.1157	-0.0419	0.5856*
Δ IPI_{t-1}	-0.4250*	0.0476	0.0340	0.9275*
Δ IPI_{t-2}	-0.2005	0.2280**	0.0141	0.2436
Δ IPI_{t-3}	-0.1356	0.3811*	0.0705	0.4567*
Sample Size	111		111	
R^2	0.4315		0.6674	

Note: (a)asterisk*, ** and *** denote significance level of 1%, 5% and 10% respectively. (b) The maximum lag length is 3.

Conclusion

This Ph.D. dissertation aim to examine the exchange rate pass through into import price by using Nonlinear Autoregressive Distributed Lag (NARDL) model and Threshold Autoregressive (TAR) model. The main contribution of this Ph. D. dissertation is to overcome the drawback of past studies where most of the past empirical studies were employed the conventional linear model which had been widely applied in this issue.

For this purpose, this Ph.D. dissertation consist of three independent research papers. The first paper employed the threshold autoregressive model to examine the exchange rate pass through into Korean import by incorporating with the threshold variables know as Monetary Stabilisation Bonds (MSBs) which helps in capturing the effect of foreign exchange intervention. The second paper employed the Nonlinear Autoregressive Distributed Lag (NARDL) model to examine the exchange rate pass through into Malaysian domestic price by considering the asymmetric effect of exchange rate during the depreciation and appreciation period. The third paper employed the threshold autoregressive model to examine a possibility of exchange rate volatility affect the level of exchange rate pass through into Malaysian domestic prices. These three papers are related to the important of exchange rate pass through. This help to provide better understanding in context of exchange rate pass through.

The main finding of the three research papers are as follows:

1. The first research paper found out that the exchange rate pass through in Korean import are still relatively high. The level of exchange rate pass through is different across industries and also different during the intervention of foreign exchange market. The significant of all short run pass through reflect the important role of foreign currency in invoicing. This imply exporters have high tendency to choose foreign currency as invoicing currency. The exchange rate pass through tend to be high during the intervention period.

2. The second research paper found out that the exchange rate pass through in Malaysian import are relatively high. The estimated results show most of the commodities exhibit the cointegration relationship. Only one commodity shows the asymmetric effect in exchange rate pass through. This imply that the depreciation and appreciation of exchange rate is not main determinant that affecting Malaysian import price. This also reflect the position of Malaysia as a price taker. Besides that, the results help in explaining the reason of less responsiveness of import prices due to the sharp depreciation in Ringgit since September 2015.

3. After taking consideration of asymmetric effects of exchange rate during depreciation and appreciation period. Third paper taking the consideration of the level of exchange rate volatility. The results show that the significant exchange rate pass through only found in the low exchange volatility regime. This may be able to be explained by price discrimination along with the presence of distribution services. The exporters might

readjust their price during high volatility period to keep their level of export. The negative coefficient of exchange rate pass through are due to the high demand of imported commodities in Malaysia. This result also confirm that different exchange rate pass through across the commodities.

In summary, the exchange rate pass through are different across industries and commodities. The conventional model may not sufficient to analyse in this issue especially when nonlinear relationship is presence. Although Malaysian import did not show asymmetric effect during the appreciation and depreciation period, however, the results show the existence of cointegrating relationship among the variables. It is important to understand the effect of exchange rate pass through in order for the central bank to choose appropriate monetary policy in managing the exchange rate regime.