Investigating the causal relationship between exchange rate variability and palm oil export: evidence from Malaysia based on ARDL and nonlinear ARDL approaches

Lee, Kam Weng and Masih, Mansur

INCEIF, Malaysia, INCEIF, Malaysia

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Kam Weng Lee[1] and Mansur Masih[2]

Abstract

Exchange rate is seen as an important economic variable that affects Malaysia's palm oil export, which the policy maker may interfere in order to ensure that it maintains its position as one of the major palm oil exporters in the world. Nevertheless, the lead-lag relationship between exchange rate and palm oil export is unclear. Similarly, it is unclear whether there exists a long run asymmetric relationship between exchange rate and palm oil export. Therefore, this study aims to investigate the lead-lag relationship between exchange rate variability and palm oil export in Malaysia and whether the relationship between the two is linear symmetric or otherwise. This study employs ARDL, VECM and VDC techniques and further extends the previous research by adopting a recent technique which is Non-linear ARDL (NARDL) by using the data extracted over the period of 2008:1 to 2017:12 from Malaysian Palm Oil Council and DataStream. Based on this study, it is found that exchange rate is the exogenous variable, while palm oil export is the endogenous variable. Further, there exists a long run asymmetric relationship between exchange rate and palm oil export. Based on such findings, it is important to note that although the exchange rate is the most exogenous variable, policy maker could, to some extent, interfere in the exchange rate regime to manipulate the palm oil export and the policy maker should take into consideration the nonlinear asymmetric relationship between them in designing a suitable policy.

Keywords: Exchange rate, palm oil export, Malaysia, ARDL, NARDL

[1]Graduate student in Islamic finance at INCEIF, Lorong Universiti A, 59100 Kuala Lumpur, Malaysia.

[2] **Corresponding author**, Professor of Finance and Econometrics, INCEIF, Lorong Universiti A, 59100 Kuala Lumpur, Malaysia. Email: mansurmasih@inceif.org

1. *Introduction*

Exchange rate is a rate at which currencies are exchanged between countries. It is also known as the value of one country's currency in terms of other country's currency. Exchange rate has long been thought to have certain impacts on the business of import and export in a country as exchange rate influences the price of those products that are traded. In Malaysia, palm oil accounts for 20% and 46% of the global oil and fats production and trade respectively. The country is one of the world's largest producers and exporters of palm oil with a 50% share of world palm oil production and 61% of exports after Indonesia. (Ming, K. K., & Chandramohan, D. (2002). Exchange rate variability is therefore considered quite an important element and has a certain impact on the palm oil export.

Theoretically, an appreciation of a currency of a particular country against other foreign country's currency indicates that the price of domestic products of that particular country (whose currency is appreciating) will become more expensive from the perspective of such foreign country and thus lessen the competitiveness of that particular country (whose currency is appreciating) with other countries majoring in producing and exporting similar commodities in the markets, thus decrease the amount of the export of the domestic products of that particular country (whose currency is appreciating) to such foreign country and vice versa.

There are some mixed results and findings based on theoretical models with regard to the relationship between exchange rate and trade levels. Study conducted by Abrahams (1980) and Thursby and Thursby (1978) observes a negative effect of exchange rate volatility on trading. Hooper and Kohlhagen (1978) did not signal significant effects on trading but an important effect on products and prices in services. Some other studies for example Frankel and Rose (1996) and De Grauwe and Skudelny (1996), revealed that most country specialists reported small or insignificant negative effects between the exchange rate and the trading. (Bostan, I., & Firtescu, B. N. (2018).

Similarly, there are also some mixed results given in certain empirical models carried out by other writers with different sample sizes, periods, locations and sectors. Some results indicate that there is a positive relationship between the exchange rate and the trade levels, while some results indicate a negative relationship between the two. Some of the previous studies even show an ambiguous relationship between the exchange rate and trade levels. Muhammed (2014) studied whether exchange rate instability in Pakistan affects import, export, trade balance, foreign exchange reserve and GDP. The result showed that depreciation of exchange rate has positive effect on exports. (Oluyemi, O., & Isaac, E. D. (2017). Carmen and Nicolae (2011) studied the effect of exchange rate on export in Romania where it discovered that a shock in exchange rate has significant effect on export. On the other hand, Mordecki G., & Miranda R. (2018) found that the commodity exports not only depend on the global demand and prices, volatility of Real Exchange Rate (RER) as an additional factor also play a role. The results suggest that exports depend positively on global demand and international prices. However, when the volatility of RER is included in the testing model, the results were rather inconclusive. (Oluyemi, O., & Isaac, E. D. (2017). A study conducted by Zakaria, Z. (2013) on the relationship of exchange rate volatility and trade between Malaysia and its major trading partners shows mixed results and concluded that the findings indicate that the relationship between export performance and exchange rates volatility is ambiguous. (Oluyemi, O., & Isaac, E. D. (2017).

All the above theoretical and empirical models with the purpose of examining the effect of exchange rate variability on the trade levels concluded that postulated impact may be positive or negative depending on the assumptions employed.

Based on the above, we note that the findings with regard to the relationship between exchange rate and trade levels were mixed both theoretically and empirically, thus remain inconclusive. This study will then make an humble attempt to examine, firstly, on the lead-lag relationship between exchange rate variability and export in Malaysia in the context of palm oil industry by employing ARDL, VECM and VDC approaches. We also included other variables such as palm oil prices and palm oil production to give the model a more complete analysis. Secondly, we would also like to make an attempt to check whether there exists long run asymmetric relationship between the exchange rate and palm oil export in Malaysia by employing NARDL approach.

Even though there are quite a number of articles examining the relationship between the exchange rate variability and the trades, however, to the best knowledge of our knowledge, there is little or no identical and specific study on the asymmetric relationship between the exchange rate and palm oil export. Therefore, this study not only employed the ARDL approach, it also extends the previous research by adopting a recent technique which is Non-linear ARDL (NARDL) developed by Shin et al. (2014) that is applicable in this study to check whether there is long run asymmetric relationship existing between the exchange rate and palm oil export. Malaysia is used as the country of focus because it is the second largest palm oil producer in the world after Indonesia, plus the Malaysian government has adopted a floating exchange rate regime during the sample period. Therefore, it is interesting to study whether the floating exchange rate regime will affect Malaysia’s palm oil export or vice versa.

In this study, for ARDL, the result shows that there exists long run relationship between the four (4) variables, namely, exchange rate, palm oil production, palm oil price and palm oil export. Meanwhile, for NARDL, first, the result show that there is a co-integration between the focused variables of exchange rate (EXR) and palm oil export (EX). Co-integration means that these two variables are moving together in the long run and each of them contains information which can predict other variables. Second, the result also shows that there exists a long run asymmetric relationship between these two variables. However, it is not the case in the short run. Third, the result also shows that in the long run, the magnitude of the negative impact is greater than that of the positive impact. When the Malaysian exchange rate appreciates by 1%, the palm oil export will decrease by 0.334%; on the other hand, when the Malaysian exchange rate depreciates by 1%, the palm oil export will increase by 0.457%. These results somehow show support to the theoretical expectation in the long run and also support a study conducted by Aliyu (2011) where appreciation of exchange rates results in reduced exports and encourage imports, while depreciation expand exports and discourage imports.

This study also employed VECM approach (which the result shows that exchange rate is the exogenous variable while the palm oil export is the endogenous variable). VDC approach is also employed to ascertain the ranking of each variable (which the result shows that exchange rate is the most exogenous variable, followed by palm oil price, palm oil production, and palm oil export being the most endogenous variable). Although exchange rate is the most exogenous variable, policy maker, to some extent is still able to manipulate the palm oil export by controlling or manipulating the exchange rate regime.

The subsequent sections of this paper are organised as follows: Section 2 reviews the literature on exchange rate variability and trade import, export where the writer presents relevant literatures that will give sound conception of the fact. Section 3 provides an avenue regarding research methodological approach and the relevant information on the time series data sets that are used for this study. Section 4 analyses the results, while Section 5 concludes the study with policy implications and limitations as well as suggestion for further research.

2. Literature review

Theoretical Underpinnings

Several studies have been conducted within the subject of exchange rate variability affecting import and export or trade balance. When one evaluates the impact of a currency fluctuation on import and export or trade balance, we should take into consideration of Marshall-Lerner theory. We normally assume that when a currency depreciates imports fall and exports increase and therefore balance of trade improves. When a currency appreciates, we normally assume exports fall and imports increase and thus our balance of trade worsens. Therefore, to improve balance of trade we want a weak or depreciating currency. The Marshall-Lerner condition is set to hold when the sum of price elasticity of demand for imports and exports is greater than 1. In other words, it means that the change in demand for imports and exports needs to be greater than the change in value of the currency. For example, if MYR depreciates by 10% and Malaysian demand for imports fell by 20% and at the same time, the demand for export increase by 20%, then this shows a strong elastic response. Overall, a depreciation of MYR would help Malaysia better off in terms of the trade balance. The Marshall–Lerner theory, however, could be used only to infer the long-run effects of a depreciation of a currency.

J-curve effect is another approach which depicts the short run effect of how a depreciation of exchange rate in a country may affect trade balance over time. The effect shows that the trade balance of a country starts experiencing deficit following depreciation of that country's currency before the trade level restores to the previous point. Immediately after the depreciation of the currency, the prices of the imports will become more expensive and the prices of exports become cheaper, leading to a bigger initial trade deficit. While the country is starting to adjust the changes, the demand for export will increase, the people will also buy lesser import products and find substitute goods. As a result, the trade balance will slowly adjust and bounce back to the previous level. The lag is caused by the fact that importers and exporters have to satisfy the pre-existing contracts, that is the reason why trade deficit may happen first. The J-curve effect supports this study to a certain extent whereby when the Malaysian currency depreciates, it will indeed stimulate the export as evidenced by the NARDL results.

Previous studies have assumed that the relationship between exchange rate volatility and export diversification is linear or symmetric. Symmetry here means that either appreciation or depreciation of a currency will result in a similar magnitude of change. For example, an increase of 1% of the currency will result in a decrease of export by 1% and vice versa. However, we believe this symmetric relationship between the two (2) variables is not quite realistic. Reason being, not all people have the same behaviour to the exchange rate volatility in a floating exchange rate regime system. When currency depreciates, export will become more competitive and promote export; on the other hand, when the currency appreciates, the opposite result will show. Intuitively, different people will react to the exchange rate volatility differently as each of them has a different risk appetite and different reaction or even different plans to embrace the volatilities. Therefore, an asymmetric relationship between exchange rate volatility and export should be more realistic and prevail nowadays. This is also in line with one of the studies conducted by Fang, W., Lai, Y., & Miller, S. M.

(2009) that five of the eight countries studied, the effects of exchange volatility are asymmetric with exports.

Further, there are some mixed results based on theoretical models for the relationship between exchange rate and trade levels. Study conducted by Abrahams (1980) and Thursby and Thursby (1978) observe a negative effect of exchange rate volatility on trading. Hooper and Kohlhagen (1978) did not signal significant effects on trading but an important effect on products and prices in services. Some other studies for example Frankel and Rose (1996) and De Grauwe and Skudelny (1996), revealed that most country specialists reported small or insignificant negative effects between the exchange rate and the trading. (Bostan, I., & Firtescu, B. N. (2018).

Empirical Underpinnings

The impact of exchange rate levels on trade has been much debated but the large body of existing empirical literature does not suggest an unequivocally clear picture of the trade impacts of changes in exchange rates. There are also some mixed empirical models found on the relationship between the exchange rate and the level of international trade and level of export. Some studies found a robust negative relationship between exchange rate volatility and trade; while others were not.

A study conducted by Zakaria, Z. (2013) on the relationship of exchange rate volatility and trade by employing regression analysis of standard export demand models as well as GARCH (1,1) models using Malaysia data from the period of January 2000 to August 2012. Result from regression analysis showed that Malaysian exports to the US and Japan are significantly related with exchange rates volatility. Result from GARCH (1,1) model showed mixed results and concluded that the findings indicate that the relationship between export performance and exchange rates volatility is ambiguous.

In a study of Real Exchange Rate (RER) volatility and exports conducted by Mordecki G., & Miranda R. (2018), the authors found that the commodity exports not only depend on the global demand and prices, volatility of Real Exchange Rate (RER) as an additional factor also play a role. This paper studies the impact of RER volatility on total exports using Johansen's methodology, including proxies for global demand and international prices. The results suggest that exports depend positively on global demand and international prices. However, when the volatility of RER is included in the testing model, the results were rather inconclusive.

Mahmood, Ehsanellah & Ahmed (2011), they worked on whether fluctuation in exchange rates affects the macro-economic variables in Pakistan. They used monthly data from 1975 to 2011.

Generalized Autoregressive Condition Heteroskedasticity (GARCH) method was used for the analysis. The result shows that exchange rate positively affected the variables.

Aliyu (2011) noted that appreciation of exchange rates results in increased imports and reduced exports while depreciation expand exports and discourage imports. Exchange rates depreciation is likely to cause a shift from foreign goods to local goods. Carmen and Nicolae (2011) studied the effect of exchange rate on export in Romania (2nd quarter 2003 – 1st quarter 2011). The authors used Vector Autoregression model and Impulse Response Function for the analysis. It was discovered that a shock in exchange rate has significant effect on export. (Oluyemi, O., & Isaac, E. D. (2017). Bahmani-Oskooee & Kovyryalova (2008), in their investigations on the impact of exchange rates volatility on international trade, 177 commodities trade between the United State (US) and United Kingdom (UK) were used. They used co-integration and error correction techniques to analyse the data covering the period of 1971 to 2003. The results showed that the volatility of the real bilateral dollar – pound rates has a short-run significant effect on the imports of 109 and exports of 99 industries. In the long run, it was revealed that the number of significant cases reduced with imports of 62 and exports of 86 industries which are significantly affected by the exchange rates volatility. (Oluyemi, O., & Isaac, E. D. (2017).

Muhammed (2014) studied whether exchange rate instability in Pakistan affects import, export, trade balance, foreign exchange reserve and GDP. He used yearly data 1952 to 2010. Correlation Removal method, multi collinearity detection and granger causality test were used for the analysis. The result showed that depreciation of exchange rate has positive effect on exports. (Oluyemi, O., & Isaac, E. D. (2017). Hasan et al, (2015) investigated the effects of exchange rate volatility on export volume from Bangladesh to the US market by using monthly time series data over the period of 1991 to 2012. The study revealed a stable and significant long run relationship between the variables. By employing co-integration technique, it is observed that in the long run, a 1% increase in exchange rate that is depreciation of Taka against US Dollar causes 2.3% increase in export volume. (Oluyemi, O., & Isaac, E. D. (2017). Oluyemi, O., & Isaac, E. D. (2017) examines the effect of exchange rates on imports and exports in Nigeria using month data from 1996-2015. Results were inconclusive, neither did the exchange rate affects import and export in Nigeria nor the import and exports affect the exchange rate. Ethier (1973) argues that exchange rate volatility could lower exports due to profit risk. De Grauwe (1988), however, suggests that exporters might increase exports to offset potential revenue losses. (Fang, W., Lai, Y., & Miller, S. M. (2009).

Confining to the palm oil industry, Talib, B. A., & Darawi, Z. (2002) conducted a study where the objectives of it are to describe a national model of the Malaysian palm oil market and to identify the important factors affecting the Malaysian palm oil industry. The model is estimated by taking stock of total oil palm area, oil palm yield, domestic consumption, exports and imports over the period of study between 1970 and 1999. The results show the importance of the Malaysian economic activity, the exchange rate and world population in affecting the palm oil industry.

Prasetyo, A., & Marwanti, S. (2017) analysed the effect of the exchange rate (IDR to US Dollar) on Indonesian CPO exports using Error Correction Model (ECM) for the data period 2010:1 – 2015:12. Result showed that the exchange rate has a weak effect on Indonesian CPO export and it was attributable to several factors including but not limited to policy factors, price factors and others.

A study was conducted by Ahmad (2010) to explore the relationship of an effective exchange rate for Malaysia and major importing countries on the export volume of various oil palm products. The result indicates evidence of a relationship between the Malaysian exchange rate and the export of crude palm oil, palm kernel expeller and palm based finished products.

3. Data and Methodology

This section of the study will present the dataset and the methodological framework. All data employed are monthly observations of the variables extracted for the period 2008:1-2017:12 from Malaysian Palm Oil Council except exchange rate which extracted from the DataStream. Total four (4) variables adopted for the purpose of this study, two (2) main/ focused variables are exchange rate and palm oil export in Malaysia; while the other two (2) controlled variables are palm oil price in Malaysia and palm oil production in Malaysia. The variables adopted can be represented by the table below:

Variables	**Representing Symbol**	**Type of Variable**
Exchange rate	EXR	Focused variable
Palm oil export	EX	Focused variable
Palm oil production	PRO	Controlled variable
Palm oil price	POP	Controlled variable

Methodologies adopt in this paper will be Autoregressive Distributed Lags Model (ARDL) as well as Non-Linear Autoregressive Distributed Lags Model (NARDL).

ARDL model also known as bounds testing approach suggested by Pesaran et al, 2001 to carry out the cointegration analysis which is appropriate for the data extracted for this particular study. There are several advantages of using ARDL compared to other cointegration techniques. It can be applied irrespective of whether the variables are stationary or non-stationary and also accommodate to smaller sample size. In addition, a simple linear transformation allows a dynamic error correction model (ECM) to be derived from ARDL (Banerjee et al, 1993). The ECM integrates the short-run dynamics with the long-run equilibrium without losing long-run information (Pesaran & Chin, 1999).

Unit root test is not a pre-requisite and compulsory prior to employ ARDL model, unlike time series technique where the variables are required to be non-stationary before proceeding to Engle Granger (EG) co-integration test and Johansen co-integration test.

Although ARDL model can accommodate both stationary and non-stationary variables, to ensure there is no variables integrate at order two or higher, it is still recommended to perform stationarity condition check because this model assumes the variables to be only at I(0) and I(1). Otherwise, the F-statistic which is computed at a later stage will show inaccurate result.

In this particular study, three (3) unit root tests are being carried out namely, Augmented Dickey Fuller (ADF) test, the Phillip Perron (PP) test and KPSS test. The tests yielded mixed results, meaning to say, some variables are found stationary and non-stationary in the level form. Owing to this reason, this study is unable to proceed with the EG and Johansen co-integration test. This, however, provide a good opportunity and supportive justification for the writer to opt for ARDL model in this study.

The ARDL technique involves two stages. At the first stage, the existence of a long-run relationship among the variables is investigated. This is done by constructing an unrestricted error correction model (UECM) with each variable in turn as a dependent variable and then testing whether or not the 'lagged levels of the variables' in each of the error correction equations are statistically significant. The test consists of computing an F-statistic testing the joint significance of the 'lagged levels of the variables' in each error-correction equation. The computed F-statistic is then compared to two asymptotic critical values. If the test statistic is above an upper critical value, the null hypothesis of no long-run relationship can be rejected. Alternatively, when the test statistic falls below a lower critical value, the null hypothesis of no long-run relationship cannot be rejected. Finally, if the test statistic falls between these two bounds, the result is inconclusive. As regards the implications of the F-statistics, if all the F-statistics in all equations happen to be insignificant, then that implies the acceptance of the null of no long run relationship among the variables. However, if at least one of the F-statistics is significant, then the null of no long-run relationship among the variables is rejected. In that case, there is a long run relationship among the variables.

Once the long run relationship has been established, the second stage of the analysis involves the estimation of the long run coefficients (after selecting the optimum order of the variables through AIC or SBC criteria) and then estimates the associated error correction model.

ARDL itself has some limitations where it assumes that the adjustment of the error correction term is both linear and symmetric. Owing to this reason, the writer would like to go one (1) step further to employ a more recent technique which applicable to this study namely NARDL model to check the variables whether there exist non-linear as well as asymmetric information. Assuming linearity in the previous model means that the changes between variables are proportionate to each other.

NARDL model, is an extension to ARDL model that developed by Shin et al. (2014) involves simultaneously capture short and long run asymmetry through positive and negative partial sum decompositions of changes in the independent variable. There are basically four (4) reasons to opt for NARDL. First, it allows modelling the cointegration relation that could exist between the exchange rate and palm oil export. Second, it permits to test both the linear and nonlinear cointegration. Third, it distinguishes between the short- and long-run effects from the independent variable to the dependent variable. Fourth, the NARDL model allows data series having different integration orders.

There are basically 5 steps involved in simulating the NARDL model. However, prior to start applying these steps, unit root test for checking stationarity condition of the studied variables are required. Similar to ARDL model, ensuring no variables integrate at order two or higher is integral because this model assumes also the variables to be only at I(0) and I(1). Otherwise, the F-statistic which is computed at a later stage will show inaccurate result.

The beginning step is to estimate the model by using the OLS estimation technique specifying lag lengths p (dependent variable) and q (for all regressors).

Second step is to do a Model Reduction using the General-to-Specific Procedure to arrive at final specification of the model. In this step, trimming and deleting insignificant lags are required.

Third step is to test for a long run co-integration using bounds testing for co-integration. In this stage, the writer is comparing the F-statistics with the critical values provided by Pesaran et al (2001) or Narayan (2005). Again, similar to the F-statistic value checking in ARDL model, if the computed F statistics exceeds the upper critical value, the null hypothesis of no cointegration can be rejected. If it falls below the lower critical value, the null hypothesis holds and cannot be rejected. If the F statistics value falls in between the lower and upper critical values, the result is inconclusive.

Fourth step is to test for both long run and short run asymmetries. The null hypothesis here is there exists symmetry relationship between the focused variables. Taking 5% significant level for the study, if the p-value is greater than 5%, then the null hypothesis holds and if the p-value lesser than 5%, the null hypothesis can be rejected and conclude there is asymmetry between variables.

Final step is to graph the cumulative dynamic multipliers.

Owing to the above two (2) specified models ARDL and NARDL, the empirical analysis has been done through Microfit software except that NARDL will be done through Stata software since Microfit software is unable to estimate the model. The following section will be discussing the results.

4. EMPIRICAL RESULTS AND DISCUSSIONS

Unit Root Test

Table 1: ADF Test

	VARIABLE	ADF	T-STAT.	C.V.	RESULT
LOG FORM	LPOP	ADF(5)=AIC	- 3.1474	- 3.4535	Non-Stationary
		ADF(1)=SBC	- 3.5820	- 3.3712	Stationary
	LEX	ADF(5)=AIC	- 6.0950	- 3.4535	Stationary
		ADF(1)=SBC	- 5.1492	- 3.3712	Stationary
	LPRO	ADF(5)=AIC	- 6.7827	- 3.4535	Stationary
		ADF(2)=SBC	- 6.9186	- 3.3743	Stationary
	LEXR	ADF(1)=AIC	- 1.4746	- 3.3712	Non-Stationary
		ADF(1)=SBC	- 1.4746	- 3.3712	Non-Stationary

	VARIABLE	ADF	T-STAT.	C.V.	RESULT
1ST DIFF. FORM	DPOP	ADF(5)=AIC	- 5.9933	- 2.8725	Stationary
		ADF(1)=SBC	- 6.4125	- 2.9200	Stationary
	DEX	ADF(5)=AIC	- 6.6324	- 2.8725	Stationary
		ADF(1)=SBC	- 8.3524	- 2.9200	Stationary
	DPRO	ADF(5)=AIC	- 6.9154	- 2.8725	Stationary
		ADF(3)=SBC	- 7.1445	- 2.9660	Stationary
	DEXR	ADF(1)=AIC	- 7.5433	- 2.9200	Stationary
		ADF(1)=SBC	- 7.5433	- 2.9200	Stationary

Table 2: PP Test

	VARIABLE	T-STAT.	C.V.	RESULT
LOG FORM	LPOP	- 2.4306	- 3.4273	Non-Stationary
	LEX	- 5.1064	- 3.4273	Stationary
	LPRO	- 2.5100	- 3.4273	Non-Stationary
	LEXR	- 1.5960	- 3.4273	Non-Stationary

	VARIABLE	T-STAT.	C.V.	RESULT
1ST DIFF. FORM	DPOP	- 7.6461	- 2.8641	Stationary
	DEX	- 22.8286	- 2.8641	Stationary
	DPRO	- 11.3720	- 2.8641	Stationary
	DEXR	- 10.4104	- 2.8641	Stationary

Table 3: KPSS Test

	VARIABLE	T-STAT.	C.V.	RESULT
LOG FORM	LPOP	0.0714	0.1434	Stationary
	LEX	0.1639	0.1434	Non-Stationary
	LPRO	0.0954	0.1434	Stationary
	LEXR	0.1551	0.1434	Non-Stationary

	VARIABLE	T-STAT.	C.V.	RESULT
1ST DIFF. FORM	DPOP	0.0815	0.4051	Stationary
	DEX	0.2590	0.4051	Stationary

	DPRO	0.1589	0.4051	Stationary
	DEXR	0.1750	0.4051	Stationary

Based on the above results, table 1 (ADF test) shows that the variable EX and PRO are found stationary in its level form while all variables are found stationary in their first differenced form. In Table 2 (PP test), variables EX is found stationary in its level form while all variables are found stationary in their first differenced form. In table 3 (KPSS test), variable POP and PRO are found stationary in its level form; while other variables are found non-stationary in its first differenced form.

Based on ADF and PP tests, this study cannot proceed with Engle-Granger (EG) or Johansen co-integration tests as their pre-requite is require all variables to be non-stationary. This, however, give a good justification to employ ARDL approach in the study on the basis that it avoids the pre-test bias.

Co-integration test: ARDL

Before proceeding to test the co-integrating relationship between the variables, checking for the existence of a long run relationship between the variables is required. It is necessary to establish that the variables have a long run relationship to rule out the possibility of a spurious relationship between the variables. Then only can proceed to the ARDL co-integration test if the variables show evidence of a theoretical relationship between them.

Table 4: F-Statistics for testing the existence of Long-Run relationship (Variable Addition Test)

Variables	F-Stat	p-value	CLB	CUB	CLB	CUB
			90%		95%	
DPOP	5.9028	[0.000]*	3.063	4.084	3.539	4.667
DEX	2.8587	[0.028]*	3.063	4.084	3.539	4.667
DPRO	5.5904	[0.000]*	3.063	4.084	3.539	4.667
DEXR	0.3604	[0.836]	3.063	4.084	3.539	4.667

The critical values are taken from Pesaran et al. (2001), intercept and trend. *denotes rejecting the null at 5 percent level

In *table 4*, instead of looking at the F-statistic, p-value could also be adopted to determine whether long run relationship exist between variables. The result shows that when the dependent variables are palm oil price (POP), palm oil export (EX) and palm oil production (PRO), they are significant at 5%. It means that the null hypothesis of no long-run relationship between variables can be rejected and concluded that there exists three (3) long run relationships.

Table 5 : ARDL Bounds Test for the existence of a Level Relationship

Variables	F-Stat	CLB	CUB	CLB	CUB
		95%		90%	
LPOP	3.5642	3.3419	4.5261	2.8081	3.8837
LEX	25.1992	3.3419	4.5261	2.8081	3.8837
LPRO	12.1769	3.3419	4.5261	2.8081	3.8837
LEXR	1.1075	3.3419	4.5261	2.8081	3.8837

After confirmed the existence of a long run relationship between the variables, the writer moves to testing of co-integration between variables. From table 5, according to the bound test with null hypothesis of no co-integration, the test result shows that F-statistics for palm oil export (EX) of 25.1992 is higher than the upper bound critical value of 4.5261 significant at 5%. Therefore, the null hypothesis can be rejected, and it can be concluded that there is co-integration between palm oil export, palm oil production, palm oil price and exchange rate, therefore the relationship between variables are not spurious and signifies that the variables attain an equilibrium in the long run. Similarly, the variable palm oil production (PRO), where its F-statistic show 12.1769 and it is above the upper critical value significant at 5%. The economic implication for such co-integration indicates that each variable contains information for the prediction of other variables. For example, regardless of the sequence, the exchange rate variability could impact on the production of palm oil. Reason being, when Malaysian exchange rate depreciates, price of palm oil become cheaper from the importers' perspective and thus import more palm oil from Malaysia. This tends to stimulate the growth of the palm oil industry and therefore the farmers need to produce more palm oils in meeting the export demand. The advantage of using ARDL co-integration is that only or at least one co-integration is required to conclude that the variables are co-integrated.

Table 6 : Results for Estimated Long-Run Coefficients using the ARDL Approach

Estimated Long Run Coefficients using the ARDL Approach
ARDL(1,0,1,0) selected based on Akaike Information Criterion

Dependent variable is LEX
116 observations used for estimation from 2008M5 to 2017M12

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
LPOP	-.047704	.051959	-.91811[.361]
LPRO	.61544	.062098	9.9109[.000]
LEXR	-.20977	.071076	-2.9513[.004]
INPT	3.3694	.69673	4.8360[.000]

Testing for existence of a level relationship among the variables in the ARDL model

F-statistic	95% Lower Bound	95% Upper Bound	90% Lower Bound	90% Upper Bound
25.1992	3.3419	4.5261	2.8081	3.8837

W-statistic	95% Lower Bound	95% Upper Bound	90% Lower Bound	90% Upper Bound
100.7968	13.3675	18.1045	11.2322	15.5348

Long run coefficient table is presented in *table 6* as above by using Akaike Information Criterion (AIC), only the variables palm oil production (POP) and exchange rate (EXR) show long run effect on palm oil export (EX) at 5% significant level. Palm oil production (PRO) has positive and significant relationship with palm oil export at 5% significant level. This implies that a 1% increase in production will lead to an increase of palm oil export by 0.62%. Thinking intuitively, Malaysia is the second largest palm oil country in the world, the more demand of the palm oil products from importer's country indicates the more production of the palm oil products that need to produce, the more palm oil product being produced, means that the stock level is readily available and thus able to meet the export demand.

On the other hand, the exchange rate has negative and significant relationship with palm oil export at 5% significant level. This implies that a 1% increase in MYR exchange rate (EXR) will lead to a decrease of palm oil export by 0.21%. Thinking intuitively, the reason being is that when the MYR exchange rate increases, the price of the palm oil will become expensive from the importers' perspective as they need to use more money to buy the palm oil, hence the palm oil export will become less competitive compare to other palm oil exporting countries. Importer countries perhaps will start increasing the demand of palm oil from Indonesia and therefore decreasing the demand from Malaysia, subsequently, the export of the palm oil reduce.

ARDL test, however, has also its limitations. It assumes that the adjustment of the error correction term is both linear and symmetric. Therefore, the writer is decided to test the variables using a more recent technique which is applicable to the study namely NARDL model which relaxes these limitations.

Non-Linear ARDL (NARDL) Model

For the purpose of NARDL model test, this paper is only focusing on two (2) focused variables which are also in line with the study that testing the relationship between exchange rate (EXR) and palm oil export (EX) in Malaysia. In addition, this study would like to probe further to check whether there exists a long run relationship between the focused variables and whether the relationship is symmetry or asymmetry.

As mentioned, NARDL model is able to capture the non-linear/ asymmetric relationship between the variables in both short and long run. The long run model is specified as:

$$EX_t = \alpha_0 + \alpha_1 EXR_t^+ + \alpha_2 EXR_t^- + e_t$$

where EX is palm oil export volume, EXR is exchange rate, and $(\alpha_0, \alpha_1, \alpha_2)$ is a vector of long run parameters to be estimated. EXR_t^+ and EXR_t^- are partial sums of positive and negative changes in EXR.

Introducing the long run model into the ARDL model will leads to the below form of NARDL equation.

$$\Delta EX_t = \beta_0 + \beta_1 EX_{t-1} + \beta_2 EXR_{t-1}^+ + \beta_3 EXR_{t-1}^- + \sum_{i=1}^{p} \varphi_i \Delta EX_{t-i}$$
$$+ \sum_{i=0}^{q} (\theta_i^+ \Delta EXR_{t-i}^+ + \theta_i^- \Delta EXR_{t-i}^-) + u_t$$

where all variables are as defined above and p and q are lag orders. The long run model is derivable from NARDL equation. Further, in the NARDL equation, $\sum_{i=0}^{q} \theta_i^+$ and $\sum_{i=0}^{q} \theta_i^-$ capture the short-run effects of respectively positive and negative changes in the palm oil export.

Next, moving to the test for a long run co-integration using bounds testing for co-integration. The below *table 7* presents the NARDL result including F-statistic.

Table 7: NARDL results

Asymmetry statistics:

Exog. var.	Long-run effect [+] coef.	F-stat	P>F	Long-run effect [-] coef.	F-stat	P>F
exr	-0.334	16.91	0.000	0.457	17.75	0.000
	Long-run asymmetry	F-stat	P>F	Short-run asymmetry	F-stat	P>F
exr		9.77	0.002		2.514	0.116

Note: Long-run effect [-] refers to a permanent change in exog. var. by -1

Cointegration test statistics: t_BDM = -6.3282
F_PSS = 13.4976

The F-statistic shows 13.4976. Comparing this F-statistic with *table 8* the critical values provided by Pesaran et al. (2001) at the table below, the F-statistic is found greater than the upper bound critical value at 5% (i.e. 4.85). Accordingly, there is evidence for cointegration between exchange rate (EXR) and palm oil export (EX) for the sample period of 2008:1 to 2017:12. This result also supporting the ARDL co-integration test earlier where the co-integration exists when the palm oil export is the dependent variable. This finding confirms the importance of taking asymmetry into account when studying the relationship among these variables.

Table 8: Critical values from Pesaran et al. (2001):

Table CI(iii) Case III: Unrestricted intercept and no trend

	0.100		0.050		0.025		0.010		Mean		Variance	
k	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$
0	6.58	6.58	8.21	8.21	9.80	9.80	11.79	11.79	3.05	3.05	7.07	7.07
1	4.04	4.78	4.94	5.73	5.77	6.68	6.84	7.84	2.03	2.52	2.28	2.89
2	3.17	4.14	3.79	4.85	4.41	5.52	5.15	6.36	1.69	2.35	1.23	1.77
3	2.72	3.77	3.23	4.35	3.69	4.89	4.29	5.61	1.51	2.26	0.82	1.27
4	2.45	3.52	2.86	4.01	3.25	4.49	3.74	5.06	1.41	2.21	0.60	0.98
5	2.26	3.35	2.62	3.79	2.96	4.18	3.41	4.68	1.34	2.17	0.48	0.79
6	2.12	3.23	2.45	3.61	2.75	3.99	3.15	4.43	1.29	2.14	0.39	0.66
7	2.03	3.13	2.32	3.50	2.60	3.84	2.96	4.26	1.26	2.13	0.33	0.58
8	1.95	3.06	2.22	3.39	2.48	3.70	2.79	4.10	1.23	2.12	0.29	0.51
9	1.88	2.99	2.14	3.30	2.37	3.60	2.65	3.97	1.21	2.10	0.25	0.45
10	1.83	2.94	2.06	3.24	2.28	3.50	2.54	3.86	1.19	2.09	0.23	0.41

Once co-integration relationship has been established, moving on to the next step to check for both long-run and short-run asymmetries between the variables.

The t-statistic shows 9.77 with the p-value of 0.002 under the "long-run asymmetry" heading. This give conclusion that the null hypothesis of long-run symmetry between variables can be rejected. In other words, the relationship between the variables are asymmetry in the long run.

On the other hand, the t-statistic shows 2.514 with the p-value of 0.116 under the "short-run asymmetry" heading. This give conclusion that the null hypothesis of short-run symmetry between variables cannot be rejected. In summary, there is long run asymmetry between variables but not for the case in the short run. If the relationship between variables are found symmetry, it gives meaning that a 1% increase in Malaysian exchange rate, will lead to decrease of 1% of palm oil export exactly. On the other hand, asymmetry gives meaning that a 1% increase in Malaysian exchange rate not necessarily lead to an exact 1% decrease in palm oil export, it could be more or less. In other words, the asymmetry means that exchange rate volatility affects exports differently during appreciations and depreciations of the exchange rate.

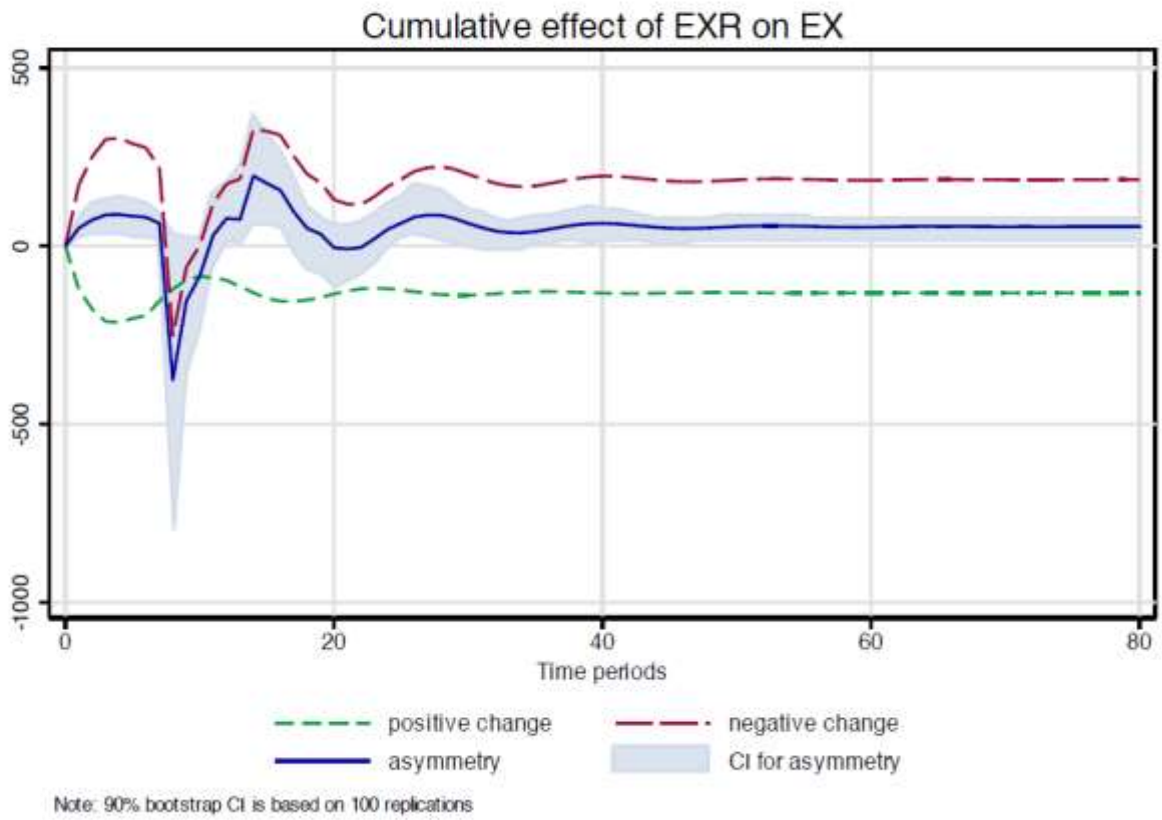
The same table also giving the information of the long run increasing and decreasing effect of independent variable on the dependent variable. When the independent variable – Malaysian exchange rate (EXR) appreciates, it decreases the dependent variable – palm oil export by 0.334%. On the opposite side, when the Malaysian exchange rate depreciates, it will increase of the palm oil export by 0.457%. This result somehow showing support to the theoretical expectation in the long run. This result also supported by the study conducted by Aliyu (2011) where appreciation of exchange rates results in increased imports and reduced exports while depreciation expand exports and discourage imports. Further, it also in line with the study conducted by Basri and Zaimah (2002) that a weak Malaysian currency tend to stimulate the growth of the quantity of palm oil export. Since NARDL approach is able to simultaneously capture short and long run asymmetry through positive and negative partial sum decompositions of changes in the independent variable – exchange rate in this study, and the result shows that the negative shock is greater than the positive shock, this could give an important policy implication to the policy makers in the sense that they might look into implementing a monetary policy (which manipulating the value of the currency) that can stimulate the growth of the export of palm oil in order to remain as one of the major palm oil exporters in the world.

From the long run model mentioned above, the $\alpha_1 = -0.334, \quad \alpha_2 = 0.457$ are derived by looking at the coefficient.

$$EX_t = \alpha_0 + \alpha_1 EXR_t^+ + \alpha_2 EXR_t^- + e_t$$

Finally, the numerical result can be represented graphically as per the *graph 1*. The graph shows the cumulative effect of exchange rate variability (EXR) on palm oil export (ER) in Malaysia. As show in the graph, the effect of a negative shock in exchange rate is found to dominate that of a positive shock with an initial negative effect. This support the saying of the magnitude of the negative change is more than the positive change at the initial stage. As time periods move on, both positive and negative change adjust accordingly and become less volatile.

Graph 1: Graphical representation of NARDL result



Vector Error Correction Model (VECM)

In *table 9*, the results show the four (4) error correction models with palm oil price (POP), palm oil export (EX), palm oil production (PRO), and exchange rate (EXR) as dependent variables respectively. The 't' ratios of the error-correction term are significant at 5% level when the palm oil price (POP), palm oil export (EX) and palm oil production (PRO) are the dependent variables but not significant when the exchange rate (EXR) is the dependent variable. That tends to indicate that the exchange rate is the exogenous variable and the rest of the variables are endogenous. Exogenous means that the government has little or no control on the variable as it mostly depends on external factors. On the other hand, endogenous variable means that it gives the government some controls and able to manipulate on it. In addition, the error-correction coefficient being significant confirms earlier findings of a significant long-run cointegrating relationship between the variables palm oil price (POP), palm oil export (EX) and palm oil production (PRO).

Table 9: Results of error correction model using the ARDL approach

Dependent Variables	ecm1(-1) Coefficient	Standard Error	T-Ratio [Prob.]	C.V.	Result
dLPOP	-.10556	.036071	-2.9263[.004]*	5%	Endogenous
dLEX	-.81150	.085596	-9.4807[.000]*	5%	Endogenous
dPRO	-.57554	.080996	-7.1058[.000]*	5%	Endogenous
dLEXR	-.014614	.019471	-.75053[.455]	5%	Exogenous

Note: * denotes significant at 5% level

Now the writer examines the error correction model of focused variable palm oil export (EX) *Table 10*. The error correction coefficient estimated at -0.8115 (0.000) is highly significant, has the correct sign and implies a faster than a moderate speed of adjustment to equilibrium after a shock. Approximately 81% of disequilibria from the previous month's shock adjusts to the long run equilibrium in the current month.

Table 10: Error correction model when DTB is dependent variable

```
          Error Correction Representation for the Selected ARDL Model
          ARDL(1,0,1,0) selected based on Akaike Information Criterion
*******************************************************************************
 Dependent variable is dLEX
 116 observations used for estimation from 2008M5 to 2017M12
*******************************************************************************
 Regressor               Coefficient        Standard Error            T-Ratio[Prob]
 dLPOP                     -.038712              .041975              -.92225[.358]
 dLPRO                       .24089              .073341               3.2846[.001]
 dLEXR                      -.17023              .059411              -2.8652[.005]
 ecm(-1)                    -.81150              .085596              -9.4807[.000]
*******************************************************************************
```

There is limitation in VECM test, which it unable to tell the relative exogenous or endogenous of the variables. Meaning to say, up until VECM, the result is only able to show which variable is leader (independent) and which variable is follower (dependent). In order to find out the strongest leader and weakest follower, VDC test need to be performed.

Variance Decomposition (VDC)

There are two types of VDC which are orthogonalized VDC and generalized VDC. Generalized VDC is prefer over orthogonalized VDC given the facts that 1) orthogonalized VDC depends on the particular ordering of the variables in the VAR; whereas generalized VDC is invariant to the ordering of the variables. 2) orthogonalized VDC assumes that when a particular variable is shocked, all other variables in the model are switched off, this is not the case for generalized VDC. Hence, in this study, generalized VDC is employed.

Based on the below *table 11* - Generalized VDC table and *figure 2*, the findings indicate that the ranking is consistent for forecast horizon of 20, 24, 36 and 48 where exchange rate being the most exogenous variable followed by palm oil price, palm oil production, and lastly, palm oil export being the most endogenous variable. These out-of-sample variance forecast results given by the generalized variance decompositions further strengthen the earlier within-sample results given by the error correction model that the exchange rate is the only exogenous variable. This finding conveys the most valuable piece of information for policy maker so that they are able to craft and implement a suitable, effective, and wisest policy in tweaking the factors along the causation chain.

Table 11: Generalized VDC (horizon 20, 24, 36, 48)

	HORIZON	LPOP	LEX	LPRO	LEXR	RANKING
LPOP	20	73.59%	8.68%	9.40%	8.34%	2
LEX	20	14.67%	61.83%	18.99%	4.50%	4
LPRO	20	18.49%	6.88%	67.97%	6.66%	3
LEXR	20	7.70%	9.93%	5.68%	76.70%	1

	HORIZON	LPOP	LEX	LPRO	LEXR	RANKING
LPOP	24	73.59%	8.67%	9.40%	8.34%	2
LEX	24	14.76%	61.72%	19.02%	4.50%	4
LPRO	24	18.70%	6.87%	67.79%	6.64%	3
LEXR	24	7.75%	9.93%	5.69%	76.63%	1

	HORIZON	LPOP	LEX	LPRO	LEXR	RANKING
LPOP	36	73.59%	8.67%	9.40%	8.34%	2
LEX	36	14.80%	61.67%	19.02%	4.50%	4
LPRO	36	18.78%	6.86%	67.72%	6.64%	3
LEXR	36	7.77%	9.93%	5.70%	76.59%	1

	HORIZON	LPOP	LEX	LPRO	LEXR	RANKING
LPOP	48	73.59%	8.67%	9.40%	8.34%	2
LEX	48	14.80%	61.67%	19.02%	4.50%	4
LPRO	48	18.78%	6.86%	67.72%	6.64%	3
LEXR	48	7.78%	9.93%	5.70%	76.59%	1

The findings could be represented graphically as below:

Figure 2: Causality Chain

Although the exchange rate is not directly affecting the palm oil export, the result may still suggest to the policy makers that they can still look into exchange rate regime to manipulate the palm oil export. The finding of this study is also in line with some other researches which found impact of exchange rate on export. The policy implication will be discussed in the conclusion and policy implication section.

Impulse Response Function (IRF)

This paper continues with IRF analysis. IRF yields the same result as VDC where it shows the impact of a shock in one of the variables to other variables in the system. Since exchange rate being the most exogenous variable, it makes sense that a shock to it will yield a higher impact to other variables compare to a shock in palm oil export (the most endogenous variable) which on the other hand yield a smaller fluctuation to other variables. *Figure 3* shows a shock to exchange rate; while *figure 4* shows a shock to palm oil export.

Figure 3: Generalized Impulse Responses to one SE shock in the equation for DEXR

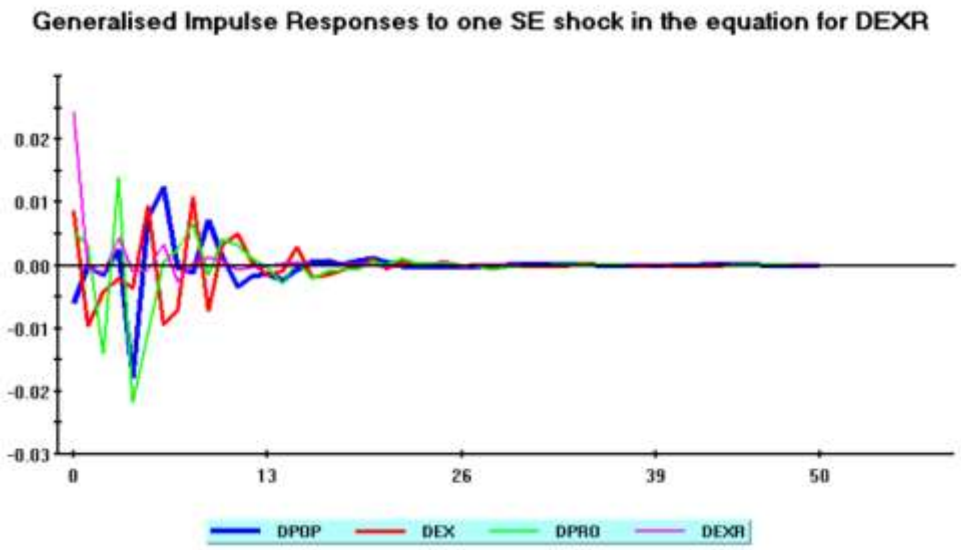
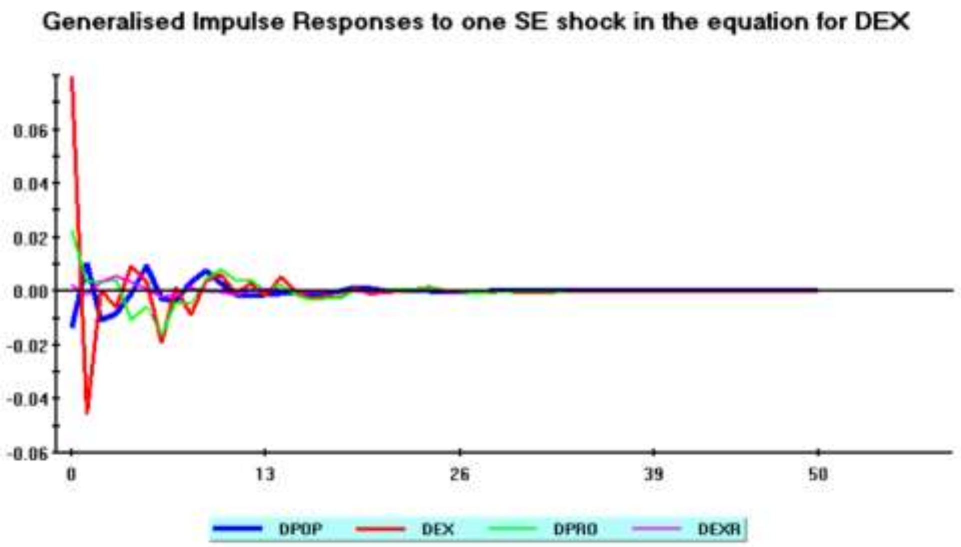


Figure 4: Generalized Impulse Responses to one SE shock in the equation for DEX



5. Conclusion and Policy Implications

This paper investigates the relationship between the exchange rate and palm oil export using monthly time series data covering the period 2008:1 to 2017:12 from Malaysian Palm Oil Council and DataStream. For this paper, the writers employed both ARDL and NARDL models and test the causal relationship between the four variables using VECM, VDC, and IRF techniques. The empirical results tend to indicate that in ARDL, there exists long run relationship between the 4 variables; meanwhile in NARDL, the result shows that there exists a long run asymmetric relationship between exchange rate and palm oil export. The VECM approach employed in this study shows that exchange rate is the exogenous variable, while the palm oil export is the endogenous variable and VDC approach employed in this study shows that exchange rate is the most exogenous variable, followed by palm oil price, palm oil production, and palm oil export being the most endogenous variable.

Despite the fact that exchange rate, being the most exogenous variable revealed by this study is influenced by the external demand and supply of currency and determined by the global markets, it could be to some extent, nonetheless, be controlled by the Malaysian monetary policy taking into consideration of the asymmetric relationship. Since Malaysia is adopting a floating exchange rate regime nowadays, the policy makers could occasionally intervene to change the direction or the pace of change of Malaysia currency value by buying or selling currencies so as to stimulate the growth of Malaysia's palm oil export in addition to any other action (through interaction with other variables, for example the palm oil production and palm oil price). Hopefully by this mechanism, the policy makers will attain the expected result and remain as one of the major exporters in palm oil.

There are some limitations in this study and this includes the use of only four (4) variables which are the palm oil export, palm oil production, palm oil price and exchange rate. For future research, other variables such as the trade balance, interest rates, spot and futures contract of palm oil could be embedded into the study. Further, comparing this study with two (2) or more countries or with other sectors within the same country could imply more meaningful result. Data period could also be divided into pre and post financial crisis to check whether the causality relationship still holds.

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