Determinants of food price inflation: evidence from Malaysia based on linear and nonlinear ARDL

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Determinants of food price inflation: evidence from Malaysia based on linear and nonlinear ARDL

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Abstract

Given the adverse impact of growing inflation on food prices and the importance of policymakers to keep the food price inflation stable, this study aims to investigate the determinants of food price inflation. This study contributes to the existing literature by employing Nonlinear ARDL (NARDL) technique to identify whether the relationship between the focused variables is linear and symmetric or not. This study finds that the variables are cointegrated in the long run. The error correction model VECM and the Variance Decompositions analysis found that the exchange rate is the most exogenous variable and the government has no control over it since it is determined by the external factors such as, supply and demand for Malaysia ringgit. Further, NARDL found that the relationship between the food price and exchange rate to be symmetric in the long run but asymmetric in the short run. Since the exchange rate is the most exogenous variable in this study and the fact that Malaysia in on flexible exchange regime, it makes it hard for the policy makers to control the fluctuations of the Malaysian exchange rate to control food price. Hence the adjustment and control of food price should be made through the reduction of the food import in order to minimise the exchange rate pass through effect on the food price inflation.

Keywords: food price inflation, exchange rate, ARDL, Nonlinear ARDL, Malaysia

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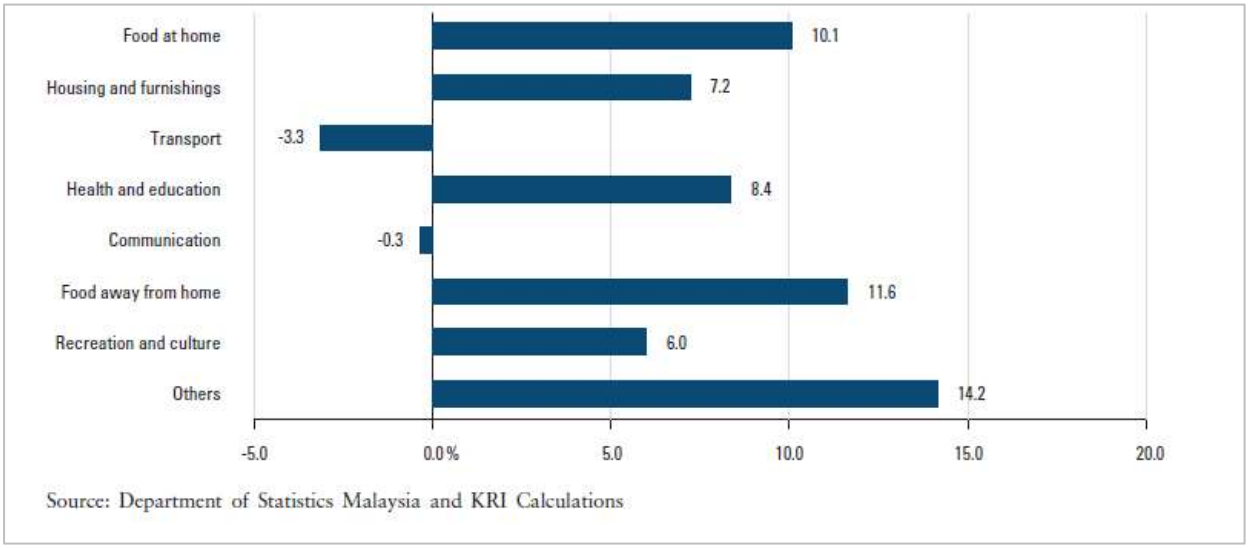
Introduction

Foods are basic living necessity for any living creatures. Hence food prices determine a large portion of living cost. According to Khazanah Research Institute's State of Households II report, in 2014, 94.6% of all households spent more on food than on any other expenditure items. Furthermore, the cumulative change in CPI from 2014 to 2016 in prices of food are also among the largest (Figure 1). It was also reported that between 2014 and 2016, households with income level below RM5,000 are cutting back on actual consumption of food despite spending more money on it given high food inflation. Food price inflation reduce income available for other purposes, or reduce food consumption, or both. Hence, the increase in the cost of food has a large effect on the cost of living in low- and middle-income.

Figure 1 Cumulative change in CPI, 2014-2016[3]



Therefore, the next relevant question is what causes food price inflation in Malaysia particularly? Studies have found several determinants of food prices such as fluctuation of oil prices, the growing population and income of nation resulting in more demand of food, speculative trading in agricultural commodities, world food prices and exchange rate movements.

[3] The State of Households 2018; Different Realities, Khazanah Research Institute, October 2018

Some literature like Trostle (2008) contends that the rapid expansion in global demand, rising crude oil prices, the depreciation of the US Dollar have all contributed to rising prices. Some other literature like Baffes (2007), Harri et al. (2009), Chen et al. (2010), and Baffes and Dennis (2013) all provide evidence indicating significant contribution of oil price to agricultural prices. Ibrahim (2015) also affirms the presence of long run significant relation between oil price increases and food price. The study also adopts nonlinear autoregressive distributed lags (NARDL) model which is used in this study. Wong and Shamsudin (2017) that also adopt NARDL approach found that the growth of real GDP and exchange rates have a significant impact on food price changes, rather than oil prices. Ahsan et. al. (2011) in their study of determinants of food price inflation in Pakistan found that demand-side factors, such as money supply, are the main cause of the increase in food prices in the short as well as the long run.

Headey and Fan (2008) implied that the raised global food prices would have an impact on the size of food and fuel import bills, exchange rate movements and foreign exchange reserves, pattern of food consumption, trade and marketing policies. Whereas Trostle (2008) notes that at micro levels, a price increase in basic necessities could be lethal for many lower-income consumers. Ivanic and Martin (2008) find that, in low-income countries, poor people are typically net consumers of food and are disproportionally more affected by the food price increase. Other the direct income effect, high food prices can also affect household welfare through various other indirect channels. For example, poor households that spend most of their income on food for survival might decide to forego their children's education, thus affecting human capital development (Park and Huh (2013)).

Hence, given the adverse impact of growing inflation on food prices and the importance of policymakers to keep the food price inflation stable, this study aims to investigate the determinants of food price inflation. This study contributes to existing literature by employing NARDL techniques to identify whether the relationship between focused variables are linear or not. If the relationship is found to be symmetric, this means that ARDL model is correct and further analysis can be done by using ARDL. Additionally, this study uses monthly data instead of annual data in order to better capture the short-term effects of the variables on food price fluctuation. Malaysia is chosen as the country of focus due to the fact that it is a developing country and the food price inflation has been growing in many years. Therefore it is

interesting to know what are the determinants of food price inflation in Malaysia and what policy makers can do based on the finding of this study. This study employs monthly data from January 2010 to May 2018 based on data availability in the database and the variables included in this study are namely crude oil price, exchange rate, consumer price index and growth domestic production.

This study finds that the variables are cointegrated in long run. Error correction model in VECM and VDCs found that exchange rate is the most exogenous variable and the government has no control over it since it is determined by external factors such as, supply and demand for Malaysia ringgit. Further, NARDL found that the relationship between food price and exchange rate to be symmetric in long run but asymmetric in short run. As exchange rate is the most exogenous variable in this study, and the fact that Malaysia in on flexible exchange regime, it makes it hard for the policy makers to control the fluctuation of Malaysian exchange rate. Hence the adjustment and control should be made on the demand side by means of reducing food import in order to minimise the exchange rate pass through effect. Malaysian government, particularly agricultural ministry should find ways to be less dependent on food import and to be more self-sufficient. Thus, the government should craft more plan and more incentive to utilise factors of production like land and labour to produce more food locally.

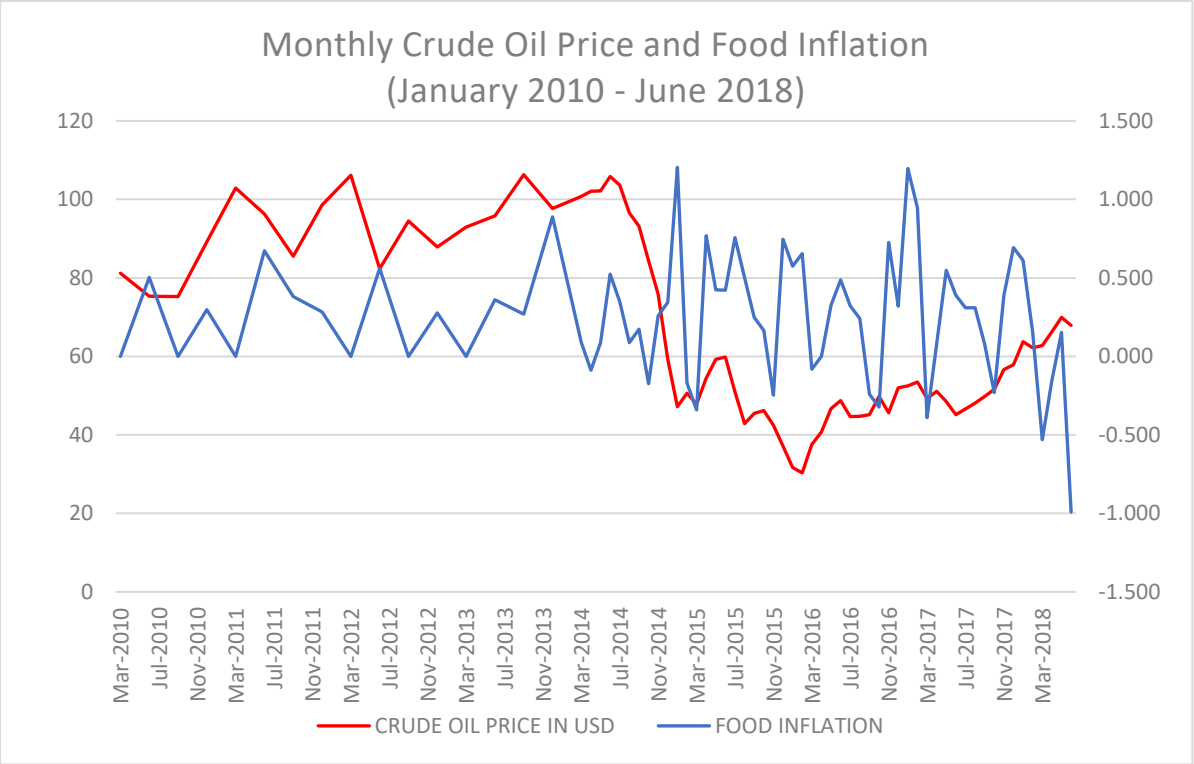
The subsequent sections of this paper are organised as follows: Section 2 describes the theoretical underpinnings of determinants of food prices inflation; Section 3 provides the empirical evidences of prior literatures; Section 4 outlines the data and methodology used in this study together the result and the economic interpretation; and lastly Section 5 concludes with policy implications and limitations as well as suggestion for further research.

THEORETICAL UNDERPINNINGS

Since the early 2000s, food prices have been rising on world markets, and it has been climbing strongly since 2006. In Malaysia, food price inflation, as measured by the year-on-year change in the Food & Beverage Index, is reported to be higher than overall inflation. Between 2011 and 2015, food price inflation was 3.6% on average, whereas overall inflation was only 2.4% over the same period. Needless to say, the constant increase in food prices requires prompt action through various interventions. High price of food creates problems for poor and low-income households as they are struggling to cope with the higher costs of food. According to Khazanah Research Institute's State of Households Report 2018 shows that despite growing expenditure of lower income households on food, the quantity consumed in fact declined due to higher prices. Moreover, on the other hand, this also means that the government will face higher food import bills- creating larger gap in trade deficit. Hence the question as being studied in this paper is what causes food price inflation? Among the main factors of the increment of price of goods, particularly price of foods as being presented by studies are world oil price fluctuation, exchange rates and national GDP.

Oil prices fluctuation is arguably highly contentious reason being made for changed in goods and commodities prices. Crude oil is the main energy supply in most industries hence the changes in prices of oil would impact the food supply chain, hence giving influence on food manufacturing costs. In 2008, due to the global food price and crude oil price crisis, the Malaysian food price inflation was also affected and Malaysian food price was at peak at that year. However, the food price response to oil prices seems to be on the asymmetry. In 2014, the crude oil price decreased significantly but the food inflation rate in Malaysia constantly fluctuated and did not respond in a similar way (Figure 1). This supports study by Ibrahim (2015) that found the crude oil price has a significant impact on the Malaysian food price inflation only when the crude oil price increases. In contrast, there was no statistical evidence found by Ibrahim (2015) to support the theory that a decrease in crude oil price will have a significant impact on the Malaysian food price inflation.

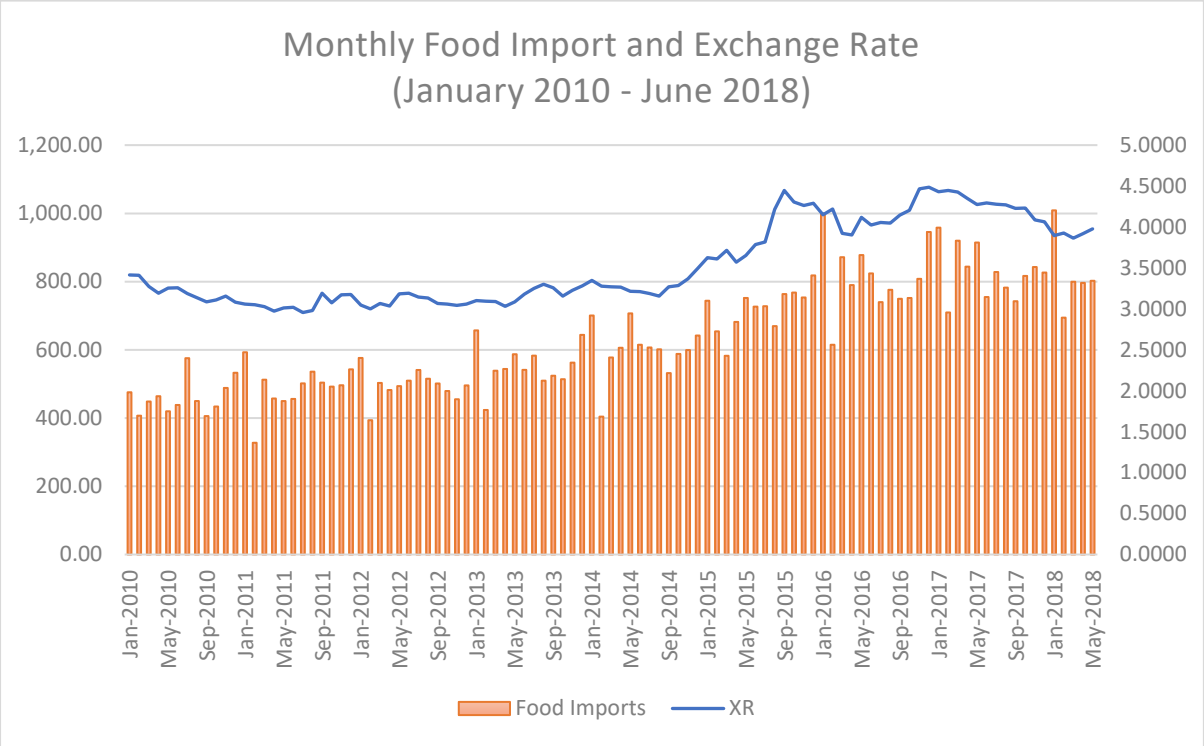
Figure 2 Monthly Crude Oil Price and Food Inflation in Malaysia, January 2010- June 2018



Source: Monthly Bulletin Statistics: Disember 2018, Center Bank of Malaysia

Other than oil prices, exchange rate is another factor that being argued by literature to cause price fluctuations particularly in food prices. Exchange rate can impact on domestic prices in two distinct channels. The first one is through direct effect on marginal cost channel by means that exchange rate alters the price of imported inputs. The second channel has more indirect effect which is through markup channel by which means that if the imported goods are cheaper than the domestic goods, the domestic prices will be inferior, resulting lower markup for domestic firms. This pass-through impact of exchange rate is relatively low for advanced economies such as the United State due to strength of US dollar, but for emerging economies such as Malaysia, the pass-through impact of exchange rate is strong enough to be reflected in the total price of imports. In Figure 2, the monthly food import was plotted on the left-axis and the exchange rate of Malaysian Ringgit to US Dollar was plotted on the right-axis for the period of study of this paper. As shown in the Figure 2, the rising of the exchange rate was followed by the food import at most of the time. However, there are few occurrences where the price of Dollar depreciating but the food import is increasing.

Figure 3 Monthly Food Import and Exchange Rate in Malaysia, January 2010- June 2018



Source: Monthly Bulletin Statistics: Disember 2018, Center Bank of Malaysia

Statistic shows that Malaysia still relies heavily on food imports, despite the fact that Malaysia has been blessed with land and natural resources. As shown in Figure 2 as well, the food import of Malaysia in always on increasing trend. Our latest food import on 2017 totalled up to RM9.9 billion as compared to RM5.9 billion in 2012. An increment on RM4 billion in 5 years. The increasing trend of food imports means that Malaysia is arguably more exposed to oil and global food crises (Ibrahim, 2015), such as the global food and oil crisis which occurred in June 2008 and June 2011. Hence, investigating and understanding the factors that lead to food price inflation in Malaysia is crucial great importance not only for making policy decisions about social welfare but also for the Malaysian food trade bills. Yeong-Sheng (2008) argues that the percentage of Malaysian household food budget across their income quartiles dropped continuously and this affects social welfare especially the lower income groups who spend the majority of their income on the food items- supports the finding from Khazanah Research Institute's report. Furthermore, according to Ibrahim (2015), the households at lower income quartiles will have a higher financial burden than the highest income quartiles when food price inflation increases in Malaysia. Food price increase directly means an

increase in cost of living, hence impacting more on low- and middle-income group who struggling to maintain their living. Thus, learning the importance of understanding the causes of food prices inflation to the policymakers, this paper will then discussed the empirical studies on the determinants of food prices.

LITERATURE REVIEW

The empirical studies about the impact of the crude oil price on food price fluctuation founds mixed empirical results. Several studies like Yu et al. (2006), Zhang and Reed (2008), Zhang et al. (2010), Naglioglu and Soytas (2011) and Reboredo (2012) found weak significant relationship between crude oil price volatility and agricultural prices. Yu et al. (2006) examined the cointegration and causality relationship between the world vegetable oil prices and crude oil prices but found no evidence to support the hypothesis. Furthermore, Zhang and Reed (2008) and Zhang (2010) also found no evidence to support that crude oil price is directly related to agricultural commodity prices such as corn and soy meal in China. Recent literature by Naglioglu and Soytas (2011) and Reboredo (2012) claimed similar result that food prices have had no reaction to the recent oil price shock.

Nevertheless, some literature found relationship between crude oil price and food price. For example, Mutuc et al. (2010) revealed a weak evidence to support the response of cotton prices to petroleum price fluctuations. Moreover, recent literatures by such as, Baffes (2007), Harri et al. (2009), Chen et al. (2010) and Baffes and Dennis (2013) found evidence that oil price fluctuations has a strong relationship on commodity prices. Ibrahim (2015) and Abdlaziz, et al. (2016) studies applied the same asymmetric cointegration method of nonlinear Autoregression Distributed Lag (NARDL) model to investigate the long- and short-run cointegration between oil price changes and food prices in both Malaysia and Indonesia. Both studies found positive long-run impact of oil prices on food price inflation while there is no significant relationship between reductions in the long-run oil price and food prices inflation. Study by Liu (2013) that study linkages between food market and input market has also found that statistically significant long-run equilibrium relationship exists between the prices of food and those of the main variable inputs consumed by the food chain, namely agricultural commodities, labour and energy.

Beside fluctuation in oil prices and movement of exchange rates, there are studies that found other causes for food price inflation. Trostle (2008) argues that the rapid expansion in global demand and other microeconomic factors have all contributed to rising prices beside rising crude oil prices and the depreciation of the United States dollar. Gilbert and Morgan (2010), on the other hand suggest additional factor i.e. rapid economic growth, especially in the People's Republic of China (PRC) and other Asian economies, and the speculative trade in agricultural commodities have influence over food prices. A study by Asian Development Bank in 2013 examines the determinant of food prices in emerging economies in Asia and found that the variation in domestic food prices is mainly accounted for by the countries' own shocks, especially at short horizons. The study also found that a shock to the common regional food price exerts a significant and large influence on domestic food prices across Asia and that the world food price shock contributes slightly to the movements of both common regional food price and domestic food prices in Asia. Furthermore, the study also found weak linkage between food prices and other world factors such as oil prices and food price futures.

Based on the above review of existing literature, it is clear that the empirical evidences also yield a mixed and inconclusive result about the determinants of food prices inflation. This result yield is depending on the study period, country and methodology used. Therefore, this paper will make a humble attempt to add to the growing literature on the determinants of food prices inflation by using a more advanced technique, namely ARDL and NARDL. NARDL will be used to identify whether the relationship between dependent variable and independent variable, which will be found out later, is linear or not, and this would have impact on the policy implication.

DATA, METHODOLOGY AND RESULT

This study employs monthly data from January 2010 to May 2018 based on data availability in the database. Data are sourced from the Monthly Statistical Bulletin of Malaysia's Central Bank (www.bnm.gov.my), except for the crude oil price. The West Texas intermediate crude oil price is taken from the US Environmental Information Administration (www.eia.gov). As the oil prices are quoted in US Dollar (USD), the oil price is then converted into Malaysian Ringgit (MYR) based on the MYR/USD exchange rate source from BNM's Monthly Statistical Bulletin. The variables used in this study are summarised in table below:

Variable	Symbol	Proxy
Food Price	FP	Food price component of the CPI
Crude Oil Price	CPM	Crude oil price in MYR
Consumer Price	CPI	Consumer Price Index
Gross Domestic Product	IPI	Industrial Production Index
Exchange rate	XR	MYR/USD

This study combines standard time series techniques, autoregressive distributed lags model (ARDL) and non-linear ARDL. Time series technique involves testing whether there is long term relationship between the variables and it does not assume causality. These are among the advantages of time series technique in comparison to the standard regression analysis.

Unit Root Test

The first step of the standard time series is to conduct unit root tests on the level and differenced forms of the variables. This step is crucial because co-integration tests in the standard time series technique require all variables to be non-stationary. Stationary variables are defined as variable that have constant mean, variance and covariance. If a variable is found to be stationary, this indicates that there is no theoretical information in the variable, hence co-integration test cannot be performed. Three tests will be conducted, namely Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and KPSS tests. ADF test (Dickey and

Fuller, 1979) takes care of autocorrelation only whilst PP test (Phillips and Perron, 1988) takes care of both autocorrelation and heteroscedasticity. The result for ADF test for level and differenced forms are tabulated in Table 1 and Table 2, while the result for PP and KPSS test are presented in Table 3 and 4 respectively.

Table 1: ADF test in level form

	VARIABLE	ADF	VALUE	T-STAT.	C.V.	RESULT
LOG FORM	LCPM	ADF(1)=AIC	115.3015	- 2.427	-3.415	Non-Stationary
		ADF(1)=SBC	110.1728	- 2.427	-3.415	Non-Stationary
	LFP	ADF(1)=AIC	395.2086	- 3.270	-3.418	Non-Stationary
		ADF(1)=SBC	390.0799	- 3.270	-3.418	Non-Stationary
	LCPI	ADF(3)=AIC	404.9310	- 3.550	3.343	Stationary
		ADF(1)=SBC	397.7429	- 3.521	-3.418	Stationary
	LIPI	ADF(1)=AIC	255.7639	- 5.719	-3.418	Stationary
		ADF(1)=SBC	250.6352	- 5.719	-3.418	Stationary
	LXR	ADF(1)=AIC	214.4382	- 2.386	-3.418	Non-Stationary
		ADF(1)=SBC	209.3096	- 2.386	-3.418	Non-Stationary

Table 2: ADF test in differenced form

	VARIABLE	ADF	VALUE	T-STAT.	C.V.	RESULT
1ST DIFF. FORM	DCPM	ADF(2)=AIC	112.5315	- 6.295	-2.933	Stationary
		ADF(1)=SBC	108.1053	- 6.298	-2.895	Stationary
	DFP	ADF(3)=AIC	388.8834	- 6.336	-2.968	Stationary
		ADF(1)=SBC	383.8482	- 7.469	-2.895	Stationary
	DCPI	ADF(3)=AIC	397.1168	- 5.093	-2.968	Stationary
		ADF(1)=SBC	391.7234	- 7.054	-2.895	Stationary
	DIPI	ADF(4)=AIC	245.9203	- 7.490	-2.930	Stationary
		ADF(1)=SBC	239.0754	-10.602	-2.985	Stationary
	DXR	ADF(3)=AIC	210.4594	- 5.156	-2.968	Stationary
		ADF(1)=SBC	206.3872	- 6.510	-2.895	Stationary

Table 3: PP test in level and differences form

	VARIABLE	T-STAT.	C.V.	RESULT
LOG FORM	**LCPM**	-1.914	-3.4287	NON-STATIONARY
	LFP	-1.8933	-3.4287	NON-STATIONARY
	LCPI	-1.9413	-3.4287	NON-STATIONARY
	LIPI	-7.4341	-3.4287	STATIONARY
	LXR	-2.5723	-3.4287	NON-STATIONARY
1ST DIFF FORM	**VARIABLE**	**T-STAT.**	**C.V.**	**RESULT**
	DCPM	-7.4005	-2.9372	STATIONARY
	DFP	-8.2955	-2.9372	STATIONARY
	DCPI	-6.3598	-2.9372	STATIONARY
	DIPI	-31.0574	-2.9372	STATIONARY
	DXR	-9.5366	-2.9372	STATIONARY

The null hypothesis of both ADF and PP test is the variable is non-stationary. Hence when the t-statistic exceed the critical value at 5% level, the null hypothesis will be rejected, indicating that the variable is stationary. Based on ADF test, all variables are non-stationary in its log level form, except for LCPI and LIPI, while all variables are stationary in the first differenced form. However, in PP test, all variables are non-stationary in log level form except for LIPI, while all variables are stationary in differenced form.

Table 4: KPSS test in level and differences form

	VARIABLE	T-STAT.	C.V.	RESULT
LOG FORM	LCPM	0.0882	0.1434	STATIONARY
	LFP	0.0822	0.1434	STATIONARY
	LCPI	0.1145	0.1434	STATIONARY
	LIPI	0.1248	0.1434	STATIONARY
	LXR	0.1164	0.1434	STATIONARY
1ST DIFF FORM	VARIABLE	T-STAT.	C.V.	RESULT
	DCPM	0.1156	0.40426	STATIONARY
	DFP	0.2088	0.40426	STATIONARY
	DCPI	0.1437	0.40426	STATIONARY
	DIPI	0.1730	0.40426	STATIONARY
	DXR	0.1945	0.40426	STATIONARY

KPSS test is different from ADF and PP as it use null hypothesis of the variable is stationary. Hence, the variable is stationary if the t-statistic is less than the critical value. Different from PP and ADF, KPSS test result indicates that all variable are stationary in both level and differenced form. Once it is confirmed that variables are stationary, vector autoregression (VAR) order selection will be performed to determine to optimum number of lag for variables used in the study. This step is important since this information will be used in Johansen co-integration test.

Table 5: Order of VAR

Selection criteria	No. of Lags
AIC	2
SBC	0

The selection criteria for the order of VAR used are based on Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC) as presented in Table 5. AIC is less concerned on over parameter and tend to choose higher order of VAR and based on the data, AIC use 2 lags, while SBC on the other hand is more concerned on over parameter and tend to choose lower order of VAR. In this study, SBC chose 0 number of lag. Disregarding the choice of 0 lag by SBC, this study will proceed with two lag order.

Cointegration test: Engle Granger and Johansen

Since the variable are tests to be stationary in differenced form, the study proceeds with Engle-Granger or Johansen cointegration tests. Engle-Granger cointegration test determines whether variables in this study are theoretically related or not (Engle and Granger, 1987). This is essential to ensure any relations between the variables are not in fact spurious. However, Engle-Granger test can only determine whether variables are co-integrated or not. It cannot identify the number of co-integrating vectors. Therefore, Johansen test is performed since this method is more advanced than Engle-Granger test. Johansen test can identify the exact number of co-integrating vectors between the variables and it is based on maximum likelihood (Johansen, 1991).

Table 6: Engle-Granger Cointegration test

VARIABLE	ADF	VALUE	T-STAT.	C.V.	RESULT	CONCLUSION
LFP	ADF(1)=SBC	370.4367	-5.4235	-4.5629	STATIONARY	COINTEGRATION

Engle Granger tests the cointegration by examining the error term. If cointegration exists, residual of cointegrating relationship should be stationary. From Table 6, the test shows that there is there is presence of cointegration according to the highest SBC value where the corresponding value of test statistic is greater than critical value.

Table 7: Johansen Cointegration test

Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	Statistic	95% Critical Value	90% Critical Value	Result
r = 0	r = 1	47.001	37.860	35.040	1 cointegration
r<= 1	r = 2	24.455	31.790	29.130	

Cointegration LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	Statistic	95% Critical Value	90% Critical Value	Result
r = 0	r>= 1	104.674	87.170	82.880	1 cointegration
r<= 1	r>= 2	57.673	63.000	59.160	

As Engle-Granger test cannot identify the number of co-integrating vectors, therefore Johansen test is performed. Based on table 7, on both Maximal Eigenvalue and Traces, the null hypothesis of no cointegration is rejected at 5% significant level. After that, the null hypothesis of one cointegration against alternative hypothesis of two cointegration fail to be rejected at 5% significant level. Thus, we conclude that there is only one cointegration.

Although it can be determined whether the variables move together in the long run, Engle-Granger and Johansen tests have its own weaknesses, namely they require all variables to be non-stationary. Additionally, the result of Johansen cointegration tests depends on the number of lags chosen and whether or not trend is included in the test. In other words, changing the number of lags will yield different result. Another issue with Johansen test is it is bias towards accepting the null hypothesis of no co-integration. Since p-value of 5% is used, i.e. error that is acceptable if null hypothesis is rejected is only 5%, this means 95% of the time the null hypothesis will be accepted.

Autoregressive Distributed Lags (ARDL) test

ARDL technique is introduced by Pesaran et al (2001). ARDL does not require all variables to be stationary and it also does not suffer from biasness like the Johansen test to identify whether there is long run relationship between the variables. The long-run relationship of the variables is detected through the F-statistic (Wald test). Long-run relationship of the series is said to be established when the F-statistic exceeds the critical value bound. ARDL can be used even for small sample size, which fit with this study that consist of only 102 observations. ARDL test comprised of two main stages, the first stage is using F-test to determine whether there is long run relationship between the variables. The calculated F-statistic will be compared against the upper and lower critical values as determined by Pesaran et al. (2001). If the F-statistics fall above the upper boundary, the null hypothesis of no cointegration can be rejected and it can be concluded that the variables move together in the long run. However, if it falls below the lower boundary, the null hypothesis cannot be rejected and there is no co-integration between the variables. It is also possible for the F-statistics to fall between the two asymptotic critical values, and this would mean that no conclusive result can be made. These results hold regardless of the stationarity of the variables.

Table 8: ARDL test of long-run relationship

Variables	F-statistics	p-value	Critical Lower Bound	Critical Upper bound	Conclusion
DFP	1.7465	0.135	3.189	4.329	No co-integration
DCPM	0.9982	0.425	3.189	4.329	No co-integration
DCPI	1.7110	0.130	3.189	4.329	No co-integration
DIPI	3.0123	0.016	3.189	4.329	No co-integration
DXR	3.3528	0.009	3.189	4.329	Inconclusive

Based on Table 8, F-statistics of four variables, namely FP, CPM, CPI and IPI is lesser that the critical lower bound of 3.189. Therefore, the null hypothesis of no co-integration cannot be rejected, meaning that there is no cointegration when the variables are the dependent variable. Meanwhile, for XR, the F-statistic value falls between the lower and upper critical bound, hence no conclusive result can be made. However, since the p-value of XR as dependent variable is less than 5%, and it can be concluded that there is a long run relationship between exchange rate, food price, crude oil price, CPI and IPI. Cointegration implies that the relationship among the variables is not spurious by means that there is existence of theoretical relationship among the variables and that they are in equilibrium in the long run. It also implies that each variable contains information for the prediction of other variables. This is one of the advantages of ARDL where only one cointegration is required to conclude that the variables are cointegrated.

However, cointegration cannot tell us the direction of Granger-causation as to which variable is leading and which variable is lagging (i.e. which variable is exogenous and which is endogenous). Hence we proceed to the next step to address this issue.

Vector Error Correction Model (VECM)

The next step is Vector Error Correction Method (VECM), where error correction term is estimated to determine whether a variable is exogenous or endogenous. If an error correction term is found to be significant, this means the dependant variable depends on the error correction term, hence it is an endogenous variable. On the other hand, if the error correction term is insignificant, this can be interpreted as the dependant variable being exogenous or a leader. The coefficient of the error term will show the speed of adjustment to equilibrium,

where a greater absolute value means a faster adjustment and vice versa. In addition, a positive coefficient means the variable will move away from the equilibrium in the long run while a negative sign means the variable will return to the equilibrium.

Table 9: VECM test

ecm1(-1)	Coefficient	Standard Error	T-Ratio [Prob.]	C.V.	Result
LFP	-0.2233	0.0800	-2.7902 [.006]	5%	Endogenous
LCPM	4.4220	1.4882	2.9715 [.004]	5%	Endogenous
LCPI	0.1226	0.0724	1.6931 [.094]	5%	Exogenous
LIPI	-1.4460	0.3783	-3.8220 [.000]	5%	Endogenous
LXR	-0.1651	0.5299	-0.3116 [.756]	5%	Exogenous

In this VECM test, a p-value of less than 5% means the null hypothesis of exogenous variable is rejected, hence the variable is endogenous. Based on Table 9 above, it shows two variables, namely CPI and exchange rate are endogenous or follower as they have p-value less than 5%. While on the other hand, food price, crude oil price and IPI have p-value higher than 5%, indicating that the variables are exogenous or leader, indicating that the variable is determined by external factors. The coefficients of error correction terms for FP, IPI and XR are negative, indicating that all variables will return to its long run equilibrium value. On the other hand, the size of absolute coefficients shows the speed of adjustment to equilibrium once there is a shock. Hence based on the result, CPI, exchange rate and food price speed of adjustment to equilibrium is relatively faster than IPI and crude oil price.

The result also shows that food price, crude oil price and IPI contain information of exchange rate and CPI. This seems intuitive in general term since the changes in exchange rate will have impact on the crude oil price since the oil price is quoted in MYR rather than USD. It is also logical that food price contains information of CPI since food price index is extracted from CPI. Being exogenous means that exchange rate and CPI are determined by external factors. While CPI depends on the movement of good prices in the country, exchange rate depends on the supply and demand for Malaysian Ringgit and few other factors that will impact the price of Ringgit such as political and stability of country. Hence based on this result, it generally shows that any changes in exchange rate and CPI will have impact on the food price, crude oil price and IPI. However, VECM does not show the relative exogeneity or endogeneity, neither does

it explicitly tell whether interest rate can be used to influence inflation. Nevertheless, since exchange rate is the exogenous variable, and not the crude oil price, preliminary result shows that exchange rate might be the determinant of food price inflation. Thus, this study will proceed with VDC to further enhance the analysis

Variance decompositions (VDC)

Although VECM can determine the endogeneity or exogeneity of a variable, it does neither tell the relative degree of endogeneity and exogeneity of the variables. Hence, we apply variance decomposition (VDC) analysis to examine proportion of the variance of a variable explained by its own past, once shocked. There are basically two ways to perform VDC test, either generalised or orthogonalised VDC. Orthogonalized VDCs are not unique and in general depend on the particular ordering of the variables in the VAR , but generalized VDCs are invariant to the ordering of the variables. Additionally, orthogonalised approach assumes when a particular variable is shocked, other variables in the system are switched off. Generalised VDC on the other hand does not make such restrictive assumptions. Therefore, this study will use generalised VDC since it does not suffer from weaknesses as mentioned before. Next, impulse response function (IRF) will be conducted to see the VDC result in graphical illustration.

Table 10: Generalised VDC

Horizon	Variable	LFP	LCPM	LCPI	LIPI	LXR	Exogeneity	Ranking
24 months	**LFP**	56.91%	0.85%	40.66%	0.41%	1.18%	56.91%	4
	LCPM	2.86%	88.07%	3.50%	3.49%	2.07%	88.07%	2
	LCPI	27.48%	5.75%	53.43%	13.31%	0.02%	53.43%	5
	LIPI	12.57%	7.13%	3.34%	72.67%	4.28%	72.67%	3
	LXR	1.41%	0.37%	1.18%	0.00%	97.04%	97.04%	1
48 months	**LFP**	56.33%	0.90%	41.22%	0.38%	1.17%	56.33%	4
	LCPM	2.91%	87.85%	3.58%	3.52%	2.14%	87.85%	2
	LCPI	27.93%	5.78%	52.74%	13.54%	0.01%	52.74%	5
	LIPI	13.27%	7.59%	3.32%	71.31%	4.50%	71.31%	3
	LXR	1.44%	0.35%	1.19%	0.09%	96.93%	96.93%	1

60 months	**LFP**	56.21%	0.91%	41.33%	0.38%	1.17%	56.21%	4
	LCPM	2.92%	87.80%	3.59%	3.53%	2.16%	87.80%	2
	LCPI	28.02%	5.79%	52.60%	13.58%	0.01%	52.60%	5
	LIPI	13.42%	7.69%	3.32%	71.02%	4.55%	71.02%	3
	LXR	1.44%	0.35%	1.20%	0.08%	96.93%	96.93%	1

The finding as shown in table 10 indicates that the ranking is consistent for forecast horizon of 24, 48 and 60 months. Exchange rate is the most exogenous variable of all, followed by crude oil price, IPI, and finally interest rate is the most endogenous. Surprisingly, CPI has the least proportion of the variance of a variable explained by its own past despite the fact that it is exogenous. The ranking can be illustrated as follows:

Figure 4 Casual chain from exogenous (left) to endogenous (right)

The VDC decomposes (or partitions) the variance of the forecast error of a particular variable into proportions attributable to shocks (or innovations) in each variable in the system including its own. The relative exogeneity/endogeneity of a variable can be determined by the proportion of the variance explained by its own past shocks. The variable which is explained mostly by its own shocks (and not by others) is deemed to be the most exogenous of all.

The result from VDCs confirms that exchange rate is the most exogenous or determined by external factors. This result does not conform to Ibrahim (2015) that found oil price to be the leader variable. Being an emerging economy, Malaysia exchange rate are much more volatile and the rate of its exchange is mostly determined by external factors i.e. supply and demand of the currency. Futhermore, Malaysia heavy reliance on import and export, 67% and 60% respectively makes exchange rate fluctuation is more sensitive towards the nation's income and domestic prices. This explains how exchange rate fluctuation is translated into food price-through imports of food supply. Furthermore, exchange rate also seems to have pass through impact on the crude oil price. However, since Malaysia government subsidise the price of oil

partly and keep the price stable, the impact of oil price on food price is insignificant. Therefore, based on the VDCs result, policy makers can reduce, or at least stabilise food inflation by keeping the exchange rate stable. However, this could hardly be done since Malaysia is on flexible exchange rate regime. If the exchange rate does not adjust, then the adjustment should be made on demand i.e. import. Hence, food import should be reduce in order to minimise the impact of pass through from the fluctuation of exchange rate.

Impulse response functions (IRF)

The information contained in the VDCS can be equivalently represented by IRFs through graphical illustration. IRFs essentially map out the dynamic response path of a variable owing to a one-period standard deviation shock to another variable. The IRFs are normalized such that zero represents the steady-state value of the response variable.

Figure 5 IRF on Food Price

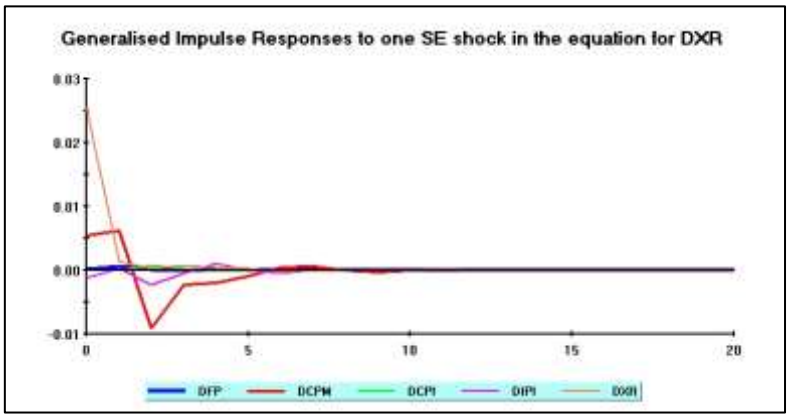


Figure 6 IRF on Exchange Rate

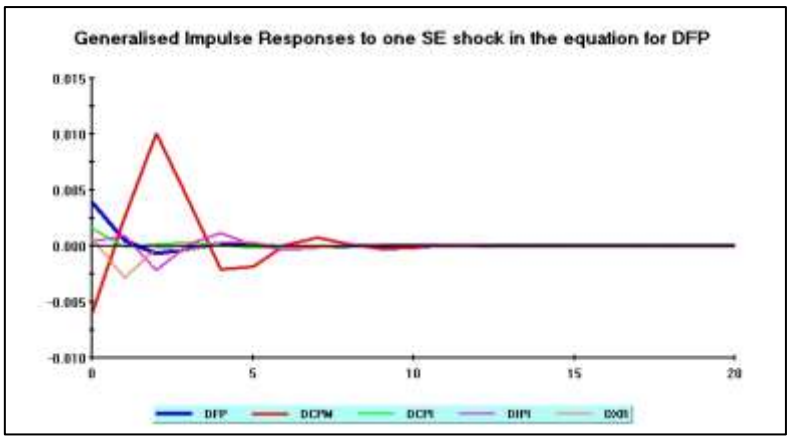
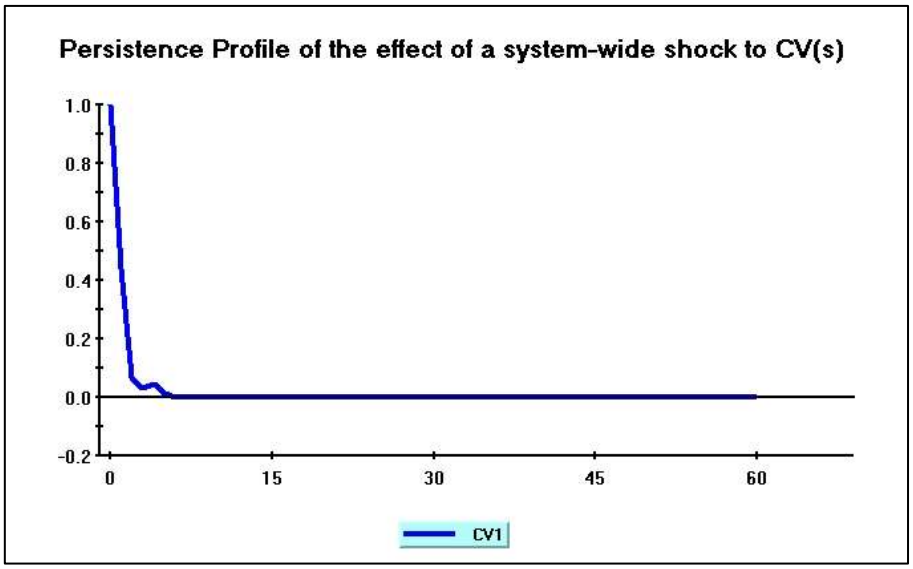


Figure 3 shows the impact of a shock in food price to other variables while Figure 4 shows the impact of a shock in exchange rate on other variables. Although food price variable is more endogenous than exchange rate, it seems that a shock to food prices creates more response from other variables. This is perhaps due to the short period data used in this study. In both cases, all variables return to their equilibrium within 10 months period.

Persistence Profile (PP)

The persistence profile is indicative of the time horizon required to get back to equilibrium when there is a system-wide shock.

Figure 7 Persistence profile of the effect of a system-wide shock



Referring to Figure 3, based on application of persistence profile, it indicates that it takes about 5 months for the for the equilibrium to be restored.

Both the persistence profiles and the IRFs map out the dynamic response path of the long-run relations. The main difference between them is that the persistence profiles trace bout the effects of a system-wide shock on the long-run relations but the IRFs trace out the effects of a variable-specific shock on the long-run relations.

Non-linear ARDL

Notwithstanding the advantages of ARDL technique in preceding discussion, ARDL also suffers from some weaknesses. Firstly, it assumes linearity and symmetrical adjustment. Linearity means proportionate change i.e. 1% change in independent variable will lead to *x*% change in the dependant variable at all times. Meanwhile, symmetrical means constant speed of adjustment before and above equilibrium i.e. a variable will increase and decrease at the same speed. These two assumptions are too restrictive and unrealistic especially for economic variables which have turned more and more erratic in view of globalisation where economies are more interrelated nowadays. Therefore, this study is going to relax these two assumptions of ARDL by going into non-linear ARDL (NARDL), a more advanced technique introduced by Shin et al. (2014).

NARDL has many advantages as it does not assume linearity or symmetric adjustment. Instead, it enables testing linear and non-linear co-integration while differentiating the short run and long run effects of regressors upon the dependent variable. If relationship between the focused variables is found to be symmetric, ARDL model is correct and can be used for further discussion. The next section that follows will discuss the results of each tests performed.

For NARDL, this paper will focus on our two focused variables: exchange rate (independent variable) and food price (dependent variable) because we want to zoom in on the asymmetric relationship of exchange rate and food price without control variables which we have already analysed in ARDL. This could give us clearer picture of the relationship between dependent and independent variables.

Table 11: Cointegration test statistics

Variables	**F-statistics**	**Critical Lower Bound**	**Critical Upper bound**	**Conclusion**
XR	4.504	3.17	4.14	Co-integration

Based on the NARDL test, the first test of long run co-integration reveals that the F-statistics is higher than the critical upper bound at 10% significance level, hence null hypothesis of no

co-integration is rejected. In other words, food price and exchange rate are co-integrated in the long run.

Table 12: Wald test for long run and short run symmetry

Independent: Exchange Rate	**F-statistics**	**p-value**	**Selected specification**
Long run	0.0057	0.940	Symmetry
Short run	6.2610	0.015	Asymmetry

As for the Wald test for symmetries, Table 12 shows that p-value for long run is insignificant, thus the null hypothesis of symmetry in long run cannot be rejected. In other word, NARDL test shows that the relationship between exchange rate and food price is symmetric in the long run. However, the p-value for short run is significant implying that the null hypothesis of symmetry can be rejected and the relationship between the variables is asymmetric.

CONCLUDING REMARKS AND POLICY IMPLICATIONS

Literature on the determinants of food price yield is mixed and inconclusive. Depending on the study period, country and methodology, some found that crude oil price has significant impact on food prices, while some found no relationship between them. Fluctuation in exchange rate is another factor that many literature investigate as the determinant of food price inflation. This study investigates the determinants of food prices by using four variables namely crude oil price in Ringgit Malaysia, exchange rate of MYR to USD, domestic price through Consumer Price Index and lastly gross domestic product through proxy of Industrial Production Index using monthly data from January 2010 to June 2018. The study uses ARDL and NARDL approach and found that the variables are cointegrated in the long run. Error correction model in VECM and VDCs found that exchange rate is the most exogenous variable and the government has no control over it since it is determined by the external factors such as supply and demand for Malaysia ringgit. Further, NARDL found that the relationship between food price and exchange rate to be symmetric in the long run but asymmetric in the short run.

As exchange rate is the most exogenous variable in this study, and the fact that Malaysia is on flexible exchange regime, it makes it hard for the policy makers to control the fluctuation of Malaysian exchange rate. Hence the adjustment and control of food price should be made by means of reducing food import in order to minimise the exchange rate pass through effect. Malaysia has always been in trade deficit in food import. For example in 2016, Malaysian imported around RM45 billion of food, while exporting only RM26 billion resulting in trade deficit of RM18 billion. Malaysian government, particularly agricultural ministry should find ways to be less dependent on food import and to be more self-sufficient. The government may find it difficult to control food and agriculture prices as this may reduce incentives for farmers to produce more with low prices. Thus, the government should craft more plan and more incentive to utilise factors of production like land and labour to produce more food locally. More incentive should be provided for farmers such as subsidies on seeds and breeds and also on machinery. Moreover, government could also have more budget on research on food technology side. Food technology can help in producing larger amount of agriculture in a more cost effective way. Lesser dependency on imported food will reduce the food price inflation eventually.

Some of the limitations on this study is that this study includes only four variables namely, crude oil price, consumer prices, growth domestic production and exchange rate. Furthermore, due to monthly data availability, this study employs short period of study of 8 years between 2010 to 2018. Hence for further research, other variables such as interest rate, trade balance and government policy could be incorporated into the study. Additionally, a longer period of study could be conducted to get a more robust result.

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