Revisiting effectiveness of interest rate as a tool to control inflation: evidence from Malaysia based on ARDL and NARDL

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Abstract

Public policy remains a paradox and a challenging pursuit in finding a delicate balance between conflicting economic goals and outcomes. Nevertheless, interest rate is a commonly used monetary policy tool to maintain a low and stable inflation. However, the effectiveness of interest rate in controlling inflation remains unanswered conclusively. Undertaking a wrong policy stance will lead to huge costs to the economy and society as a whole. Therefore, the purpose of this study is to investigate the lead-lag relationship between inflation and interest rate, and whether the relationship between the two variables is linear. These will determine whether interest rate is an effective tool in the context of Malaysia. This study extends prior literature by using a more recent monthly time series data and advanced techniques known as NARDL and ARDL. Based on this study, it is found that inflation rate is the most exogenous variable while interest rate is the most endogenous variable, hence policy makers have no influence over inflation. A crucial policy implication is policy makers should not use interest rate to control inflation but instead, they should focus on supply side policies to manage inflation.

Keywords: Monetary policy, NARDL, ARDL, Inflation, Interest rate

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INTRODUCTION

Policy makers are often in a dilemma with regards to which policy stance to be pursued or which macroeconomic variable should be focused on. Some of the policy stances that can be pursued include stable exchange rate, sustainable GDP growth, low unemployment, stable interest rate and low inflation. Some of the goals are conflicting with each other, for instance the trade-off between inflation and unemployment as illustrated by the Phillips curve. There is also political motive where policy makers will try to win the public's vote, for example by restraining from raising tax rate although this action can prevent overheating in the economy and contain inflation. The complicated trade-offs, conflicting objectives and competing priorities render public policy making to be a very delicate matter that must be deal with a great care.

One of the most targeted macroeconomic variables is inflation rate. Excessive inflation comes with a negative connotation since this would have adverse impacts on the economic activities as a whole while investors' confidence may be lost. The huge cost associated with prolong period of high inflation leads to many developed and developing economies to employ inflation-targeting strategy. Policies that can be used to control inflation include managing the supply or demand side of the economy. Demand side policy includes changing the tax rate or interest rate.

Theoretically, increasing interest rate will reduce inflation through several channels, including lowering consumption and investment as the cost of financing and cost of capital increase. This would lead to lower aggregate demand and therefore inflation. However, some proponents of this idea states that changing interest rate would not have much influence on inflation, especially for developing economies, as they are very vulnerable to external shocks. It may also come with a negative repercussion as exchange rate will appreciate, and thus affecting external trade. Thus, there is no conclusive evidence that interest rate is an effective policy tool to contain inflation.

There are abundant of literatures that try to empirically investigate whether or not policy makers should use interest rate to control inflation. Prior literatures by Nchor and Darkwah (2015) and Masih, Al-Hajj and Umar (2008) found evidence in support of using interest rate to control inflation since interest rate is the leading variable. In

contrast, Bonga-Bonga (2017) found interest rate to be an ineffective tool based on a study conducted in South Africa. Therefore, it can be seen that previous literatures also yield inconclusive results, possibly due to different countries, periods, variables and methodologies used in the studies.

Based on the above, the major question on the effectiveness of interest rate as a monetary policy tool to control inflation remains unanswered with certainty. Nevertheless, policy makers are still using it to target a low and stable level of inflation. Should interest rate be an ineffective tool, this may lead to wrong policy decision and the implication is very huge and can be very costly. Therefore, it is very important to determine whether interest rate can be used to contain inflation. This study will make a humble attempt to identify the lead-lag relationship between interest rate and inflation rate, as the focus variables, while exchange rate and GDP are chosen as controlled variables.

This study will contribute to existing literatures by employing very recent technique knowns as NARDL, to identify whether the relationship between focus variables are linear or not. If the relationship is found to be symmetry, this means that ARDL model is correct and further analysis can be done by using ARDL. Malaysia is used as the country of focus because it is a developing economy that has been less impacted by the global financial crisis. In the case of Asian Financial Crisis in 1997, Malaysia is a country that does not rely on international aid and it recovered relatively faster than other neighbouring countries. Therefore, it is interesting to know what policy stance is best used by this country.

Based on this study, it is found that interest rate cannot be used as a policy measure to control inflation since inflation is the most exogeneous variable while interest rate is the most endogenous variable. The direction of causality is from inflation to interest rate, instead of the other way around. The relationship between inflation and interest rate is also found to be symmetrical. The policy implication to this study is the central bank of Malaysia should not use interest rate to control inflation. Instead, the government should focus on stimulating the supply side of the economy to manage inflation effectively.

The subsequent sections of this paper are organised as follows: Section 2 describes the theoretical underpinnings of inflation and interest rate; Section 3 provides the

empirical evidences of prior literatures; Section 4 outlines the data and methodology used in this study; Section 5 deliberates on the results and the economic interpretation; while Section 6 concludes with policy implications and limitations as well as suggestion for further research.

THEORETICAL UNDERPINNINGS

The Central Bank of Malaysia recently increased its overnight policy rate (OPR) to 3.25% in January 2018, after keeping it at 3% since July 2016. In the Monetary Policy Statement (MPS) in November 2017, it is stated the Monetary Policy Committee may consider revising the level of monetary accommodation in the economy. Additionally, when the OPR was raised to 3.25%, the MPS states that the most recent decision is to normalise the level of monetary accommodation and went further by stating that strong growth in 2017 is projected to continue in 2018. Thus, there are some indications that the policy decision is trying to control inflation in view of the recent strong growth in Malaysian economy. However, the Governor of the Central Bank of Malaysia in his speech in February 2018 states that the central bank is pursuing inflation anchoring, a deviation from the normal practice of inflation targeting, as the central bank views inflation targeting to be not ideal for small and open economy like Malaysia.

Inflation is one of macroeconomic variables that has significant impact on the growth and well-being of an economy. There are two sides of arguments for and against inflation, although the general most popular view is inflation comes with drawbacks, hence there are a lot of countries who deploy inflation-targeting strategy as a part of their monetary policy. The case of hyperinflation in Germany that peaked in November 1923, where the government was excessively printing money to fund the war costs, thus leading to currency devaluation, is a valuable lesson that too high of an inflation is detrimental to the economy.

The case against inflation is numerous. Firstly, when inflation in the economy high, economic growth can be stunted since domestic goods and services lose its competitiveness, therefore lowering exports volume and proceeds. Households and companies also may choose to purchase imported goods which are now cheaper due to the high inflation. Additionally, periods of high inflation will cause households to lose their purchasing power, and thus lowering consumption, while companies may choose

to defer capital investment in expectation of lower demand for goods and services. As a result, the country's currency will depreciate while national output will shrink, thus further aggravating the situation. The uncertainty associated with high inflation will also affect foreign investments and reduce the value of household savings. These are some of the justifications used by the economists and policy makers to pursue inflation-targeting regime.

On the other hand, inflation is not always a negative phenomenon. Some economists argue that higher inflation may be required to induce growth in a stagnant economy. It can promote recovery through monetary and fiscal expansionary policies. Additionally, when the public anticipate higher inflation in the future, they will choose to spend now instead of deferring their spending to a future where price of goods are expected to be higher. This would have a direct impact to aggregate demand. Secondly, a higher inflation can lower debt burden at both government and household levels. Higher wages during inflationary period would also ease debt burdens as people would have more money to pay back their debts. Hence, there are arguments in support of inflation.

Notwithstanding, it is clear that when inflation is excessive and too high, it would adversely impacting the economy. Therefore, it is extremely crucial to contain inflation at a level that can stimulate growth while at the same time do not overheat the economy. However, what is considered to be excessive inflation or optimum level of inflation to induce growth is beyond the scope of this paper. Instead, based on the precedent discussion, it has been established that controlling inflation is important and thus, this paper will proceed with mechanisms that can be used to control inflation.

Since inflation is determined by the aggregate supply and demand in an economy, it follows that theoretically, policy makers can influence either the demand or supply sides of the economy to control inflation. Since aggregate demand is made up of consumption, investment, government expenditures and net exports, changing the level of one of the variables should have an impact on aggregate demand and therefore inflation. Policy makers can either use fiscal or monetary policies to do so. For instance, increasing tax rate should reduce consumption and investment since households and firms are left with lower disposable income and revenue, thus lowering aggregate demand and price level. However, government can now increase their fiscal

expenditures with higher tax collection, thus leading to crowding out effect. This policy initiative is also unfavourable since the government may lose the public vote. Alternatively, contractionary monetary policy of reducing money supply or increasing interest rate may be used to lower inflation in theory. Government also may influence supply side of the economy by increasing investment in human capital or technology to heighten productivity, therefore increasing aggregate supply and reducing price level.

The above arguments stand in theory although empirical evidences yield mixed results. Nonetheless, this study will only focus on interest rate, specifically whether interest rate can be used to control inflation in the context of Malaysia, a developing economy. It will determine whether interest rate is the leading or lagging variable and the result will determine whether it can be used to control inflation. Before going further, this paper will discuss the theoretical answer to this thesis statement.

There are many literatures that suggest interest rate can be used to control inflation, and this may happen through various channels. Firstly, when a central bank increases interest rate, the cost of borrowing will increase. In the context of Malaysia, the Central Bank of Malaysia may increase the overnight policy rate (OPR) as part of its contractionary monetary policy. OPR is the rate at which banks borrow from each other, hence higher OPR will directly increase the cost of borrowing for banking institutions in Malaysia. This leads to higher cost of funds and thus affecting borrowers with variable rate loans as the loans are tagged to base lending rate (BLR). Consequently, borrowers will be left with lower disposable income and consumption may be reduced, thus reducing the price level. Higher cost of borrowing will also reduce investments by corporations, hence further reducing demand in the economy.

At the same time, higher interest rate will encourage people to save more of their money and defer current consumption as they anticipate higher return from savings. This also will also further reduce current consumption. Higher interest rate would also attract foreign investment and hot money from foreign investors, thus increasing the demand for domestic currency. As a result, domestic currency will appreciate and adversely affecting the net exports in an economy as exports loses its international competitiveness. The combined implication is inflation will be further reduced.

However, there are some literatures that argue interest rate can be used to control inflation only in certain conditions. Masson et al. (1998) states that there are prerequisites for effective inflation targeting, firstly central bank must be independent of the ruling government and secondly, policy makers should not target other nominal variables. Roger (2010) states that monetary policy tool may fail to control inflationary pressure due to heighten influence of external shocks to emerging and developing economies. Others claim that monetary policy such as changing interest rate by itself is insufficient to contain inflation as it can only moderate consumption while the supply side of the economy remains unchanged (Giap and Cheng, 1995). Instead, a more comprehensive fiscal policy that addresses the supply side is crucial to achieve a sustainable growth in long term.

Premised on the above arguments, it cannot be concluded whether interest rate as a monetary policy tool can be used to control inflation or not. This paper will then discuss prior empirical studies to determine whether this tool is effective in controlling inflation.

LITERATURE REVIEW

The growing literatures that study the effectiveness of monetary policies and the relationship between interest rate and inflation signify the importance of this issue. Masih and Masih (1997) conducted a multivariate test on Pakistan by using variables such as money supply, prices, output, interest rate and exchange rate. The study shows that CPI and money supply is the leading and lagging variables respectively. In other words, changing money supply is not an effective tool to control inflation. Additionally, the paper identified output and inflation as the exogeneous variables while output, money supply and exchange rate are endogeneous, i.e. can be internally determined. Bonga-Bonga (2017) conducted an empirical research to assess the effectiveness of monetary policy in South Africa during periods of inflation targeting. They employed SVECM methodology and found that monetary policy shocks are not able to influence inflation level. Instead, it has an impact on manufacturing production and therefore economic growth, but not inflation.

Other study performed by Nchor and Darkwah (2015) on Ghana uses Error Correction Method (ECM) found that inflation is endogeneous, thus it can be controlled by the policy maker to a certain extent. Additionally, Masih, Al-Hajj and Umar (2008) performed a study on Saudi Arabia by using data from 1986 to 2004. By employing

ARDL methodology, the authors found that in a closed economy, interest rate leads inflation rate. In other words, interest rate can be used to control inflation. On the other hand, in an open economy, exchange rate is exogenous while interest rate and inflation rate are endogenous variables. Cioran (2010) performed a regression analysis on Romania and it was found that there is a significant relationship between interest rate and inflation rate, thus interest rate is an efficient instrument that central banks can use to prevent inflation.

Some studies produce a mixed result, depending on the study period. A research conducted by Ma and Park (2005) use cross spectral analysis to determine the impact of the 1997 Asian Financial Crisis on two of macroeconomic variables, namely interest rate and inflation rate. The authors found that prior to the financial crisis, the leading variable is inflation rate while interest rate is the lagging indicator. This means that interest rate cannot be used to contain inflation. However, the causality was reversed during the crisis in 1997, where interest rate is leading inflation rate. Gokal and Hanif (2004) conducted a study on inflation and economic growth in Fiji and they found that the direction of causality is from GDP growth to inflation.

In the context of Malaysia, Poon and Tong (2009) conducted an empirical analysis on the feasibility of inflation targeting in Malaysia. Using methodologies of Julius and Johansen (1990) and VECM, the author identified that interest rate and exchange rate have significant impact on inflation in the short run. Based on VECM, he found that exchange rate is exogenous while other variables namely inflation, money supply and interest rate are endogenous. The author further argues that a necessary condition for an effective inflation targeting policy is transparency, without which the target to contain inflation would be unsuccessful.

Based on the above, it is clear that the empirical evidences also yield a mixed and inconclusive result, 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 effectiveness of interest rate in controlling inflation by using a more advanced technique, namely ARDL and NARDL. A long time series data will be used in an attempt to capture as much historical information in the chosen variables as possible. NARDL will be used to identify whether the relationship between inflation rate and interest rate is linear or not, and this would have impact on the policy implication.

DATA AND METHODOLOGY

This study utilises monthly data extracted from Datastream, for a period from March 1988 to September 2015 based on data availability in the database. Table below summarises the variables used in this study/

Variable	Symbol	Proxy
Interest rate	IR	90-day Treasury bill discount rate
Inflation rate	IN	Consumer Price Index
Exchange rate	ER	MYR/USD
Gross Domestic Product	IP	Industrial Production Index

Methodology used in 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.

Firstly, unit root tests will be conducted on the level and differenced forms of the variables. This step is important 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 entails 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 null hypothesis of both tests is there is no co-integration. On the other hand, KPSS use null hypothesis of there is co-integration between the variables (Kwiatkowski et al., 1992). Once it is confirmed that variables are non-stationary, VAR order selection will be performed to determine to optimum number of lag for variables used in the study. This step is crucial since this information will be used in Johansen co-integration test. Next, Engle-Granger co-integration test will be performed, to determine 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).

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 co-integration 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 10% is used, i.e. error that is acceptable if null hypothesis is rejected is only 10%, this means 90% of the time the null hypothesis will be accepted.

Therefore, this paper will proceed with ARDL technique introduced by Pesaran et al. (2001), a more advanced technique compared to the standard time series. ARDL does not require all variables to be stationary and it also does not suffer from biasness like the Johansen test. ARDL is a bound testing approach that can be used even for small sample size, although this is not a concern in this study with 331 data points. 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 co-integration 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.

Once it is confirmed that there is a long run co-movement between the variables, the second stage in ARDL technique is estimating the long-run coefficients of the variables. 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 actually 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.

Although VECM can determine the endogeneity or exogeneity of a variable, it does neither tell the relative strength nor rank the variables. Thus, this study will perform variance decomposition (VDC) analysis to determine the relative strength, and this step is crucial for policy makers. There are two ways to perform VDC test, either generalised or orthogonalised VDC. Orthogonalised VDC is inferior since it is not unique and depends on the particular ordering of the VAR, but generalised VDC is unique and does not depend on the ordering of the variable. Additionally, orthogonalised approach assumes when a 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.

Notwithstanding the advantages of ARDL technique in preceding discussion, ARDL also suffer 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. On the other hand, symmetrical means constant speed of adjustment from 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 to the dependant variable. If relationship between the focus variables is found to be symmetry, ARDL model is correct and can be used for further discussion. The next section that follows will discuss the results of each tests performed.

EMPIRICAL RESULTS AND DISCUSSION

Unit root test

Table: ADF test

	VARIABLE	ADF	VALUE	T-STAT.	C.V.	RESULT ADF
LOG FORM	LIR	ADF(5)=AIC	414.4136	- 3.232	- 3.466	NON-STATIONARY
		ADF(1)=SBC	404.6150	- 3.172	- 3.505	NON-STATIONARY
	LIN	ADF(5)=AIC	1,466.4000	- 2.018	- 3.405	NON-STATIONARY
		ADF(1)=SBC	1,458.0000	- 2.319	- 3.410	NON-STATIONARY
	LER	ADF(5)=AIC	798.0890	- 2.152	- 3.405	NON-STATIONARY
		ADF(1)=SBC	789.7582	- 1.867	- 3.410	NON-STATIONARY
	LIP	ADF(3)=AIC	623.2221	- 1.806	- 3.381	NON-STATIONARY
		ADF(2)=SBC	612.9377	- 1.747	- 3.375	NON-STATIONARY

	VARIABLE	ADF	VALUE	T-STAT.	C.V.	RESULT
1ST DIFF FORM	DIR	ADF(4)=AIC	409.2818	- 7.244	- 2.817	STATIONARY
		ADF(1)=SBC	401.0507	- 11.846	- 2.798	STATIONARY
	DIN	ADF(4)=AIC	1,460.5000	- 9.787	- 2.830	STATIONARY
		ADF(1)=SBC	1,453.1000	- 11.888	- 2.908	STATIONARY
	DER	ADF(4)=AIC	794.9560	- 7.319	- 2.830	STATIONARY
		ADF(1)=SBC	788.1878	- 12.854	- 2.908	STATIONARY
	DIP	ADF(2)=AIC	619.8580	- 12.942	- 2.878	STATIONARY
		ADF(1)=SBC	613.1590	- 22.569	- 2.908	STATIONARY

Table: PP test

	VARIABLE	VALUE	T-STAT.	RESULT PP
LOG FORM	LIR	-2.9076	-3.4711	NON-STATIONARY
	LIN	-2.023	-3.3971	NON-STATIONARY
	LER	-2.094	-3.3971	NON-STATIONARY
	LIP	-3.0556	-3.3971	NON-STATIONARY
	VARIABLE	VALUE	T-STAT.	RESULT PP
1ST DIFF FORM	DIR	-14.2625	-2.8824	STATIONARY
	DIN	-14.311	-2.8755	STATIONARY
	DER	-17.6313	-2.8755	STATIONARY
	DIP	-39.9512	-2.8755	STATIONARY

Table: KPSS test

	VARIABLE	VALUE	T-STAT.	RESULT KPSS
LOG FORM	LIR	0.11481	0.14218	STATIONARY
	LIN	0.19605	0.14096	**NON-STATIONARY**
	LER	0.12965	0.14096	STATIONARY
	LIP	0.24862	0.14096	**NON-STATIONARY**
	VARIABLE	VALUE	T-STAT.	RESULT KPSS
1ST DIFF FORM	DIR	0.099694	0.42182	STATIONARY
	DIN	0.30152	0.42	STATIONARY
	DER	0.071843	0.42	STATIONARY
	DIP	0.46267	0.42	**NON-STATIONARY**

Based on ADF and PP tests, all variables are non-stationary in its log level form while they are stationary in the first differenced form. However, KPSS yield a mixture of result where LIN and LIP are found to be non-stationary in the log level form, while LIP is also non-stationary in the first differenced form. Based on KPSS, this study cannot proceed with Engle-Granger or Johansen co-integration tests as they require all variables to be non-stationary. Therefore, ARDL will be used in the later section, since it does not require all variables to be non-stationary, to identify whether there is long run relationship between the variables. Nevertheless, this study will use the ADF and PP tests at this juncture to enable carrying out Engle-Granger and Johansen tests.

VAR order selection

Selection criteria	No. of Lags
AIC	3
SBC	1

Prior to the co-integration tests, this study attempts to identify the order of vector autoregression (VAR), and this information is crucial for the next step. The selection criteria used are based on Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC). AIC is less concerned on over parameter and tend to choose higher order of VAR and based on the data, AIC use 3 lags. SBC on the other hand is more concerned on over parameter and tend to choose lower order of VAR. in this case, SBC has chosen one number of lag. Given the two opposite nature of AIC and SBC, this study will choose two lag order, i.e. the midpoint of AIC and SBC results.

Co-integration tests: Engle-Granger

VARIABLE	ADF	VALUE	T-STAT.	C.V.	RESULT	CONCLUSION
LIR	ADF(5)=AIC	405.8548	- 3.659	- 4.133	NON-STATIONARY	NO COINTEGRATION
	ADF(1)=SBC	397.9229	- 3.545	- 4.133	NON-STATIONARY	NO COINTEGRATION

Based on Engle-Granger co-integration test, this study found no co-integration between the variables. This can be attributed to the nature of variables used in this study where according to KPSS, there is a mixture of stationary and non-stationary variables, hence rendering the Engle-Granger test to be invalid.

Co-integration tests: Johansen

Lag order 2, Unrestricted intercept and trend

Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	23.711	31.000	28.320

Cointegration LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	50.415	58.930	55.010

Lag order 2, Unrestricted intercept but restricted trend

Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	24.053	31.790	29.130

Cointegration LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	57.004	63.000	59.160

Based on Johansen test, similar result is obtained where there is no co-integration between the variables based on both maximal eigenvalue and trace. This study repeated the test by changing the intercept and trend as well as the lag order but all tests lead to the same result of no co-integration. It is emphasised that the result may be invalid as variables are found to be a mixture of stationary and non-stationary. Therefore, this study will proceed with ARDL test.

Co-integration tests: ARDL

Variables	F-statistics	p-value	Critical Lower Bound	Critical Upper bound	Conclusion
DIR	5.5499	[.000]	3.539	4.667	Co-integration
DIN	1.9811	[.097]	3.539	4.667	No co-integration
DER	2.6883	[.031]	3.539	4.667	No co-integration
DIP	2.4591	[.046]	3.539	4.667	No co-integration

According to the bound test with null hypothesis of no co-integration, the test result shows that F-statistics for interest rate of 5.5499 is higher than the upper bound critical value of 4.667. Therefore, the null hypothesis can be rejected and it can be concluded that there is a long run relationship between interest rate, inflation rate, exchange rate and GDP, and the relationship is not spurious. However, when inflation rate, exchange rate and GDP are the dependant variables, the results show there is no co-integration. This is one of the advantages of ARDL where only one co-integration is required to conclude that the variables are co-integrated. Since it has been established and confirmed that there are theoretical link between the variable, this paper will then

proceed to VECM and VDC to identify causality and the relative strength of each variable.

Vector Error Correction Model (VECM)

ECM	Coeff	S.E.	T-ratio (P-value)	Conclusion
LIR	-0.062707	0.014503	-4.3238[.000]	ENDOGENOUS
LIN	-0.004525	0.0036725	-1.2320[.219]	EXOGENOUS
LER	-0.008053	0.012803	-.62901[.530]	EXOGENOUS
LIP	-0.026839	0.020316	-1.3211[.187]	EXOGENOUS

In VECM test, a p-value of less than 10% means the null hypothesis of exogenous variable is rejected, hence the variable is endogenous. Based on the VECM table, interest rate is the only variable that is endogenous while inflation rate, exchange rate and GDP are exogenous or determined by external factors. The result shows that inflation rate, exchange rate and GDP contain information of interest rate and this seems intuitive in general term. It is possible to predict whether interest rate will rise or fall by referring to inflation rate, exchange rate and GDP. For instance, when inflation rate is accelerating, policy maker may choose to reduce interest rate to contain inflation. In another case, when a currency is depreciating and losing its value, policy maker may raise interest rate to create more foreign investment inflow, thus demand for domestic currency and appreciating the currency. When GDP growth is negative or an economy is shrinking, the government may reduce interest rate to stimulate consumption and investment and thus, increasing GDP. Based on the VECM test, it can be seen that the direction of causality is from inflation, exchange rate and GDP to interest rate, thus it is consistent with the theory. 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 interest rate is the only endogenous variable and the causality is from inflation to interest rate, the result preliminary shows that interest rate may be ineffective in controlling inflation. This study will proceed with VDC to further enhance the analysis.

Prior to that, by looking at the coefficients of error correction terms, it can be seen that all signs 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. Based on the result, interest rate and GDP speed of adjustment to equilibrium is relatively faster than inflation rate and exchange rate.

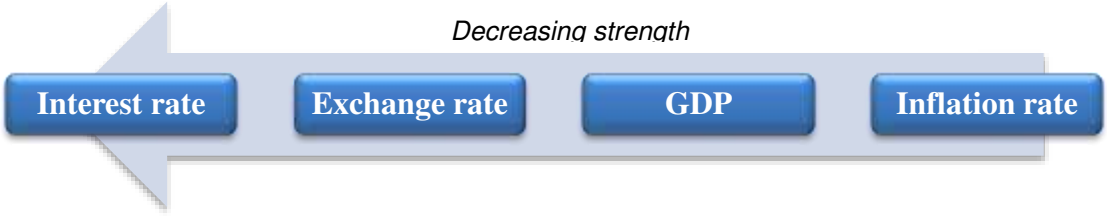
Variance Decomposition (VDC)

	HORIZON	DIR	DIN	DER	DIP	RANKING
DIR	24	93.25%	1.26%	4.07%	1.42%	4
DIN	24	1.21%	97.21%	0.37%	1.21%	1
DER	24	3.31%	1.00%	95.17%	0.51%	3
DIP	24	1.07%	0.38%	2.80%	95.76%	2

	HORIZON	DIR	DIN	DER	DIP	RANKING
DIR	36	93.25%	1.26%	4.07%	1.42%	4
DIN	36	1.21%	97.21%	0.37%	1.21%	1
DER	36	3.31%	1.00%	95.17%	0.51%	3
DIP	36	1.07%	0.38%	2.80%	95.76%	2

This study uses generalised VDC given its strength over the orthogonalised approach. A variable is deemed as the most exogenous if the forecast error variance is mostly explained by its own shock.

The finding indicates that the ranking is consistent for forecast horizon of 24 and 26 months. Inflation is the most exogenous variable of all, followed by GDP and exchange rate, and finally interest rate is the most endogenous. This is in line with our VECM result where only interest rate is endogenous. The ranking can be illustrated as follows:



This result confirms that interest rate cannot be used to control inflation as inflation rate is exogenous or determined by external factors. This can be explained by the fact that Malaysia is an open developing economy with high reliance on imports and exports, 67% and 60% of GDP respectively, to generate the economy. Therefore, Malaysian government cannot influence inflation rate by using monetary policy since it is dependent on foreign demand for export, where increase in demand for export from foreigners will increase domestic inflation in Malaysia, and the price level of imported goods, where increase in import price will lead to cost push inflation as price of imported input increased. In short, the VDC result shows that interest rate cannot be used to influence inflation as inflation is mainly determined by external factors.

GDP comes next after inflation and this may be explained by the nature of GDP where it is influenced by a large number of factors and components, namely consumption by household, investment by firms, government expenditures and net exports. Therefore, it is difficult for the Malaysian government to influence GDP on its own since government expenditure only contribute to 13% of GDP, lower than the world average of 17%.

Exchange rate being in the third rank of VDC is also intuitive and can be explained by the fact that Malaysia is highly dependent on exports and imports, which will then have influence on the exchange rate. However, exchange rate is not the most exogenous variable probably due to certain degree of intervention by the Central Bank of Malaysia to keep a stable exchange rate within certain level because it would have a direct impact on net exports and therefore GDP as well as economic growth.

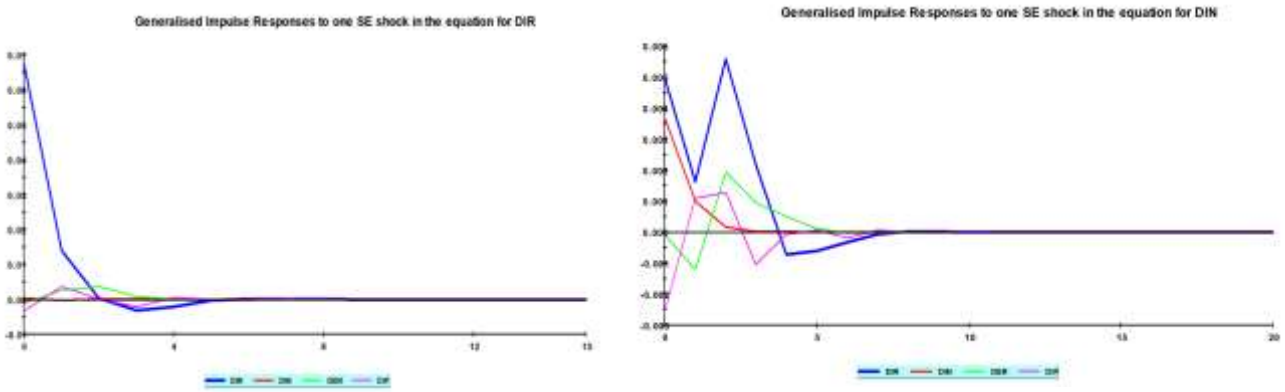
Finally, interest rate is the weakest of all variables and it can be influenced by the central bank. This makes sense because interest rate is directly influenced by the central bank through Overnight Policy Rate (OPR) which is determined by the Monetary Policy Committee of the Central Bank on a quarterly basis.

To conclude, the VDC result shows that interest rate is not an effective tool to control inflation since inflation is determined by external factors. Alternatively, policy maker must consider other policy decisions such as changing the supply side of the economy to control inflation.

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.

The first graph on the left shows the impact of a shock in interest rate to other variables. Since interest rate is the most endogenous or weakest, it can be seen that a shock in interest rate yield the least response in inflation rate and the impact to other variables is quite minimal. In contrast, when inflation rate, being the most exogenous, is being shocked in the second graph on the right, there is a huge response from other



variables. In both cases, all variables return to their equilibrium within 10 months period.

NARDL

For the purpose of NARDL test, this paper will only focus on two variables, namely interest rate and inflation rate, consistent with the thesis statement of this study which is determining whether interest rate can be used to control inflation. Hence, this paper would like to know the relationship between these two variables, specifically whether there exists a long run relationship between them and whether the relationship is linear or non-linear.

Co-integration test statistics

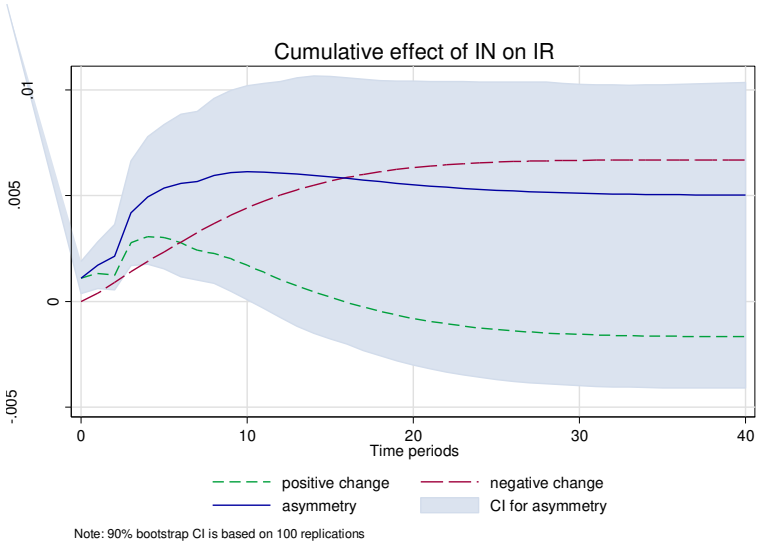
Variables	F-statistics	Critical Lower Bound	Critical Upper bound	Conclusion
IN	7.2458	3.17	4.14	Co-integration

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, interest rate and inflation rate are co-integrated in the long run.

Wald test for long run and short run symmetry

Independent: Inflation rate	F-statistics	p-value	Selected specification
Long run	0.9155	0.339	Symmetry
Short run	0.6895	0.407	Symmetry

As for the Wald test for symmetries, it can be seen that the p-values for both long and short run is insignificant, thus the null hypothesis of symmetry in long and short run cannot be rejected. In other word, NARDL test shows that the relationship between inflation rate and interest rate is symmetry in long and short term, hence symmetric ARDL model is suitable for this study. The graph below shows the cumulative effect of inflation on interest rate all lies within the confidence interval for symmetrical relationship (i.e. shaded area).



The symmetrical relationship between these two variables may be due to decisions by policy makers to keep inflation rate and interest rate stable since Malaysia as a

developing economy is highly dependent on foreign investment. Thus, it is imperative for the Malaysian government to keep inflation rate stable to retain investor confidence. Failure to do so may result in capital outflows and this would have adverse impacts on GDP. Keeping inflation rate stable could also be for political reason to win the people's vote and accelerating inflation may cause the public to lose trust in the government.

CONCLUDING REMARKS AND POLICY IMPLICATIONS

The policy makers' dilemma on what economic objective to be pursued and which policy tools to be used remains as a question with no definitive answer. This paper questions the use of interest rate as a policy measure to control inflation, a proposition that has been widely accepted in theoretical literature. Based on NARDL, focus variables are found to have symmetrical relationship. Therefore, ARDL model is used to identify the causality and relative exogeneity between the variables. It is found that inflation is the most exogenous variable and the government has no control over it because it is determined by external factors, possibly due to Malaysia being an open economy with high reliance on external trade. On the other spectrum, interest rate is the most endogenous variable as it can be directly influenced by the central bank through Overnight Policy Rate (OPR). Therefore, this study shows that interest rate cannot be used to control inflation and the direction of causality is from inflation to interest rate and thus, Malaysian government should not use interest rate to achieve a low and stable inflation.

The policy implication is policy makers in Malaysia should not use interest rate to influence inflation. Since the study shows that inflation is determined by external factors, policy makers should instead focus on stimulating the supply side of the economy to increase output and thus, reduce inflation. Some of the measures that can be done include increasing investment in human capital to heighten productivity. Instead, it can be seen that Malaysian government has been allocating some budgets for scholarships on yearly basis and a lot of students have been sent to study abroad in developed countries to increase human capital quality. Additionally, Malaysian government should allocate more resources on research and development (R&D) to encourage technological enhancement. Alternatively, tax exemption can be granted to corporations who invest in R&D to achieve the same policy goal. Although these

supply side policy measures are very long term and a lot of uncertainty is involved as it would take years before a clear result can be measured, the potential benefits of long term sustainable growth without a rise in inflation is very valuable.

Some of the limitations of this study include it only uses four macroeconomic variables, namely interest rate, inflation rate, exchange rate and GDP. For further research, other macroeconomic variables such as, money supply and trade balance can be incorporated since Malaysia has high reliance on external trade. Additionally, periods of study can be grouped according to periods with and without crisis to identify whether the direction of causality holds even during the economic crises.

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