Is residential property the ultimate hedge against inflation ? new evidence from Malaysia based on ARDL and nonlinear ARDL

Nur Suhairah Aqsha and Mansur Masih

INCEIF, Malaysia, INCEIF, Malaysia

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Nur Suhairah Aqsha [1] and Mansur Masih[2]

Abstract

Residential property is seen as a good investment asset which can protect the real wealth of investors against increase in prices of goods and services. Despite rising house prices, consumer home buying power is still going strong in Malaysia. Nevertheless, many believe that over longer time horizon, house prices could decline jeopardizing the real returns on investment especially during inflationary pressure. Therefore, this paper aims to analyze the inflation-hedging abilities of Malaysian housing properties both in the long run and short run. We extend current literature using relatively advanced technique of NARDL (Shin et al, 2014) in order to examine the intrinsic asymmetric relationship among the variables. Different hedging tools are included for comparison purpose namely, gold price and stock price. Overall, we find that house price responds to inflation rate asymmetrically in the long run. Gold has asymmetric linkage with inflation but the NARDL estimation result is insignificant, whereas stock price is proven to be a much better option as it reacts symmetrically over both short- and longer-time horizon. However, house ownership can still hedge against inflation in the long-run since the home prices have risen faster than inflation rate during the recent housing bubbles. The findings tend to suggest that ignoring potential nonlinearity may lead to misleading evidence as house prices can be influenced by different macroeconomic determinants. Therefore, it could be of major importance for more effective property investment and policymaking in the context of the Malaysian house market.

Keywords: Residential Property, House Price, Inflation, Hedging, Nonlinear ARDL, Malaysia

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

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

Introduction: Motivating the Issues at Hand

The function of real residential property as a powerful inflation hedge has been widely examined since the 1990s. Previous studies are mainly motivated by historical views that house property should be expected to increase in value over time and thus, viewed as both a good investment asset and an effective tool to hedge against inflation. From an investment point of view, direct investment in real property can attend to both consumers' needs to own a home and investors' desire to guard their investment against inflation. On this basis, the objective of rational investors is not only to gain profit from their property investments return but also to protect from downside risk. Among the biggest risk facing the market today, inflation risk has become one of the major concerns as it can erode the real returns from investment. Precisely, a positive correlation between asset returns and inflation rate signifies that purchasing power due to inflation can be partially or wholly compensated for by the rise in housing returns. At this point, house is said to be a good protection against inflation[3].

Likewise, householders in Malaysia have actively bought and invested in houses in spite of rising cost of housing. This rampant house price growth can give detrimental effects as many believe that real property market might crash soon and cause fall in house price over time. Despite the vast number of researchers contributing studies on the effect of residential property investment to hedge against inflation, a simple conclusion that can be made throughout the literature is that the results are mixed. On symmetric cases, Stevenson (2000) and Anari and Kolari (2002) show that housing property can act as stable inflation hedge in the long run whilst on the other hand, Hamelink and Hoesli (1996) and Amonhaemanon et al (2013) deduce that it cannot hedge against inflation over time. The aforementioned literature are examined through positive relation between housing returns and inflation rate. However, the asymmetric setting on the relationship between house prices and inflation has not yet been thoroughly studied in Malaysia. The ambiguous results could be caused by different inflation regime dependency and nonlinearity responds of asset prices to rise and fall of inflation. Therefore, this mechanism brings about an important research question whether house investment can still provide inflationary hedge against falls in general price level.

[3] As return on residential property investment is difficult to measure, we reflect the profit gain through house prices in line with previous literature

Therefore, the objective of this paper is to investigate the asymmetric relationship between house prices and inflation. This study can contribute in several ways. First, to analyze the potential nonlinearity and asymmetry between house prices and inflation rate, our study employs the novel asymmetric Autoregressive Distributed Lag (NARDL) method making further steps on the nonlinear house price modelling for Malaysian house market in particular. Secondly, apart from house prices, we also examine the hedging ability of different instruments namely, gold price and stock price for comparison purpose. We want to examine the investment role of gold and stocks for an emerging Malaysian market.
Based on the main conclusion of our study, we found that house price can be a good hedge against inflation in the long run, despite the asymmetric relationship found between house price and inflation rate. The result for the shorter time period is inconclusive due to a small significant and positive relationship between housing returns and inflation rate. Moreover, gold is not a hedge against inflation due to insignificant results. Lastly, stock is considered a better option as a hedging tool as it reacts symmetrically both in the short run and long run and is positively correlated with inflation rate. Therefore, during shorter time period investors can opt to use stock as a hedging tool, whilst over longer time horizon, residential property is a much better option to hedge against inflation.

The findings of this research would help policymakers and investors in many ways. First, the asymmetric relationship between investment in residential property and inflation shows that home values have risen more rapidly than inflation. On this ground, policymaker and investors should care about deflationary periods in which house prices rises. This also calls for government to take action in controlling house prices to make residential property affordable to all. Second, the finding also shows effects of different hedging instruments used in Malaysia to protect against inflation. This provide beneficial information to investors on which hedging tools are better off and worse off both in the short- and long-run period.

The rest of the paper is structured as follows: the second section discusses the theoretical framework, the third section shows findings from the previous literatures, the fourth section explains the overview of the data sources and methodology while the fifth section explores findings of the empirical results. Finally, the last section summarizes the main findings and provides possible directions for future research.

1. Theoretical Underpinnings

The economic theory of rising house price in Malaysia over the past few decades comes with the notion that owning a property can either give investment benefits or just merely provide consumption effects. According to PropertyGuru Malaysia's consumer sentiment survey, despite of unaffordability in buying a house, expensive cost of living and higher rejections of house financing rates, many Malaysians find it a necessity to actively acquire and invest in housing property as they believe house prices will continue to escalate as demand to own a home increases and this can be an effective tool to hedge against any financial trouble in order to maintain their real wealth. Since house can have a dual motive of being both investment and consumption goods, it is imperative to make an analysis of housing prices in the context of Malaysia, to better understand their relationship with rising inflation.

In this regard, Anari and Kolari (2002) stated that there are two transmission channels by which higher general prices of goods and services can stimulate a boom in housing prices. From consumer point of view, an increase in general price level could send construction budgets even higher in terms of more costly building materials and rise in construction labor wages. These higher expenditure of new (pricier) houses will lead to higher replacement costs of existing houses as its close substitute, therefore causing a hike in both property prices. On the contrary, the second channel through investor sentiment equates the price of a house as an investment good to the present value of actual or imputed rents, an instance earnings from rental after deducting maintenance charges and depreciation (net rent).

In this aspect, price stability plays a crucial role in the growth and well-being of the economy since different price level can significantly influence consumption choices and investment decisions. The aim of property developers and policymakers is not only to maximize positive returns but also to reduce investment risks through incorporating inflation-hedging assets, a technique that involves choosing assets whose value tends to rise with inflation. A continuous surge in the price levels of goods and services can affects function of money in terms of reduction on its purchasing power ability, thus, inflation has become one of the major concerns among investors because it can jeopardize the real gains from their investment. Formulating a possible link between hedging capability of a real property asset in the context of house price vis-a-vis inflation has become a great attention by many. This is to justify the inflation-hedging capacities of real property whether it is capable or not to shield their investment against a rise in inflation over a period of time.

In line with the foregoing, there are two conflicting views concerning the inflation hedging potential of house property in Malaysia. An optimistic view suggests that house property is a popular option as it appreciate in value over time and it can provide recurring rental income. During times of financial stress, an expected increase in inflation may motivate investors to convert their current assets into house property to protect themselves from rising inflation. Moreover, home values and rents are also considered as worthwhile investments especially during times of market distortion and price instability. One of the many reasons is due to the expanding population growth and limited land availability in Malaysia as both factors contribute to the rise in housing demand irrespective of the level of price appreciation and therefore its potential to combat inflation as it normally grows against currency during inflationary periods.

Furthermore, real property houses increase proportionately to inflation. When inflation occurs, the price of houses will keep up with the rate of inflation and so does the rent rates. This supplementary in value translate to additional cost affected by the inflation factor such as building material cost, maintenance cost and labor wages. Although inflation influence other factors (income, expenditure tax charged, expenditure, etc.) nevertheless in this case, property investors and private landlords will be at an advantage since inflation correlate fairly well with home prices. With regard to its effect on housing loan, inflation exhibits a positive impact on real property financing. As most house purchases in Malaysia are financed through loan applications, the real value of the Ringgit Malaysia at the initiation time of financing is much higher when compared to the actual value towards the end during loan repayment time. This occur on the grounds that amount of loan are not corrected for inflation and the borrower will act as (property investors or homeowners) the ultimate beneficiary.

However, the effect can also be counterproductive in a way that policymakers will try to fight inflation through contractionary monetary policy by reducing the money supply and increasing the interest rates. This in turn make cost of financing more expensive, affect GDP and further dampen inflation. On the other hand, curbing inflation might give opposite effects on the ability of house property to generate positive cash flow in investment. A more pessimistic view claims that home prices in Malaysia have climb at a faster rate than inflation over the past few years and thereby might encounter falling in price in the near future. Many calls for government intervention to adopt prudential measures to prevent housing price bubble from happening. The continuous appreciation in house price might put the bubble at risk anytime as when the housing bubble burst occurs, the likely panic sale will widen the gap between the supply and demand side for housing properties. This will further contribute to the episode of boom-bust cycle in home prices and can give a detrimental effect to the whole economy.

As a respond toward these ongoing issues, the new government has vowed to address the concerns on rising property residential prices through its newly announced budget 2019. This includes among others reduction in house prices of new residential launches (that are not subject to price controls) by a 10% discount and providing more affordable homes to reduce the burden on consumers. Additionally, there are other disputes on faulty basis that investing in residential properties might be or not be a good investment. This arise due to improper budgeting, weak investment strategy and the shortcomings of individual home that is far riskier compared to the overall housing market in terms of location risk and illiquidity. Through contradicting views, the role of house price as inflation hedge is also ambiguous and gives mixed theoretical basis on whether residential property can act as a good inflation hedge or vice-versa, in providing a perverse inflation hedge tool over the short- and long-run basis.

Though existing literatures shows that house price determinants are associated with common set of macroeconomic variables such as interest rate, economic growth, exchange rate and other housing economic features, this study will make a humble attempt to investigate the effect of housing prices as an effective tool to hedge against inflation in the context of Malaysia. It will decide the lead-lag relationship whether residential properties as expressed by house prices is the leader or follower and the results will determine whether it can be used to control inflation. Before going further, this paper will explain the notion of inflation hedge and how it can be measured. In simple terms, inflation can be defined as 'too much money spent chasing too few goods' thus resulted in an upsurge in price of general goods and services. In this respect, any asset or commodities that can safeguard investors funds against rising inflation is considered to be a functional hedging tool. In line with this definition, we define a positive correlation between house price and the CPI as evidence that returns gain from property investment will counterbalance (entirely or partially) a rise in inflation. Since evidently there is inconclusive result on whether housing properties offers an effective inflation hedge, and this variation could possibly be because of the time-varying factor between house prices and inflation, we will use the nonlinear ARDL technique by Shin et al. (2014) to reach for an empirical answer for the determination of possible asymmetric and nonlinear relationship between house prices and the inflation rate in Malaysia. Unlike previous studies, we will also extend our study in NARDL to include other inflation tools such as gold and stock price for comparison purposes.

2. Previous Literature: Is house prices a hedge against inflation?

As we have previously mentioned in the theoretical background section, past researches show indecisive results in determining the role of house prices as a tool to hedge against inflation. Through mixed number of findings in the property literature, we will first explore studies which indicate that house price can hedge against inflation. Furthermore, we will also analyze articles showing either opposing or indeterminate results. Lastly, we will analyze the possible linkage between house prices and inflation to better understand the bigger picture of asymmetric relationship between the two variables.

For the first set of past literatures, Bond & Seiler (1998) and Stevenson (1999) provide evidence that residential properties gives a significant and positive relationship with rising inflation. While the former indicates that return gain from real estate can hedge against both expected and unexpected inflation, the later proves that with mix results, residential market can act as a tool to hedge against inflation whilst commercial market portray lack of evidence in providing some degree of immunization (protection) against rapid increase in general prices. Based on ARDL models, Anari and Kolari (2002) assesses the long-run cointegration between residential estate returns and the price of non-housing CPI where they exclude the housing costs from the price of goods and services to prevent redundant result and biasness in analyzing how inflation influence housing prices. The empirical findings infer a stable inflation hedge in the US for the period 1968 till 2000. Moreover, Wu and Pandey (2012) discover that realized housing prices has the capabilities of providing a modest hedge against inflation during most time periods of housing bubble in the US. They deduce that by adding residential real estate into investment portfolios consist of varieties of financial assets such as stocks and bonds, the generated returns can potentially boost inflation hedging ability of the mix portfolio investments.

Many research efforts have also shown asymmetric and nonlinear relationship in formulating the house price models. Kuan,Wang and Lee (2008) conduct a study to investigate the inflation hedging effectiveness of real estate investment using a nonlinear vector correction model that provide threshold of low and high regime of inflation rates. They discover that housing return can only function as a hedging tool during higher level of inflation rate (0.83 percent). Besides that, Hong, Khil and Lee (2013) revisits the empirical relation between housing return and inflation in the US, UK and Korea by examining how negative and positive inflation shocks can influence the link between these two. Overall, they conclude that there exists negative relationship between housing returns and inflation based on the positive inflation shock results that dominates. This implies that housing returns is a long run inflation hedge. More recently, Christou et al (2018) claims the presence of possible structural breaks and nonlinearity between US home prices and non-housing CPI based on the quantile regression approach. They deduce that house price is a good hedge against inflation when both are cointegrated at lower quantiles and higher price levels only.

For the second stream of previous studies, Li and Ge (2008) apply an Autoregressive Integrated Moving Average (ARIMA) and Hedrick-Prescott Filter to observe the hedging characteristic of housing properties in Shanghai from 1997 to 2005 and find that there is no significant relationship between residential prices and three different types of inflation: actual, expected and unexpected. Amonhaemanon et al (2013) examines the condition of real estate in the context of Thailand. Following Fama and Schwert (1977) framework, they show that real estate returns is not an efficient hedge against inflation as residential prices changes under numerous economic conditions. Studies on nonlinearity between housing returns against expected inflation is documented by Fang, Wang, and Nguyen (2008) based on the Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH) model. They find that the leverage shock between bad news is more significant compared to good news, proving the inability of inflation hedge of housing investment in Taiwan. More recent work conducted by Yeap and Lean (2017) show that housing asset investment in Malaysia does not offer inflation protection in the short time horizon since house price react to both consumer and energy inflation asymmetrically in the short run.

We will further analyze the mechanism following which house prices and inflation interacts to better understand their differing in results. Firstly, when a rise in the property investment return can fully or partly offset loss in purchasing power due to inflation, this can be a good hedging tool (Fang, Wang and Nguyen, 2008). Second, through Fisher (1930) theory of one-for-one move between nominal interest rate and expected inflation, predicted nominal return on property investment should be equivalent to expected inflation including real return. Thirdly, growth in house price is seen as a rebound in the aftermath of previous crises from the very low values. Moreover, the improved efficiency in housing markets in terms of enhanced availability of mortgage products and secondary market has stirred the demand to own a house and this promote further rise in residential price (Glindro et al, 2011). Fifth, the inflation illusion hypothesis examines the possibility of house mispricing whereby wrong assumption is made regarding the co-movement of inflation and real interest rate. This will result to increase in house prices during deflationary period, vice-versa (Brunnermeier and Julliard, 2008). Sixth, continuous upward pressure on the value of residential properties will eventually face downward correction soon after, diminishing its potential as inflation hedging instrument (Glindro et al, 2011). Seventh, though many claims that house prices appreciate with rise in general goods and services, the case could be different if we take into account various economic environments.

Based on the above, prior studies tend to find mixed and inconclusive results on the asymmetric relation between house prices and inflation, depending on different regulatory policy, structural reforms and economic inequality across different nations. Whereas housing price is influenced by factors such supply and demand of housing, construction cost, land demographic, interest rate and economic growth (Au Yong et al, 2018); inflation, on the other hand, are more sensitive to external factors such as global commodity prices and the government monetary and fiscal policy (sales and service tax, subsidies, minimum wages) (BNM, 2010). Due to all this reasonings, it is necessary to take into consideration potential asymmetric relationship between house prices and inflation. To the best of our knowledge, this paper intends to fill the gap making further step out of the existing methodology by addressing the issue within NARDL framework.

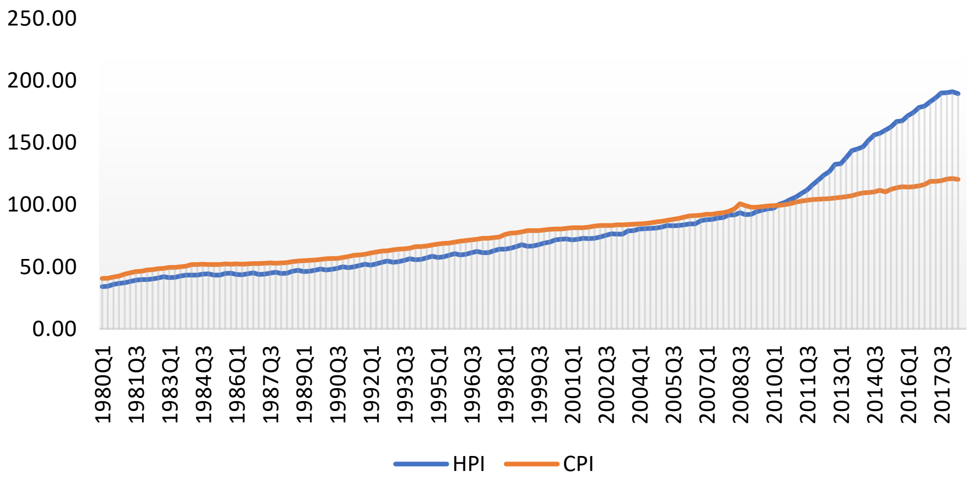
3. Data and Methodology

For the empirical analysis, this study utilizes quarterly Malaysian data covering sample time period from 1986:Q1 to 2018:Q2 with 126 observations. In order to represents an enrichment to the existing literature, this study employs five different variables whereby we zoom in to focus on the relationship between House Price Index (HPI) and Consumer Price Index (CPI) as a proxy of inflation. Based on the data availability in the database, we ensure that we cover the longest possible data span taking into account market boom and bust cycles, as well as innovations in the housing market that may give different reactions through different time period. Apart from the focus variables, Interest Rate (IR), Industrial production as a proxy of Gross Domestic Product (GDP) and MYR/USD Exchange Rate (XR) are added as control variables. In the property literature, these variables are proved to have a long run cointegration with house prices (Katrakilidis and Trachanas, 2012). All data are extracted from DataStream.

$$HPI = \int (CPI, IR, GDP, XR)$$

HPI is used as an indicator to measure the capacity of residential investment return to hedge against rising inflation. In this case, the nominal rate of return of house price must be positively correlated with inflation rate. Moreover, HPI is also expected to increase overtime if there is fall in interest rate charged (make house less affordable) due to increasing cost of mortgages. Higher economic growth can also encourage consumption and lead to rise in asset's price and vice versa providing a bi-directional causal relationship between these two variables. In one way or another, growth in the housing market can also be influenced by the value of currency considering foreign investors and imported construction materials. Figure 1 shows the co-movement between the housing price and the consumer price index.

Figure 1: Data plots of HPI against CPI



Extending the existing statistical test or granger causality and the ARDL test proposed by Paresan, Shin and Smith (2001), this paper highlights the use of asymmetric nonlinear cointegration approach of Shin et al (2014) to motivate the methodology and model structure in order to determine any possible nonlinearity between HPI and CPI. The advantages of NARDL and limitations of other techniques will be elaborated in the result section. As an illustration of the non-linear ARDL, the following model that links a quarterly data of housing price index (HPI) and inflation rate in terms of consumer price index (CPI) will be used in which the relation between these two variables are theoretically motivated. To begin, we employ the following nonlinear asymmetric long-run model specified as;

$$HPI_t = \alpha_0 + \alpha_1 CPI_t^+ + \alpha_2 CPI_t^- + e_t$$

where $(\alpha_0, \alpha_1, \alpha_2)$ is a vector of long run parameters to be estimated whereas CPI_t^+ and CPI_t^- are partial sums of positive and negative changes in CPI. We then disintegrate an exogenous variable of interest CPI_t which denoted the inflation rate (CPI) into both positive and negative partial sums of increases and decreases such as;

$$CPI_t^+ = \sum_{i=1}^{t} \Delta CPI_t^+ = \sum_{i=1}^{t} \max(\Delta CPI_i, 0) \quad \text{and} \quad CPI_t^- = \sum_{i=1}^{t} \Delta CPI_t^- = \sum_{i=1}^{t} \min(\Delta dr_i, 0)$$

where $CPI_t = CPI_0 + CPI_t^+ + CPI_t^-$.

Based on the above formulation, the long run relation between HPI and CPI is α_1 and α_2 for respectively the increase and decrease in the latter. In the empirical formulation, both positive and negative partial sums disintegrations are framed in the long run equation based on standard ARDL setting to see the impact of short and long-run asymmetries shocks. The NARDL framework in its error correction form is developed as per below;

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

where all variables are as defined above and p and q are lag orders. The long run parameters in first equation are derivable from above equation, whereby $-\beta_2/\beta_1 = \alpha_1$ and $-\beta_3/\beta_1 = \alpha_2$. In addition, $\sum_{i=0}^{q} \theta_i^+$ and $\sum_{i=0}^{q} \theta_i^-$ capture the short-run effects of respectively positive and negative changes in fluctuation of house prices. In the NARDL model, the asymmetric reactions of HPI as the dependent variable to both positive and negative variations of the CPI as the independent variable are encapsulated through positive and negative cumulative dynamic multipliers linked with unit changes in CPI_t^+ and CPI_t^- as below;

$$m_h^+ = \sum_{j=0}^{h} \frac{\partial HPI_{t+j}}{\partial CPI_t^+}, \quad m_h^- = \sum_{j=0}^{h} \frac{\partial HPI_{t+j}}{\partial CPI_t^-}, \quad h = 0, 1, 2, \ldots$$

Note that as $h \rightarrow \infty, m_h^+ \rightarrow \alpha_1$ and $m_h^- \rightarrow \alpha_2$

For comparison purpose, we include other hedging tools such as gold price (GP) and stock price (KLCI) to differentiate the effectiveness of different hedging instruments against house price to protect against inflation in Malaysia. Quarterly data for GP and KLCI are drawn from KITCO historical data chart and DataStream database respectively, covering the period from first quarter of 1986 till second quarter of 2018.

4. Empirical Results and Interpretations

A standard procedure for any regression analysis should start off by testing whether the variable is non-stationary or stationary. OLS regression assume for many years that the variables are stationary in their original state. In reality, it is non-stationary thus conventional regression method cannot be used. This first step is important for testing theoretical relationship between variables through cointegration. First of all, the variables are transformed into logarithms to make the variance stationary. Stationarity is derived when the variables have constant mean and finite variance. The first difference is then taken to turn the series stationary in the mean. However, no conclusion can be made about the long theoretical relationship between the differenced variables since the trend components has been removed.

Table 1
Augmented Dickey Fuller Unit Root Test

Series in logarithms	**Include an intercept and a linear trend**				
	ADF	Value	T-Statistics	Critical Value	Outcome
lnHPI	ADF(4)=SBC	377.5181	-1.760	-3.405	Non-Stationary
	ADF(4)=AIC	387.3890	-1.760	-3.405	Non-Stationary
lnCPI	ADF(1)=SBC	440.2042	-1.667	-3.467	Non-Stationary
	ADF(2)=AIC	446.7788	-1.381	-3.514	Non-Stationary
lnIR	ADF(2)=SBC	43.6884	-3.727	-3.514	Stationary
	ADF(4)=AIC	50.9938	-3.453	-3.405	Stationary
lnGDP	ADF(5)=SBC	246.2216	-2.034	-3.495	Non-Stationary
	ADF(5)=AIC	257.5027	-2.034	-3.495	Non-Stationary
lnXR	ADF(1)=SBC	206.9899	-2.112	-3.467	Non-Stationary
	ADF(1)=AIC	212.6305	-2.112	-3.467	Non-Stationary
Series in first difference	**Include an intercept but not a trend**				
	ADF	Value	T-Statistics	Critical Value	Outcome
ΔlnHPI	ADF(3)=SBC	376.8242	-3.4509	-2.9209	Stationary
	ADF(3)=AIC	383.8547	-3.4509	-2.9209	Stationary
ΔlnCPI	ADF(1)=SBC	438.7715	-8.5016	-2.9926	Stationary

	ADF(1)=AIC	442.9897	-8.5016	-2.9926	Stationary
ΔlnIR	ADF(1)=SBC	40.3668	-7.4001	-2.9926	Stationary
	ADF(3)=AIC	45.6429	-6.4725	-2.9209	Stationary
ΔlnGDP	ADF(4)=SBC	244.8619	-4.5843	-2.9491	Stationary
	ADF(5)=AIC	253.9522	-4.9534	-2.8952	Stationary
ΔlnXR	ADF(1)=SBC	204.9306	-7.2141	-2.9926	Stationary
	ADF(1)=AIC	209.1488	-7.2141	-2.9926	Stationary

Notes: The ADF is used to test the stationarity of the variables both in log form and difference form. The null hypothesis state that variables are non-stationary. Hence, when T-statistics (at 95% level of confidence) is less than the critical value (in absolute term), we conclude the variable as non-stationary. Vice-versa, when the T-statistic is bigger than the critical value, we reject the null and conclude the variable as stationary.

Three forms of unit root tests will be conducted. Firstly, we apply the augmented Dicky-Fuller (ADF) test in **Table 1** whereby the findings suggest that all examined variables except for interest rate are not significant at 5 percent level, thus null hypothesis of non-stationarity cannot be rejected. Consequently, all variables turn out to be stationary in their first differences. Since ADF test only corrects autocorrelation problem, we will proceed with the second unit root test for robustness checks. We perform Phillips-Perron (PP) test from **Table 2** that can take care of both autocorrelation and heteroskedasticity issues via Newey West adjustment. The result shows that all series are not stationary I(0) in their log level form but become stationary I(1) once differenced.

Table 2
Phillips-Perron Unit Root Test

Series in logarithms	**Include an intercept and a linear trend**			Series in first difference	**Include an intercept but not a trend**		
	T-Statistics	Critical Value	Outcome		T-Statistics	Critical Value	Outcome
lnHPI	-0.8618	-3.5313	Non-Stationary	ΔlnHPI	-12.1424	-2.8402	Stationary
lnCPI	-1.4298	-3.5313	Non-Stationary	ΔlnCPI	-9.2931	-2.8402	Stationary
lnIR	-2.8300	-3.5313	Non-Stationary	ΔlnIR	-16.0207	-2.8402	Stationary
lnGDP	-1.5239	-3.5313	Non-Stationary	ΔlnGDP	-10.5188	-2.8402	Stationary
lnXR	-2.1426	-3.5313	Non-Stationary	ΔlnXR	-10.0223	-2.8402	Stationary

Notes: The PP is used to test the stationarity of the variables both in log form and difference form. The null hypothesis state that variables are non-stationary. Hence, when T-statistics (at 95% level of confidence) is less than the critical value (in absolute term), we conclude the variable as non-stationary. Vice-versa, when the T-statistic is bigger than the critical value, we reject the null and conclude the variable as stationary.

Table 3
Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Stationarity Test

Series in logarithms	Include an intercept and a linear trend			Series in first difference	Include an intercept but not a trend		
	T-Statistics	Critical Value	Outcome		T-Statistics	Critical Value	Outcome
lnHPI	0.1570	0.14223	Non-Stationary	ΔlnHPI	0.3558	0.40257	Stationary
lnCPI	0.1476	0.14223	Non-Stationary	ΔlnCPI	0.1483	0.40257	Stationary
lnIR	0.08592	0.14223	Stationary	ΔlnIR	0.1509	0.40257	Stationary
lnGDP	0.1787	0.14223	Non-Stationary	ΔlnGDP	0.4867	0.40257	Non-Stationary
lnXR	0.09471	0.14223	Stationary	ΔlnXR	0.07339	0.40257	Stationary

Notes: The Kwiatkowski–Phillips–Schmidt–Shin (KPSS) is used to test the stationarity of the variables both in log form and difference form. The null hypothesis is different from the first two-unit root tests as the variables is stationary when T-statistics (at 95% confidence level) is lesser than the critical value, otherwise – non-stationary

KPSS test is then applied. The result from **Table 3** show inconsistency in terms of non-stationarity/stationarity for both level and differenced form. Interest rate (lnIR) is found out to be not stationary in both conditions. Therefore, the outcomes from KPSS test cannot be used to proceed with Granger Causality test as the estimation might be misspecified. For this reason, we will conduct cointegration test using all the variables that could be taken as I(1) on the basis of ADF and PP test.

Table 4
Test Statistics and Choice Criteria for Selecting the Order of the VAR Model

No. of Orders	Selection Criteria	
	SBC	AIC
4	1317.4	1169.8
3	1278.6	1166.1
2	1284.1	1206.8
1	1278.1	1235.9

The results based on AIC and SBC are in conflict towards choosing the optimum order of VAR. The final decision will be based upon the trade-off between lower order and higher order of VAR selection

Next, we carry out the order of Vector test based on **Table 4** to determine the appropriate lags structure in the cointegration model**.** The selection is based upon Akaike Information Criterion (AIC) that are more inclined towards selecting maximum order to address serial correlation problems and Schwarz Bayesian Criterion (SBC) whose concerns are on the inclusion of redundant information due to overparameterization and thus, selects the minimum lag. Given the two-opposite nature of AIC and SBC, we conclude that the appropriate order of VAR as two (from the midpoint of the results), consistent with many researches that use the same technique.

Engle Granger and Johansen Cointegration Test

We applied standard Engle Granger cointegration test in order to verify whether the variables are theoretically related, converging together over the long term. Any proof of cointegration implies that the relationship among the variables are in fact not spurious. From **Table 5,** the test shows no cointegration between the variables and it does not move together in the long run. However, there are certain limitations within this method. Firstly, there are issues on order of the variables, since it cannot indicate which variable as dependent variable. Secondly, it can only test the presence of one cointegrating relationship. Engle Granger use residuals from a single relationship thus it cannot treat possibility of more than one cointegrating vectors. Lastly, the technique relies on two step estimators. First step will generate the residual series whilst the second step estimate regression for stationarity. Error in the first estimation can be transmitted into the second one.

Table 5

Engle-Granger Cointegration Test

OLS regression of lnHPI on other variables	**Unit root tests for residuals**				
	ADF	Value	T-Statistics	Critical Value	Outcome
lnHPI	ADF(5)=SBC	243.6241	-2.2040	-4.5299	No Cointegration
	ADF(5)=AIC	252.0850	-2.2040	-4.5299	No Cointegration

Notes: The Engle-Granger test checks whether the variables are moving together (cointegrated) or not. The error term would be stationary, when its test statistic is greater than the critical value at 95% confidence interval thus proving cointegrating relationship

To overcome these weaknesses, we implement Johansen's cointegration test. From **Table 6**, we conclude that there is one cointegration based on both Maximal Eigenvalue and Traces statistic. This denotes that each variable contains information for prediction of other variables. The variables in our model consist of various macroeconomic determinants that can influence housing price movements. Therefore, its long terms relation can give implications for the extent of effectiveness of a government's short run fiscal, monetary, and exchange rate stabilization policies.

Table 6
Johansen Cointegration Test

Test of the Stochastic Matrix	Cointegration with unrestricted intercepts and unrestricted trends in the VAR					
	Null	Alternative	Statistic	95% Critical Value	90% Critical Value	Outcome
Maximal Eigenvalue	r = 0	r = 1	47.0214	37.0700	34.1600	1 Cointegration
	r<= 1	r = 2	23.3315	31.0000	28.3200	
Trace Statistics	r = 0	r>= 1	94.7097	82.2300	77.5500	1 Cointegration
	r<= 1	r>= 2	47.6883	58.9300	55.0100	
Test of the Stochastic Matrix	**Cointegration with unrestricted intercepts and restricted trends in the VAR**					
	Null	Alternative	Statistic	95% Critical Value	90% Critical Value	Outcome
Maximal Eigenvalue	r = 0	r = 1	63.0005	37.8600	35.0400	1 Cointegration
	r<= 1	r = 2	23.3571	31.7900	29.1300	
Trace Statistics	r = 0	r>= 1	119.6644	87.1700	82.8800	1 Cointegration
	r<= 1	r>= 2	56.6638	63.0000	59.1600	

Notes: The statistic refer to Johansen's cointegration test based on unrestricted intercept and restricted trends in the VAR. From the above results, we choose one cointegrating vector according to eigen value and trace tests statistics at 95% confidence interval. If the test is significant, we will reject null hypothesis and accept the alternative, which suggests an existence of cointegrating vectors. The underlying VAR model of order 2 is computed using 128 quarterly observations.

Nonetheless, Johansen test comes with limitations as this test assume all variables are non-stationary. In addition, the test is also sensitive to number of lags in the order of VAR whereby changes in order of lag can bring about to different results. Moreover, the pretest is biased in favor of accepting the null at 95% of the time. We want to overcome all this limitations problem, thus, we will conduct ARDL technique as it can be applied regardless of whether the independent variables are I(0) or I(1).

Long-run Structural Modelling (LRSM)

Before moving on to ARDL, LRSM technique is conducted to bypass some of the major limitation of Granger causality. Since the conventional cointegration method is based upon estimation of cointegrating vectors that is not backed up by theory, LRSM will solve this issue through testing long-run coefficient of the variables against its theoretically expected value. This is done by imposing both exact- and over-identification restrictions grounded on the basis of theories and economics under review. In this case, we want to focus on identifying the causality chain between house price (HPI) and inflation (CPI) together with other variables.

Table 7
LRSM Test

Variable	ML estimates subject to exactly identifying restrictions			
A1=1	Coefficient	Standard Error	T-Ratio	Outcome
lnHPI	1.0000	*NONE*	*NONE*	*NONE*
lnCPI	-3.059	1.164	-2.628	Significant
lnIR	-0.1876	0.06242	-3.005	Significant
lnGDP	0.9248	0.1740	5.315	Significant
lnXR	-0.1769	0.1260	1.404	Insignificant
Regressor	**ML estimates subject to over identifying restrictions**			
A1=1; A5=0	Coefficient	Standard Error	T-Ratio	Outcome
lnHPI	1.0000	*NONE*	*NONE*	*NONE*
lnCPI	-3.480	1.323	2.630	Significant
lnIR	-0.1728	0.06724	2.569	Significant
lnGDP	0.9425	0.1962	4.804	Significant
lnXR	-0.0000	*NONE*	*NONE*	*NONE*
LR Test of Restrictions	CHSQ(1) = 1.7726[0.183]			

Notes: The result above shows the maximum likelihood estimates subject to exactly identifying and over identifying restrictions. In exact identification, we are normalizing the coefficients by imposing restriction 1 to our focus variable treated as dependent. Over identifying tests the computed long run coefficient against it theoretically expected values. The significant results are given in the result column in the table. When p-value is greater than 5%, we fail to reject the null hypothesis which suggests that the restriction is correct.

When we imposed an exact identification of unity on the coefficient of HPI in **Table 7,** we found that all variables are significant at 95 percent confidence interval except for XR. We then imposed over-identifying restriction of unity on that variable which was insignificant whereby the restrictions of zero on the coefficient of XR was accepted by the Chi-squared statistics. Hence, we proceed with the latter restriction for the remainder of the study. From the result, it is apparent that CPI, IR and GDP are all significantly correlated with HPI suggesting that the regressors are long-term drivers of house price, which is supported by prior studies. GDP is found to be positively correlated with HPI while IR is negatively correlated with HPI, supporting our earlier theories. However, the negative relationship between HPI and CPI might be caused by the potential asymmetric nonlinear relationship between the two focus variables used in our study. The result will be discussed at later stage of this paper.

Autoregressive-Distributed Lag (ARDL) Cointegration Test

The ordinary cointegration method based upon the linear ARDL model is first introduced by Pesaran et al (2001) to avoid pretesting problems associated with alternative cointegration techniques. The analysis employed can perform better in determining cointegration using small sample size. It also have the upper hand in dealing with different order of variables whether it is I(0) or not, allowing for statistical interference over long run estimations. The ARDL test involves two main stages.

At the first stage, the existence of the long run relation between the variables is tested by computing F-statistic (Wald test). This is done by setting up each variable in turn as a dependent and testing whether the null hypothesis of non-cointegrating relation between the joint lagged levels of the right hand side of the model is significant or not. In that case, the computed F-statistic need to exceed the upper critical bound to confirm the presence of a long run relationship among the variables. From **Table 8,** we can deduce that the computed F-statistic in house pricing models and its determinants is slightly above the upper critical bound rejecting the null of no long run relationship between the variables regardless of whether it is I(0) or I(1). This result indicates that the residential price and other macroeconomic variables in Malaysia are theoretically related in the long run. Although house prices and the examined macroeconomic determinants may temporarily shift away from each other, in the long-run they tend to come back to equilibrium. On the other hand, when inflation, economic growth and exchange rate act as the predictor, there is no evidence of cointegration. The above test results suggest that house price is endogenous (significant F-statistic) and that other corresponding regressors can be treated as the long-run forcing variables for the explanation of HPI.

Table 8
Test of long-run relationship in ARDL

Model	F-statistics	p-value	95% Critical Lower Bound	95% Critical Upper bound	Outcome
HPI (HPI, CPI, IR, GDP, XR)	4.3796	[.002]	3.189	4.329	Cointegration
CPI (HPI, CPI, IR, GDP, XR)	2.5345	[.033]	3.189	4.329	No Cointegration
IR (HPI, CPI, IR, GDP, XR)	4.5144	[.001]	3.189	4.329	Cointegration
GDP (HPI, CPI, IR, GDP, XR)	2.4471	[.039]	3.189	4.329	No Cointegration
XR (HPI, CPI, IR, GDP, XR)	2.0045	[.085]	3.189	4.329	No Cointegration

Notes: The critical values are based on F Table of Pesaran et al. (2001), unrestricted intercept and trend with five regressors. If it is lesser than the lower bound, we fail to reject the null of no long run relationship among the variables, otherwise – there is long run relationship. If the values fall within the bound, the result is inconclusive. On this basis, unit root test needs to be carried out.

The second stage comprises of estimation of the long run coefficient and associated error correction model through ARDL and VECM. The error correction term taken from the model is a vital component in the study as it will unfold the process of short run adjustment back to long run equilibrium given a deviation from last quarter shocks. The intended lag structure is determined by SBC, AIC and adjusted LR test wherefore the estimated standard errors are obtained using the model selected by Schwarz Bayesian Criterion (SBC). The estimate of the long run coefficients are summarized in **Table 9.** It implies that CPI, IR and GDP have significant effects on the fluctuations of house pricing in Malaysia.

Table 9
Test of long-run coefficients in ARDL when lnHPI is dependent variable

Regressor	Coefficient	Standard Error	T-Ratio	p-value
lnCPI	4.9169	1.0697	4.5965	[.002]**
lnIR	-0.27405	.16405	1.6705	[.097]*
lnGDP	1.0162	.32349	-3.1414	[.002]**
lnXR	-0.19898	.35848	-.55506	[.580]
INPT	-12.7988	3.4598	-3.6993	[.004]**

Notes: * and ** signifies significant at 90% and 95% confidence interval respectively

From the test result, CPI is seen to be the strongest determinant that can explain the distribution of house prices over time. The coefficient of the inflation rate indicates that a 1 percent increase in CPI will rise the value of housing properties by 4 percent on average, ceteris paribus putting aside all factors equal. It is followed by the effect of IR and GDP which may downgrade the housing prices by 0.27 percent and increase the rates by 1 percent respectively. The result is consistent with the study by Adam and Fuss (2010) which claimed that falls in interest rates has a negative effect on house prices while economic growth have a positive effect. All three significant variables denote that the relationship is interconnected with house price in the long run. However, when the price to purchase general goods and services increase due to external factors and changes in government policies, price for residential properties might rise or fall in response, bringing into light the possibility of nonlinear relationship.

As stated earlier, cointegration test whether there is a long-run relationship among the variables. It does not unfold the process of short run adjustment to bring about the long run equilibrium. Hence, there could be possibility of short-run deviations from the long-run occurrence. Cointegration also does not tell us the direction of causality chain as to which variable is the leader and which is the follower. To clarify the process better, we will proceed with error-correction model.

Vector Error Correction Model (VECM)

As mentioned in previous section, the error correction model shows feedback effect of the short run deviation of house price from the long run equilibrium. The lagged error term of $e_{t-1}$is an important element in explaining the dynamics of cointegrated system to determine how fast the rapid movement of house prices respond to rising and falling of inflation rate. The coefficient being significant will decide whether the variable is endogenous or exogeneous in proving the existence of long run cointegrating relationship between the variables. The size of the coefficient of ECM signifies the speed of adjustment to equilibrium and the intensity of arbitrage activity to bring about the balance in the model. Finally, the VECM allows us to differentiate between the long-term and short-term of Granger causality.

Table 10
VECM Result

Dependent Variable	ECM(-1) Coefficient	Standard Error	T-Ratio	p-value	Critical Value	Outcome
ΔlnHPI	-0.05485	0.00954	-5.7510	[.000]	5%	Endogenous
ΔlnCPI	0.01187	0.00478	2.4809	[.014]	5%	Endogenous
ΔlnIR	0.34162	0.12343	2.7676	[.007]	5%	Endogenous
ΔlnGDP	-0.00324	0.02703	-0.1199	[.905]	5%	Exogeneous
ΔlnXR	0.01118	0.03259	0.3431	[.732]	5%	Exogeneous

Notes: The significant of p-value or t-ratio at 95% confidence level indicates whether the deviation from equilibrium give significant relationship or not on the dependent variable (HPI). If the error term coefficient is found to be significant, the corresponding variable is the follower (endogenous), otherwise – it its insignificant the corresponding variable is the leader (exogenous).

Based on **Table 10,** the ECM coefficient for HPI, CPI and IR are found to be significant and this implies that the correspondent variables mentioned are lagging in nature (endogenous). This demonstrate that all three variables depend on the deviation of other variables and bear the burden of short-run adjustment to bring about to long term balance in the equation. The ECM coefficient is not significant for GDP and XR, so they are leading (exogenous) and does not depend on the deviations of other variables. Both GDP and XR receives exogenous shocks and will transfer these shocks across the model. As a result, we can conclude that the prediction of the movement in HPI, CPI and IR depend on changes in GDP, XR or other factors. An instance, CPI is endogenous as it relies on many domestic factors such as rise and fall in money supply and aggregate demand for goods and services. On this basis, when the amount of economic consumption is greater that the production of goods, this can contribute to GDP growth and thus, increases in prices (inflation). Moreover, policy maker may choose to control interest rate to influence (not regulate) the appreciation and depreciation of exchange rate. Higher IR can attract foreign investment, resulting in demand for home currency and further promote import activities. On the other hand, varying trends of house prices also could depend on internal factors such as expansionary/contractionary government policies. Instinctively, both GDP and XR is an exogenous variable because a change in both variables cannot be managed by one country. Malaysian exchange rate, an instance, is an independent variable because its fluctuations mainly depends on foreign exchange trading that is determined in the global market.

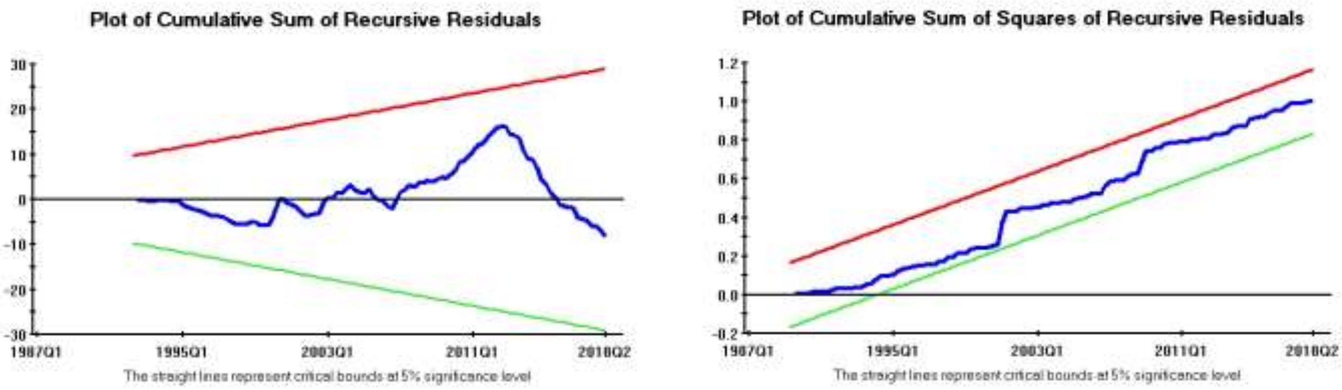
Table 11
Error correction model when ΔlnHPI is dependent variable

Regressor	Coefficient	Standard Error	T-Ratio	p-value
ΔlnCPI	0.14490	0.05175	2.8001	[.006]
ΔlnIR	0.008076	0.00340	2.3723	[.019]
ΔlnGDP	0.14103	0.03074	4.5871	[.000]
ΔlnGDP1	0.09477	0.03116	3.0416	[.003]
ΔlnGDP2	-0.07193	0.03278	-2.1947	[.030]
ΔlnXR	-0.00586	0.00945	-0.62071	[.536]
ECM (-1)	-0.02947	0.01506	-1.9568	[.053]

Notes: The result of Error Correction model is shown above. The t-statistic or p-value of the coefficients of the differenced variables decide whether the effects of these variables on the housing prices are significant or not in the short-run. A positive sign means the variable move away from the equilibrium while a negative sign means the variable will come back at faster speed to bring about to the equilibrium.

From **Table 11**, the error correction coefficient estimated at -0.02947 is significant indicating that approximately 3 percent of the imbalances from the previous quarter chock will adjust to bring about long run equilibrium in the current quarter. This implies that the coefficient has slow speed of adjustment to equilibrium once shock. We find that CPI, IR and GDP have significant impact on the housing prices in the short run. This result confirms our earlier findings of a significant long run cointegrating relationship between the variables in the context of rising Malaysian property market. Moreover, CPI is positively correlated with housing prices (HPI). Increase in the price of goods and services relates to housing market in which the rapid upswing can drive up the value of residential property. This is consistent with our theoretical framework mentioned in earlier chapter. Furthermore, GDP growth is positive at ΔlnGDP and ΔlnGDP1 but becomes negative at ΔlnGDP2. This can be explained by the effect of rapid changes in house price towards economic growth at different time period. When economic times are booming, certain parts of the housing market usually see healthy growth since it fuels consumer spending on properties. During recession, people cut offs their consumption on real properties hence it will negatively affect house price.

Figure 2: Plot of CUSUM and CUSUM-squared



Next, we evaluate the stability of the long-run relationship between house prices and its macroeconomic fundamentals. We depend upon the CUSUM and CUSUM-squared tests that can identify whether the coefficients have changed overtime and show the location where the structural change occurred. As can be seen from **Figure 2,** the plot of both sum of recursive residuals and its sum of squared stays within the critical bound at 5 percent significance level, signifying that the housing price model is stable. It shows that the model is not subject to structural instability as indicated by the two statistics.

Nevertheless, ARDL and VECM pose some limitations. ARDL assumes linearity and symmetric relationship between house price and inflation which might show irregular moves in the context of a constantly changing economic environment. VECM, on the other hand, can only identify absolute endogeneity and exogeneity without giving any info on the strongest leader and the weakest follower among the variables. Hence, we apply more advanced nonlinear ARDL model.

<u>Non-linear autoregressive distributed lags (NARDL)</u>

Looking at the traditional cointegration approach, the house price is expected to move proportionately and at the same speed when inflation rate increases and decreases. The reality could be far from the truth as there might be nonlinear and asymmetric cointegration between the two focus variables used in our study. Therefore, we employed NARDL bounds testing developed by Shin et al. (2014) which can utilize positive and negative partial sum decompositions in order to distinguish possibilities of asymmetric effects both in the long run and the short run. NARDL can also solve the convergence issues in the model due to overparameterization. Notwithstanding the fact that this technique does not directly model asymmetric error correction, the dynamic multipliers in NARDL will determine the adjustment patterns in view of rapid economic changes. This allow us to further analyse the nonlinear and asymmetry patterns between house prices and inflation rate. NARDL methodology has been conducted by Katrakilidis and Trachanas (2012) to investigate the macro-economic drivers of housing prices dynamics in Greece and Yeap and Lean (2017) to examine inflation hedge properties of housing in Malaysia.

Therefore, we will focus on two main variables: housing price (HPI) as the regressand and inflation rate (CPI) as the regressor since we want to highlight the asymmetric relationship between both variables without taking into account other control variables which we examined in ARDL. To the best of our knowledge, we extend this research by providing additional insight on different hedging tools than can curb inflation in the context of Malaysia. Other than house price index (HPI), we include gold price (GP) and stock price (KLCI) for comparison purpose in order to sharpen our understanding of the concepts.

Table 12
Wald tests for short- and long-run asymmetries (with quarterly data)

Hedging items against inflation (CPI)	Long-run W_{LR}	Short-run W_{SR}	Selected specification
House Price (HPI)	15.30*	0.1685	NARDL with LR asymmetry
	[0.000]	[0.682]	
Gold Price (GP)	0.6026	7.191*	NARDL with SR asymmetry
	[0.439]	[0.008]	
Stock Price (KLCI)	4.898	0.01558	Symmetric ARDL
	[0.280]	[0.901]	

Notes: The estimation is based on NARDL equation in methodology section. The table reports the results of the short- and long-run symmetry tests. W_{SR} denotes the Wald test for the short-run symmetry testing the null hypothesis whether θ+i = θ−i. W_{LR} corresponds to the Wald test for the long- run symmetry testing the null hypothesis whether β+i = β−i. The p-values are in brackets whereby the rejection of the null hypotheses of short- and long-run symmetry is at 95% confidence level.

Based on the result of the Wald test in **Table 12**, we will first compare the best suited NARDL model with different hedging items as the dependent variable against inflation rate as the dependent one. Firstly, we can see that the CPI affects HPI in an asymmetric manner in the long run indicating that there is an imbalance reaction of housing price dynamics to fluctuations of inflation rate in the long run horizon. Furthermore, short-run asymmetry effects are captured by changes in CPI on GP. It shows the ineffectiveness of gold price to hedge the consumer inflation in the short time period when there is changes in CPI. KLCI and CPI is asymmetry, implying that price rigidity is not observed. We will then proceed with bound cointegration test using F-test on the joint hypothesis that the lagged level variables are together equivalent to zero. This will verify if there is any possibility of a long-run cointegrating relationship among the examined variables when the result is significant. The test outcomes in **Table 13** confirm that F-statistic for the joint significance of HPI and KLCI are both significant as the lagged variables are found to exceed the upper bound at 6.1758 and 5.4599 respectively. The significance of the parameters on GP is well below the lower critical bound implying that inflation rate and gold price is not theoretically related in the long run.

Table 13
Bounds test for cointegration in the nonlinear specifications

Dependent Variable	F-Statistic (F_PSS)	95% Lower Bound	95% Upper bound	Outcome
House Price (HPI)	6.1758	3.790	4.850	Cointegration
Gold Price (GP)	1.8384	3.790	4.850	No cointegration
Stock Price (KLCI)	5.4599	3.790	4.850	Cointegration

Note: FPSS-Nonlinear denote the PSS F-statistic testing the null hypothesis β_x=θ=0 and β_x=θ+ =θ- =0 respectively. When F-test is found to be insignificant, t-test will be used as an alternative to show the presence of long-run relationship between the variables. When F-test is found to be significant, the insignificance of t-test could be ignored.

The estimates of the asymmetric and nonlinear ARDL results are shown in **Table 14**. To decide on the final specification, it should be notified that the preferred specification is selected by trimming/deleting insignificant lags (stationary regressors). Including significant lags, in practice, are prone to inaccuracies of the test results and may lead to faultiness in the dynamic multipliers. We will first explain the asymmetric manner in which CPI affects different hedging items used in this study (captured by $\boldsymbol{lnCPI^{+}_{t-1}}$ and $\boldsymbol{lnCPI^{+}_{t-1}}$**).** Then, we will move on to examine the magnitude of the long-run coefficients for asymmetric cases ($\boldsymbol{L^{+}_{lnCPI}}$ and $\boldsymbol{L^{-}_{lnCPI}}$) between the variables. Finally, we will continue with the analysis of the short run dynamics (associated with $\Delta\boldsymbol{lnCPI^{+}_{t-i}}$).

Table 14
NARDL estimation results (final specification)

HPI		GP		KLCI	
NARDL with LR asymmetry		NARDL with SR asymmetry		NARDL with LR asymmetry	
$\ln HPI_{t-1}$	-0.3167**	$\ln GP_{t-1}$	-0.05119**	$\ln KLCI_{t-1}$	-0.1557**
	[0.000]		[0.035]		[0.000]
$lnCPI^{+}_{t-1}$	0.0274**	$lnCPI^{+}_{t-1}$	0.5183	$lnCPI^{+}_{t-1}$	1.9129**
	[0.005]		[0.226]		[0.034]
$lnCPI^{-}_{t-1}$	-0.4527**	$lnCPI^{-}_{t-1}$	-4.6716	$lnCPI^{-}_{t-1}$	20.31*
	[0.002]		[0.572]		[0.066]
$\Delta\ln HPI_{t-2}$	0.1215**	$\Delta\ln GP_{t-2}$	0.2890**	$\Delta\ln KLCI_{t-3}$	0.2368**
	[0.010]		[0.000]		[0.004]
$\Delta\ln HPI_{t-3}$	0.1546**	$\Delta lnCPI^{-}_{t-4}$	-68.615**	$\Delta lnCPI^{+}_{t-2}$	-29.887**
	[0.039]		[0.008]		[0.049]
$\Delta\ln HPI_{t-4}$	0.6353**			$\Delta lnCPI^{+}_{t-4}$	32.58**
	[0.000]				[0.035]
$\Delta lnCPI^{+}_{t-4}$	0.3709**				
	[0.025]				
$\Delta lnCPI^{-}_{t-1}$	1.2301**				
	[0.011]				
$\Delta lnCPI^{-}_{t-2}$	-1.1637**				
	[0.027]				
Constant	0.8451**	Constant	4.6613	Constant	34.528*
	[0.001]		[0.667]		[0.081]
L^{+}_{lnCPI}	0.865**	L^{+}_{lnCPI}	10.125	L^{+}_{lnCPI}	12.288**
	[0.000]		[0.267]		[0.007]
L^{-}_{lnCPI}	-14.296**	L^{-}_{lnCPI}	91.255	L^{-}_{lnCPI}	13.462*
	[0.001]		[0.512]		[0.058]
R^2	0.6626	R^2	0.2265	R^2	0.2113
Adjusted R^2	0.6188	Adjusted R^2	0.1262	Adjusted R^2	0.1090

Notes: This table reports the estimation results of the best-suited NARDL specifications for the pass-through of the CPI to house prices, gold prices and stock prices. For the lagged variables, we only present those with significant coefficients. L^{+}_{lnCPI} and L^{-}_{lnCPI} are the asymmetric positive and negative long-run coefficients between different hedging tools and the CPI. P-values are in brackets whereby $*$ and $**$ denote the significance at the 90% and 95% confidence levels, respectively.

The asymmetric long run effect of the CPI on HPI is significant for positive and negative changes of the CPI. The coefficients linked to negative direction of the $lnCPI^{-}_{t-1}$ are negatively correlated at -0.4527 for HPI. This result captures the earlier data plots shown in previous chapter which infers that when time goes by, the fall in CPI will lead to increase in HPI (proportionate relationship). In this regard, investors should take precaution about deflationary downside pressure in which house price grow in value. This can be explained through Malaysia's steadily falling inflation rate in recent months due to subdued rise in price (side-effects of GST removal) along with the threat faced by the economy from US-China trade war. Moreover, the escalation in house prices in Malaysia are mainly driven by the inadequate availability of prime property and a strong market headwind for first half of this year. In contrarily, the $lnCPI^{-}_{t-1}$ coefficient is much higher for KLCI compared to HPI (20.31 and -0.4527). This suggests that the variation of stock prices following a 1 percent falls in CPI is higher compared to house prices. This may be due to market condition in Malaysia that act more similar to stock investment compared to property investment. For GP, the asymmetric short-run effect is insignificant for both changes in CPI suggesting that gold is not a good hedge against inflation in Malaysia with emerging gold markets. Bottom line, we can also deduce that houses are set to get more expensive against gold price, thus, a much better option for inflation hedging tool.

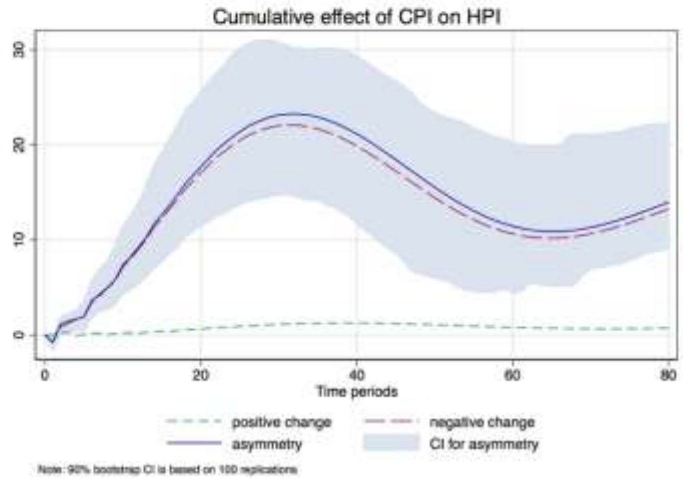
Next, we turn to the analysis of the long-run coefficients which capture the relationship between the involved variables at the long run equilibrium. For long-run asymmetric case in HPI, we note that the long run coefficients for L^{+}_{lnCPI} is positively significant at 0.865 percent whereas the L^{-}_{lnCPI} is negatively significant at -14.296 percent. This confirms the above analysis showing that a continuous decrease in the CPI bring about to an increase in house prices in the long run. In this case, investors can still profit from house return during deflationary period. For stock price, both positive and negative variations for CPI are moderately positive. This means that at long run equilibrium, stock price and house price moves together. Regarding the GP, both long-run coefficients are insignificant in this study.. Nevertheless, our results show that the downward changes in CPI has greater impact compared to those associated with upward changes[4].

The short-run impacts of the CPI on HPI are symmetric. The $\Delta lnCPI^{+}_{t-i}$ is significant and positively correlated at 0.3709 percent. For the $\Delta lnCPI^{-}_{t-i}$, the short run effect is positive at lag 1 (1.2301) and negative at lag 2 (-1.1637). As a result, house price can act as inflation protection in the short run looking at the much higher and significant coefficient at the first lag[5]. The small

[4] The reported result for negative long-run is multiplied by -1. Accordingly, it needs to divide by -1
[5] At the 5% significance level, the short-run effect of the CPI on house prices in Malaysia is the summation of the short-run coefficients 1.2301 (lag 1) + -1.1637 (lag 2) = 0.0064

number does not really justify its short run hedging abilities. For KLCI, the short run impact for $\Delta lnCPI^{+}_{t-i}$ highly positive at lag 4 (32.58). In this case, KLCI works as a good hedging tool against inflation in the short run in Malaysia. The analysis of the dynamic effects between HPI and CPI can be further supplemented by analysing the dynamic multipliers, considering the fully asymmetric case found earlier. **Figure 3** plots the dynamic effects of positive and negative variations in CPI where we can see that fall in CPI has an upswing effect on HPI shown by red line. While increasing CPI has temporary negative impact on HPI. The blue line shows an upward trend of asymmetry over time. This confirms previous findings about the long run asymmetric relationship between HPI and CPI.

Figure 3: Consumer price index and Malaysian house price dynamic multipliers



The overall results suggest that when there is an increase in inflation, the housing market in Malaysia respond instantly in the short run (converging together). At the opposite side, over longer time period, the co-movement will turns opposite illustrating that impact of deflationary pressure on CPI significantly dominates against inflationary changes. This means during deflationary period over the long run, house prices rises above inflation. Investors can profit from the fall in CPI. Therefore, the above findings depicts that house ownership can be an effective inflation hedge both in the long run (home prices appear to keep up with inflation and in recent years has outpaced it) and short run (especially during times of inflationary pressure).

Variance Decomposition (VDC)

The VDC is a method used to analyze the relative degree of exogeneity and endogeneity of the variables. Through decomposition techniques, we will determine which variable is the most exogenous and which is the most endogenous by looking at the proportion attributable to its own past shocks. The variable that can be explained by its own shocks (not through other variables) is considered to be the ultimate leader (exogenous). From **Table 15/16** and **Figure 4**, we determine the economic pecking order from the most exogenous to the most endogenous variable. Both generalized and orthogonalized give the same ranking of variables except in the orthogonalized forecast horizon number 6. This might be due to the feature of orthogonalized VDC that is more unique and realistic compared to generalized VDC.

Table 15
Orthogonalized Forecast Error Variance Decomposition

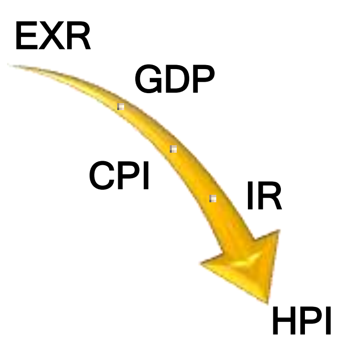
Variable	Relative Variance in Period 6					
	lnHPI	lnCPI	lnIR	lnGDP	lnXR	Rank
lnHPI	**81.76%**	6.60%	7.62%	3.68%	0.34%	4
lnCPI	7.62%	**88.92%**	1.13%	1.10%	1.24%	2
lnIR	18.66%	0.85%	**73.01%**	5.31%	2.18%	5
lnGDP	4.92%	3.49%	3.23%	**85.56%**	2.79%	3
lnXR	2.75%	0.10%	0.26%	0.24%	**96.65%**	1
Variable	**Relative Variance in Period 12**					
	lnHPI	lnCPI	lnIR	lnGDP	lnXR	Rank
lnHPI	**54.40%**	18.67%	14.77%	11.87%	0.29%	5
lnCPI	9.04%	**83.09%**	2.97%	3.82%	1.08%	3
lnIR	20.09%	3.46%	**59.79%**	13.22%	3.45%	4
lnGDP	3.98%	4.63%	3.90%	**84.43%**	3.07%	2
lnXR	2.79%	0.05%	0.19%	0.37%	**96.59%**	1
Variable	**Relative Variance in Period 18**					
	lnHPI	lnCPI	lnIR	lnGDP	lnXR	Rank
lnHPI	**39.43%**	25.09%	17.68%	17.33%	0.47%	5
lnCPI	9.85%	**77.59%**	4.82%	6.83%	0.90%	3
lnIR	19.91%	6.75%	**49.30%**	19.75%	4.29%	4
lnGDP	3.56%	5.43%	4.33%	**83.50%**	3.18%	2
lnXR	2.82%	0.04%	0.15%	0.48%	**96.51%**	1

Table 16
Generalized Forecast Error Variance Decomposition

Variable	Relative Variance in Period 6					
	lnHPI	lnCPI	lnIR	lnGDP	lnXR	Rank
lnHPI	**63.87%**	8.00%	18.25%	8.62%	1.26%	5
lnCPI	7.18%	**87.65%**	0.17%	1.45%	3.55%	3
lnIR	16.18%	0.82%	**75.81%**	6.86%	0.32%	4
lnGDP	4.77%	2.68%	1.41%	**89.71%**	1.44%	2
lnXR	2.63%	0.21%	0.83%	0.94%	**95.39%**	1
Variable	**Relative Variance in Period 12**					
	lnHPI	lnCPI	lnIR	lnGDP	lnXR	Rank
lnHPI	**45.73%**	20.08%	25.27%	6.74%	2.18%	5
lnCPI	8.51%	**82.50%**	0.87%	4.74%	3.37%	3
lnIR	17.32%	2.20%	**63.97%**	15.96%	0.55%	4
lnGDP	3.87%	3.75%	1.93%	**88.82%**	1.64%	2
lnXR	2.67%	0.13%	0.71%	1.22%	**95.27%**	1
Variable	**Relative Variance in Period 18**					
	lnHPI	lnCPI	lnIR	lnGDP	lnXR	Rank
lnHPI	**34.42%**	26.49%	27.19%	9.19%	2.72%	5
lnCPI	9.29%	**77.51%**	1.77%	8.34%	3.09%	3
lnIR	17.18%	4.41%	**54.19%**	23.36%	0.85%	4
lnGDP	3.47%	4.49%	2.27%	**88.03%**	1.75%	2
lnXR	2.69%	0.09%	0.63%	1.44%	**95.15%**	1

Notes: Table 15A & 15B, row read as the percentage of the variance of forecast error of each variable into proportions attributable to shocks from other variables, including its own. The column read as percentage in which variable contributes to other variables in explaining observed changes. The diagonal line of box (highlighted) shows the relative exogeneity.

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



From our results (based on the end of the generalized forecast horizon number 18), the flow of the casual chain are as follows: House price (34%), consumer price index (78%), interest rate (54%), GDP growth (88%) and MYR per USD exchange rate (95%). The findings reveal that the exchange rate is the most leading variable whilst the house price is the most lagging variable, thus, further strengthening our earlier results given by the error correction model that the HPI will likely follow behind (rather than leading) other macroeconomic variables used in this study. Within this framework, Malaysian XR is the strongest of all variable and this can be explained through the external symptoms of sliding local currency that hit Malaysian economy over the past years – trade wars between US-China, increased political uncertainty due to government change and lower commodity price which affected Malaysia as a commodity exporter. Through government's mixed floating and controlled exchange rate policy, the value of our XR nowadays is mainly determined by the market force of supply and demand as BNM choose not to lift a finger (intervene) as much as before.

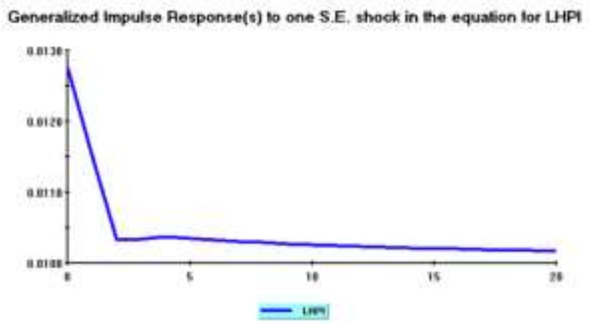
Although GDP components can also be determined through other macroeconomic variables which can be controlled by the government, GDP comes next after XR and this is justified through its nature which is predominantly influenced by private consumption and foreign direct investment. As Malaysia moves towards Industrial Revolution 4.0, the spending on digital technologies will act as the main catalyst to GDP growth in the coming years. Furthermore, inflation rate being in the middle rank of VDC is also instinctive and can be explained through mix factors that can encourage inflation dynamics in Malaysia. While CPI can be predicted globally through volatile capital flows and fluctuations in exchange rate, it can also be contained domestically as such; through BNM's action to adopt inflation anchoring framework over inflation targeting since the Malaysia's emerging economy is more susceptible to real external shocks.

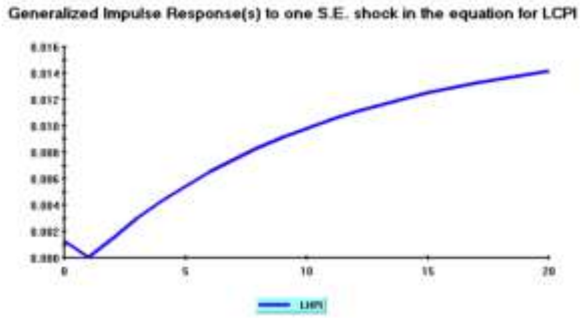
Interest rate is relatively more endogenous, implying that a change in GDP and CPI would cause rise and fall in IR. Much of interest rate manipulation would be dictated by government monetary policy (through its overnight policy rate), influenced by the need to balance between supporting GDP growth and managing inflationary pressure. Finally, house price is the most endogenous variable as government has put many efforts in controlling the rising value of residential property in Malaysia through various mechanisms. This include reducing construction cost through tax exemption from Sales and Service Tax (SST) and setting up a National Affordable Housing Council to increase quota of affordable house. From the above results, we can see that the VECM and VDC findings slightly contradicts whereby the former indicates both HPI and CPI (as our focus variables) as endogenous variables while the latter imply that CPI as slightly exogenous. While VECM is a within-the-sample test, VDC can forecast beyond the sample period and it gives relative granger-causal chain among the variables. Despite the different in ranking orders, both are useful to policymakers and property investors depending on their goals. We will go with VECM results as it implies that investors can protect against inflation through house prices.

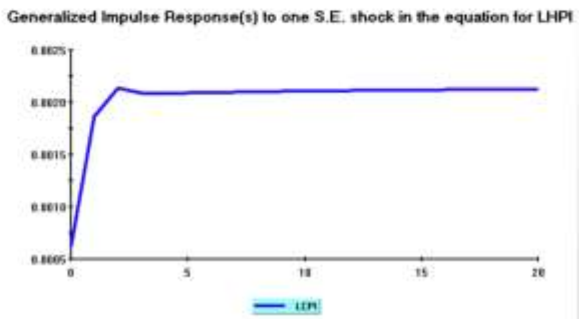
Impulse response functions (IRF) and persistence profile (PP)

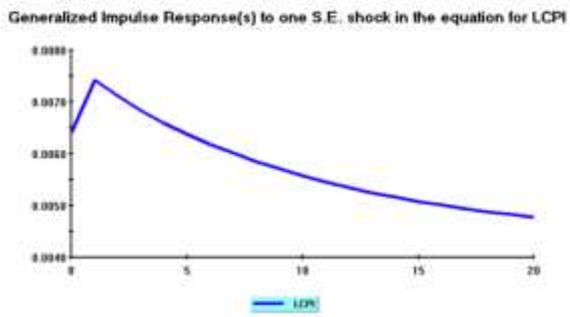
We then applied the generalized IRFs which essentially maps the dynamic response of a variable's shock (from VDC) towards other variables and how long will it take to normalize. Consistent with the earlier results, we found that the house price variable reacts more strongly to a 1 percent SD shock to the inflation rate (vice-versa). In line with our earlier discovery, this proves HPI as the most endogenous variable.

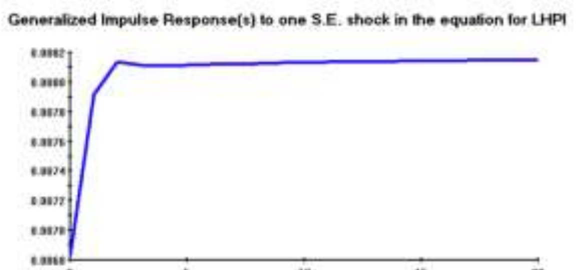
Figure 5: Generalized impulse responses to one SE shock in the equation of LHPI and LCPI

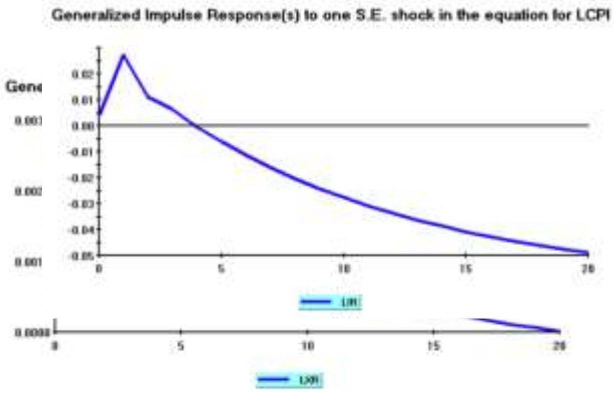


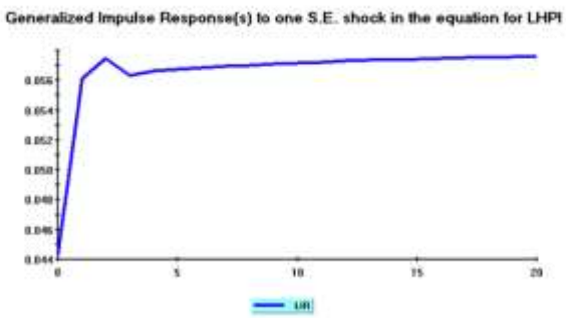


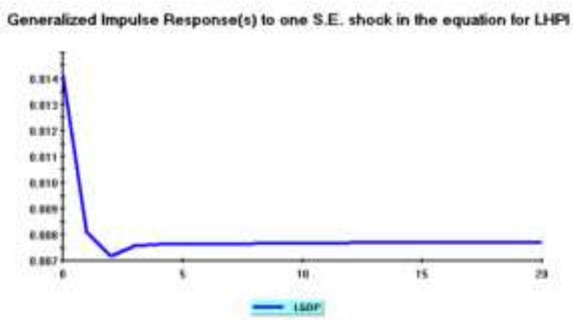


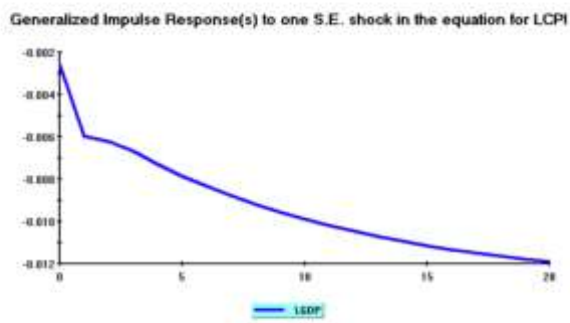






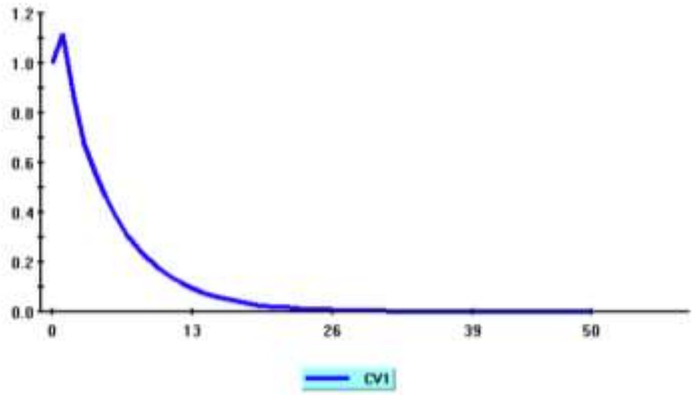






Lastly, we implement the persistence profile analysis which illustrate that if the whole cointegrating relationship of Malaysia is shocked, it will take about 6 years (26 quarters) for the equilibrium to be restored.

Figure 6: Persistence profile of the effect of a system-wide shock



5. Concluding remarks and Policy Implications

The growing economic ambiguities due to rapid growth in house price and inflation rate have raised some interesting question about the possibility of nonlinear relationship between house prices and inflation in Malaysia. Based on theoretical intuition, the asymmetric adjustment in the house price modelling can be explained by different market reactions during expansion (deflationary period) and contraction (inflationary pressure) phases whereby house prices respond more strongly to downward pressure in price compared to an upward swing. In this paper, we set up the use of NARDL model to better understand the asymmetric effects of both house prices together with different hedging apparatus (gold price and stock price) against inflation rate (consumer price index) for the period between 1986:Q1 to 2018:Q2. This advanced technique introduced by (Shin et al. 2014) can help to determine not only the nonlinear directions of inflation on Malaysian house prices but also its asymmetric reactions associated with positive and negative shocks in the economy's price level to better interpret inflation hedging characteristic of house prices.

Our findings first imply that there is evidence of asymmetric relationship between house prices and inflation rate both in the long-run. In contrarily, the symmetric result in short run remain unconvincing due to a very low signicant result. However, this might imply that over the long run, house prices respond more strongly in deflationary period whilst in the short run, the value in house property have a greater impact during inflationary pressure. The inverse relationship over time implies that house prices appear to be in tandem with inflation rate at earlier stage but has outpaced it in recent years. Moreover, gold is found not to be a good hedge against inflation due to the condition of small and emerging gold markets in Malaysia. Moreover, stock price reacts symmetrically against inflation in the short run as well as long run, indicating that over the short run, investors can also opt to use real estate stocks as better tool to hedge against inflation.

These outcomes would give some far-reaching valuable implications to property investors and policymakers. Firstly, to answer our research question earlier, we conclude that residential property can act as a good hedge against inflation in the long run. Although investors can take advantage of the rise in price when inflation decreases, policymakers should put extra attention about the deflationary periods since it leads about to rapid increase in house price. This significant deceleration is caused by replacement of GST to a less severe SST indicating that the effect will likely be temporary. Secondly, rise in house price are good for house owners, but it might be counterproductive in a way that it will make housing property less affordable for first time buyers as younger generation faced difficulties to buy a home. Thus, government should take action to correct the house price over the long term to bring it closer to inflation line ensuring houses are affordable for all Malaysian according to their income level. Lastly, although both stock price and house price can be an effective hedge against inflation over the long run in comparison to gold price, housing property is considered as the best form of investment because of the possibility of capital appreciation as houses are set to get more expensive compared to the other two.

Some of the limitations of this study include it only use five macroeconomic variables, namely inflation rate, interest rate, GDP and exchange rate. For further research, other macroeconomic variables such as foreign direct investment and trade balance can be incorporated since housing market has high reliance on foreign investments. Additionally, periods of study can be categorized according to pre- and post-financial crisis to further investigate if housing property can be used as a hedge or safe haven during economic pressure. We could also extend this study by using expected inflation to acquire more robust result on house hedging effectiveness.

References

Adams, Z., and Füss, R. (2010). Macroeconomic determinants of international housing markets. Journal of Housing Economics, 19(1), 38-50.

Anari, A., and Kolari, J. (2002). House prices and inflation. Real Estate Economics, 30(1), 67-84.

AuYong, H. N., Yip, C. Y., Woo, K. H., and Senadjki, A. (2018). The Dynamics of Housing Prices in Malaysia: Findings from Focus Group Discussions in MATEC Web of Conferences, EDP Sciences, 150, 49- 59.

Amonhaemanon, D., De Ceuster, M. J., Annaert, J., and Le Long, H. (2013). The inflation-hedging ability of real estate evidence from Thailand: 1987-2011. Procedia Economics and Finance, 5, 40-49.

Bond, M., and Seiler, M. (1998). Real estate returns and inflation: an added variable approach. Journal of Real Estate Research, 15(3), 327-338.

Brunnermeier, M. K., and Julliard, C. (2008). Money illusion and housing frenzies. The Review of Financial Studies, 21(1), 135-180.

Christou, C., Gupta, R., Nyakabawo, W., and Wohar, M. E. (2018). Do house prices hedge inflation in the US? A quantile cointegration approach. International Review of Economics and Finance, 54, 15-26.

Fang, W. S., Wang, K. M., and Nguyen, T. B. T. (2008). Is real estate really an inflation hedge? Evidence from Taiwan. Asian Economic Journal, 22(2), 209-224.

Hin Li, L., and Lin Ge, C. (2008). Inflation and housing market in Shanghai. Property Management, 26(4), 273-288.

Fisher, I. (1930). The Theory of interest rates. New York. Macmillan.

Glindro, E. T., Subhanij, T., Szeto, J., and Zhu, H. (2011). Determinants of house prices in nine Asia-Pacific economies. International Journal of Central Banking, 7(3), 163-204.

Hamelink, F., and Hoesli, M. (1996). Swiss real estate as a hedge against inflation: new evidence using hedonic and autoregressive models. Journal of Property Finance, 7(1), 33-49.

Hong, G., Khil, J., and Lee, B. S. (2013). Stock returns, housing returns and inflation: is there an inflation illusion? Asia-Pacific Journal of Financial Studies, 42(4), 511-562.

Katrakilidis, C., and Trachanas, E. (2012). What drives housing price dynamics in Greece: New evidence from asymmetric ARDL cointegration. Economic Modelling, 29(4), 1064-1069.

Kuan-Min, W., Yuan-Ming, L., and Binh, N. T. T. (2008). Asymmetric inflation hedge of housing return: A non-linear vector error correction approach. International Real Estate Review, 11(1), 65-82.

Lin Lee, C. (2014). The inflation-hedging characteristics of Malaysian residential property. International Journal of Housing Markets and Analysis, 7(1), 61-75.

Pesaran, M. H., Shin, Y., and Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. Journal of applied econometrics, 16(3), 289-326.

Shin, Y., Yu, B., and Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in an ARDL framework. In Horrace, W.C. and Sickles, R. C.(eds), Festschrift in Honor of Peter Schmidt. Springer Science & Business Media, New York, 281-314.

Stevenson, S. (1999). The performance and inflation hedging ability of regional housing markets. Journal of Property Investment & Finance, 17(3), 239-260.

Stevenson, S. (2000). A long-term analysis of regional housing markets and inflation. Journal of Housing Economics, 9(1-2), 24-39.

Wu, C. Y., and Pandey, V. K. (2012). The impact of housing on a homeowner's investment portfolio. Financial Services Review, 21(2), 21 -30.

Yeap, G. P., and Lean, H. H. (2017). Asymmetric inflation hedge properties of housing in Malaysia: New evidence from nonlinear ARDL approach. Habitat International, 62, 11-21.