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Structural break and consumer prices: the case of Malaysia

Siti Marsila Mhd Ruslan¹ and Kasypi Mokhtar^{1*}

Abstract: This paper studies the dynamic behaviour of both linear and non-linearity of consumer prices in Peninsular Malaysia and Sabah from 2004 to 2015. For linear tests, monthly prices data of consumer price index (CPI) for nine groups of goods and services were analysed using the unit root tests and cointegration tests with structural breaks; while for non-linear test, NARDL test is incorporated. The findings indicated that (i) both Zivot and Andrews unit root test and Perron unit root test provided fairly similar results; most of the breakpoints occurred in 2008, followed by 2012 and 2013, (ii) the variables did not cointegrate in the Johansen cointegration test which indicates that no stable long-run relationship was reflected in the CPI for all groups, except for “transport”, and (iii) the Gregory and Hansen test demonstrated some form of cointegration with a structural break(s) existed, with a most recorded break in 2008 (iv) the NARDL test shows a fair impact of asymmetrical interaction for all groups except for Housing, Water, Electricity, Gas, and Other Fuels; Health and Recreation Services and Culture. Overall, this study intends to match the structural break points and the groups affected with the corresponding critical economic incidents.

ABOUT THE AUTHORS

Siti Marsila Mhd Ruslan is a senior lecturer at University of Malaysia Terengganu. Her research interest are mostly related to maritime economics, supply chain and macroeconomics. She received her Ph.D in Economics from International Islamic University Malaysia and has published articles in several journals such as International Journal of Recent Technology and Engineering, Asian Academy of Management Journal of Accounting and Finance, Institutions and Economics, and International Journal of Advanced and Applied Sciences.

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PUBLIC INTEREST STATEMENT

This paper analyses the dynamic behaviour of consumer prices in Peninsular Malaysia and Sabah to indicate the existence of structural break as well as asymmetrical interactions that are applied on the monthly consumer price index for nine different groups of goods and services between 2004 until 2015. To further understand the issue, this paper incorporated linear analysis with a break (Zivot and Andrews test; Perron test and Gregory and Hansen test), as well as non-linear test such as NARDL. As a result, it shows that most structural breaks happened in the year 2008, where the global financial and oil crisis had led to the increased food prices and other commodities. The NARDL test further explains the asymmetrical interaction, with a few groups recorded substantial difference for the partial sums. Finally, the overview of each year that intertwined with the break and the groups affected are being discussed, including its economic incidence, events, and policy implementations undertaken by the government.

Subjects: Macroeconomics Policy; Prices; Business Fluctuations

Keywords: CPI; structural break; economic policy

JEL classification: E3; E5; E6; E7

1. Introduction

Many production and consumption activities require the inputs of energy and commodity. Consequently, these activities become a key source of economic growth and subsequently, inflation. Generally, the price of goods and services are susceptible to structural breaks interlinking with macroeconomic series as they are usually affected by exogenous shocks or regime changes in economic events such as changes in economic policy, reforms in certain regulation, current international climate, and institutional developments. Accordingly, the implementation of certain policies is heavily dependent on the direction, strength, and stability of the relationship between goods and services consumption and prices. This paper fills the gap in the empirical literature on the stability between goods and services consumption and prices by studying the situation in Malaysia.

During the independence of Malaysia in 1957, its economy completely depended on rubber and tin. However, the economic transformation in 1970 s has turned Malaysia into a modern state as depicted by the industrial and services sectors which now account for almost 90% of the gross domestic product (GDP). For example, Malaysia's involvement in heavy industry and national car production captured nearly 80% of the domestic automobile market in the early 2000 s. In addition, the export growth was underpinned by increasing manufacturing exports and higher prices for commodity exports. By 2015, Malaysia was rated as the 26th largest trading nation in the world, with a total global trade of 175 USD.7 billion.¹ Nonetheless, this achievement is slightly lower compared to 2004 when Malaysia ranked 17th globally and emerged as a major exporter of electronic goods.

Within the period of 2004 to 2015, Malaysia has successively experienced several economic changes such as the Ninth Malaysia Plan which outlined the strategies for strengthening the growth potential of the economy and enhancing national resilience for the year 2006–2010 and Tenth Malaysia Plan for the year 2011–2015 which aimed to achieve a higher income country status by the year 2020. In 2009, several transformation plans were announced for further economic development in respective sectors under the concept of 1 Malaysia, People First, Performance Now based on the National Transformation Policy (NTP): the (i) Government Transformation Programme (GTP), (ii) Economic Transformation Programme (ETP), (iii) Political Transformation Programme (PTP), (iv) Community Transformation Programme (CTP), (v) Social Transformation Programme (STP), and (vi) Fiscal Transformation Programme (FTP).

Simultaneously, Malaysia was also affected by several global crises including high and volatile energy prices in 2005. Nevertheless, the Central Bank of Malaysia (2006) reported that the rate of inflation had remained within a manageable range as the growth in labour productivity and capacity, and increased competition had moderated the price increases. In the first half of 2008, sharp escalation of global fuel and commodity prices had increased the inflationary pressures which shifted to the rapid economic slowdown in the second half of that year. Even though Malaysia recorded declining exports and industrial production during the period, the country registered an economic growth of 4.6% in 2008 due to the strong growth in the first half of the year. Furthermore, the Central Bank of Malaysia (2009) assured that the inflation had continued to moderate from 8.5% in July 2008 to less than 4% by the beginning of 2009.

Similar situation occurred in 2010 as the significant increase in global energy and commodity prices caused inflation and weaken the ringgit exchange rate (Central Bank of Malaysia, 2011). This resulted in higher domestic food and fuel prices, and increased cost of living for households,

particularly the lower-income segment. The Malaysian economy finally managed to migrate into a period of adjustment in 2015 with the ongoing implementation of fiscal reforms which are vital in supporting the sustainable growth of the economy: implementation of goods and services tax (GST), support through the Bantuan Rakyat 1 Malaysia (BR1M) scheme, reduction of individual income tax rates for the 2015 assessment year, and savings derived from lower domestic fuel prices during the year (Central Bank of Malaysia, 2016).

Although economic structures and economic development stages are different for various countries, most empirical studies proved that economic growth has a correlation with inflation. Nevertheless, details regarding economic growth are subject to change over time and no empirical work has been performed to explore the possible variations and instability, particularly on the prices of goods and services in Malaysia. Earlier research by Katrin et al. (2008) outlined the “two perspectives approach” in the conduct of monetary policy by the Bank of Japan that focused on risks to price stability over different time horizons. Their findings proved that inflation was related to money growth and real output growth at lower frequencies, in addition to the output gap at higher frequencies.

Apart from that, Altansukh et al. (2016) studied the globalisation of CPI inflation by analysing core, energy, and food components. They tested the structural breaks in the relationship between domestic inflation and corresponding country-specific foreign inflation series for OECD countries using the monthly frequency. The overall pattern of globalisation in aggregate inflation was found to be largely driven by the convergence of the mean levels of the core component from the early 1990 s. Notably, this was compatible with the introduction of inflation targeted in a majority of their sample countries. Furthermore, short-run foreign energy inflation often contributed to the globalisation effect. In addition, Benati (2002) investigated breaks in inflation dynamics for 23 inflation series from 18 countries, and their implications for the serial correlation properties of inflation. All inflation series displayed high structural breaks as they appear to coincide accurately with identified macroeconomic events. Nevertheless, Benati (2002) suggested that inflation is not a highly persistent process in general.

Moreover, Durevall et al. (2013) established models of inflation to identify the importance of factors contributing to CPI inflation for three major components, namely prices of cereal, food, and non-food items. They found that movements in international food and goods prices that were measured in the domestic currency determined the long-run evolution of domestic prices. In the short run, agricultural supply shocks affected food inflation and cause large deviations from long-run price trends. Monetary policy seemed to minimise price shocks but money supply growth affected the short-run price inflation for non-food prices. Subsequently, they suggested that global food prices and domestic agricultural production should be considered in the analysis of inflation in developing economies with a large share of food in consumer prices.

Unfortunately, the instability of an economic system may be reflected in the parameters of the models and can induce misleading results when used for inference or forecast. Hence, the current research carefully analysed the specification of the model and included potential structural breaks in it to draw relevant conclusions. Notably, three main issues were addressed, namely the tendency of conventional unit root tests to be inferior in distinguishing between the unit root and near unit root. This means that they tend to accept the null hypothesis on the existence of unit root even when it is absent. Second, structural breaks in the data can substantially distort standard inference procedures for cointegration. Finally, neglecting this structural break problem will adversely affect the stability of the parameters within each subperiod because the bias in parameters also leads to conventional unit root tests to accept the null hypothesis of a unit root, even though the series are stationary.

Nonetheless, structural breaks in the consumer prices of goods and services have to be studied as the consumer market is highly correlated with the economic system. For instance, the financial

crisis in 2008 affected the global economic climate negatively and caused a recession in most economies. Accordingly, the governments adopted many preventive measures to revive their economy which impacted the public consumption habit heavily. This implied that changes in spending habit may be one of the factors causing structural breaks in the relationship between goods and services consumption and economic growth. Therefore, public spending and consumption structural break should be considered when constructing estimation and prediction models for economic growth in the future.

Similarly, several other studies also highlighted the relationship between CPI and the issues regarding structural break. For example, Hegwood and Nath (2013) examined whether the inclusion of structural breaks may aid to comprehend the extremely slow convergence in relative prices across 17 cities in United States (US) using long CPI time series data between 1918 and 2010. Compared to the results obtained by other panels without a structural break, they discovered that the speed of convergence with structural break was faster. Moreover, the application of structural break resulted in a half-life of 3.9 years which is 64% shorter than the half-life estimate with no structural break and no bias correction. These researchers also indicated that the break point was in 1985; the beginning of the Great Moderation period and other macro variables stabilised inflation and its impact on relative prices across US cities.

Also, Göktaş and Dişbudak (2014) studied the concept of volatility and uncertainty in inflation via CPI index for the period of 1994 until 2013 in Turkey. Using Bai-Perron test, two different break points in terms of mean and variance were detected, namely February 2002 and June 2001. In addition, inflation was revealed to be the reason for inflation uncertainty in the periods prior to the break points. Notably, if the structural breaks were not considered, a bidirectional causality relationship was detected in the series.

In this research, the CPI data of Malaysia for the last 10 years which may be slightly affected by economic incidents, reforms, or measurements were tested. Notably, structural changes in the data of CPI for several groups of goods and services may influence the result of the stationary test. Consecutively, linear and non-linear cointegration tests are incorporated to reflect different angles of cointegrating relations and its asymmetrical interactions between the variables (CPIs of Peninsular Malaysia and Sabah). As the “stationarity nature” of the results may differ between unit root test with breaks and unit root test without breaks, different cointegration tests (linear (Johansen Test), structural break (Gregory and Hansen Test) and non-linear (NARDL Test) cointegration tests) were performed. Apart from that, the rest of the paper is organised as follows: (i) the next section presents the data used, (ii) the third section discusses the econometric method, (iii) the fourth section explains the empirical findings of both unit root tests and cointegration tests, (iv) the fifth section deliberated on the findings, and lastly (v) the sixth section concluded the research and provides relevant remarks.

2. Description of the data and the model

The independent variable of this research was the change of CPI in Peninsular Malaysia, whereas the dependent variable was the change of CPI in Sabah. The following equation was derived to investigate the relationship:

$$\Delta P_t^i = \alpha + \beta \Delta P_t^j + \varepsilon_t \quad (1)$$

where P_t^i and P_t^j denote prices for a homogenous commodity in markets i and j respectively, in the period t .

All data were based on monthly observations from 2004 to 2015. The main data sources for this study were the Department of Statistics Malaysia and National Archive of Malaysia. Aggregate data and disaggregated data for CPI in Peninsular Malaysia and Sabah were applied instead of the

actual retail price for various goods and services. Due to the data constraint issue, only nine main groups were analysed:

- (i) Food and non-alcoholic beverages
- (ii) Alcoholic beverages and tobacco
- (iii) Clothing and footwear
- (iv) Housing, water, electricity, gas, and other fuels
- (v) Furnishings, household equipment, and routine household maintenance
- (vi) Health
- (vii) Transport
- (viii) Recreation services and culture
- (ix) Miscellaneous goods and services

3. Methodology and empirical results

3.1. Unit root test incorporating structural break

Generally, there are two types of unit root test. The first type is relatively common in the literature, comprising the augmented Dickey–Fuller (ADF) test developed by Dickey and Fuller (1979) and the Phillips and Perron (PP) test (Phillips & Perron, 1988). Notably, these tests have been criticised because of their bias towards non-rejection of the null hypothesis of a unit root against the alternative of (trend) stationarity in the presence of structural breaks and low proficiency for near-integration processes. Similarly, the KPSS stationarity test developed by Kwiatkowski et al. (1992) also suffers from size distortions in the presence of structural breaks and tends to reject the true null hypothesis of stationarity excessively.

Contrary to the first type, the second type of test allows the incorporation of one break in the series. Zivot and Andrews (1992) hereafter (ZA) and Perron (1997) developed a new category of unit root test that is able to incorporate an endogenous structural break including a possible shift in regime. Nevertheless, these two tests have several differences; Perron's test has one more time shock (or jump) dummy variable compared to ZA's test (C. C. Lee & Chang, 2005). Furthermore, the ZA test selects the break point as the t-statistic on the coefficient of the autoregressive variable to test whether the null of a unit root is the most negative (Perron, 2006). On the other hand, the Perron test selects the break point at the absolute value of the t-statistic on the coefficient of the autoregressive variable or when the change in slope on the break term is maximised (Altinay & Karagol, 2004). As the current research explores structural breaks within the period sample, the results of both ZA's test and Perron's test were taken into account in examining the stationarity state among all groups tested.

The procedures in the ZA test indicate the structural break endogenously without the hassle of selecting a break point subjectively (Zivot & Andrews, 1992). This endogenous selection of break point has a major effect on the unit root results. Generally, the ZA test outlines three models to test for a unit root. First, Model A (2) allows a one-time change in the level of the series, whereas the second model or Model B (3) permits a one-time change in the slope of the trend function. Third, Model C (4) combines the one-time changes in the level of the series and the trend function slope.

$$\text{ModelA} : \Delta y_t = c + \alpha y_{t-1} + \beta_t + \gamma DU_t + \sum_{j=1}^k d_j \Delta y_{t-j} + \varepsilon_t \quad (2)$$

$$\text{ModelB} : \Delta y_t = c + \alpha y_{t-1} + \beta_t + \vartheta DT_t + \sum_{j=1}^k d_j \Delta y_{t-j} + \varepsilon_t \quad (3)$$

$$\text{Model C} : \Delta y_t = c + \alpha y_{t-1} + \beta_t + \vartheta DT_t + \gamma DT_t + \sum_{j=1}^k d_j \Delta y_{t-j} + \varepsilon_t \quad (4)$$

These equations are similar to the ADF unit root test except for the inclusion of dummy terms. DU_t is the dummy variable indicator for a mean shift at each possible break date (TB), while DT_t is the corresponding trend shift variable.

Formally,

$$DU_t = \begin{cases} 1 & \text{if } t > TB \\ 0 & \text{otherwise} \end{cases} \quad (5)$$

and,

$$DT_t = \begin{cases} t - TB & \text{if } t > TB \\ 0 & \text{otherwise} \end{cases} \quad (6)$$

Similarly, Phillips and Perron (1988) proposed a dummy variable to the ADF test to account for structural changes. Notably, the differences are the null hypothesis of the test is a unit root with an exogenous structural break occurring at a particular time T_B and the alternative hypothesis states that the series are stationary with an exogenous change in the trend at that particular time T_B .

Accordingly, Tables 1 and 2 present the unit root test results for the CPI in Peninsular Malaysia and Sabah. Prior to these tests, the unit root test without break (Appendix A) reported that the series in levels behave like unit root processes and the unit root was strongly rejected. The classic unit root tests do not include structural breaks and this could lead to a wrong decision when the null hypothesis is not rejected (Hansen, 1992; Pitarakis, 2014). Nonetheless, the differences in test results may be explained by the properties of the unit root tests. The non-rejection of the first CPI series can be caused particularly by the ADF test inferiority in the presence of possible break (D. I. Harvey et al., 2014). Similarly, size distortions in the structural break presence explain the null hypothesis rejection of stationarity in the KPSS test results, and the rejection of a unit root in the ZA and Perron tests for the CPI series in levels. Rahman and Saadi (2008) elaborated that this implies the alternative could be a unit root with breaks.

Generally, the results in Appendix A suggest that the data may have more than one structural break. Therefore, further unit root tests, namely ZA's test and Perron's test, including structural break are employed. The ZA test and the Perron test were applied under the premise of null hypothesis, whereby the variable under investigation contained a unit root with a drift that excluded any structural break. Consequently, the alternative hypothesis defined the series as a trend-stationary process—one-time break in the trend variable occurred at an unknown point in time. The results in Tables 1 and 2 show the outcome for the ZA test and Perron test at the series level, indicating that almost all groups were non-stationary at level (non-rejecting the null of unit root). When considering the structural breaks, all variables were detected to have breaks either inclusive of "intercept" or at the "intercept and trend". The "intercept" break can be interpreted as a one-time change in the level of the series, whereas the "intercept and trend" break combined one-time changes in the level of the series and the slope of the trend function. Notably, most structural changes took place around 2008 to 2010.

Since the outcome set of the ZA test and the Perron test have minor dissimilarity, this research has several structural break points. Nevertheless, both results depict that the null of unit root for most CPI in Sabah and Peninsular Malaysia can be rejected at 1 % significance level. Apart from that, the test endogenously identified the most significant structural break in every time series examined in the study. Other studies that incorporated the same procedures also experienced a fairly similar nature on both results.

Table 1. Unit root test with a structural break (ZA)

Variable	ZA									
	Intercept and Trend	Critical Value			Year of Break	Intercept	Critical Value			Year of Break
		1%	5%	10%			1%	5%	10%	
All items—Sabah	–				–	–2.902	–5.34	–4.93	–4.58	2008M11
All items—Peninsular	–5.109**	–5.57	–5.08	–4.82	2008M09	–4.033	–5.34	–4.93	–4.58	2008M09
Food, non-alcoholic beverages—Sabah	–6.166***	–5.57	–5.08	–4.82	2011M01	–3.312	–5.34	–4.93	–4.58	2011M01
Food, non-alcoholic beverages—Peninsular	–4.293	–5.57	–5.08	–4.82	2008M05	–3.604	–5.34	–4.93	–4.58	2008M04
Alcoholic beverages, tobacco—Sabah	–3.410	–4.80	–4.42	–4.11	2008M04	–4.745*	–5.34	–4.93	–4.58	2010M10
Alcoholic beverages, tobacco—Peninsular	–4.555	–5.57	–5.08	–4.82	2008M09	–4.464	–5.34	–4.93	–4.58	2010M10
Clothing, footwear—Sabah	–4.651	–5.57	–5.08	–4.82	2008M12	–2.687	–5.34	–4.93	–4.58	2008M01
Clothing, footwear—Peninsular	–4.651	–5.57	–5.08	–4.82	2008M12	–4.646*	–5.34	–4.93	–4.58	2008M12
Housing, water, electricity, gas, other fuels—Sabah	–4.832	–5.57	–5.08	–4.82	2013M01	–5.439***	–5.34	–4.93	–4.58	2014M01
Housing, water, electricity, gas, other fuels—Peninsular	–3.595	–5.57	–5.08	–4.82	2014M01	–4.018	–5.34	–4.93	–4.58	2014M01
Furnishings, household equipment, routine household maintenance—Sabah	–4.771	–5.57	–5.08	–4.82	2010M12	–3.352	–5.34	–4.93	–4.58	2013M01
Furnishings, household equipment, routine household maintenance—Peninsular	–5.085**	–5.57	–5.08	–4.82	2012M03	–3.722	–5.34	–4.93	–4.58	2014M01
Health—Sabah	–3.632	–5.57	–5.08	–4.82	2007M02	–3.690	–5.34	–4.93	–4.58	2014M01
Health—Peninsular	–3.830	–5.57	–5.08	–4.82	2008M01	–3.522	–5.34	–4.93	–4.58	2014M01

(Continued)

Table 1. (Continued)

Variable	ZA									
	Intercept and Trend	Critical Value			Year of Break	Intercept	Critical Value			Year of Break
		1%	5%	10%			1%	5%	10%	
Transport—Sabah	-5.949***	-5.57	-5.08	-4.82	2008M09	-3.777	-5.34	-4.93	-4.58	2008M10
Transport—Peninsular	-7.268***	-5.57	-5.08	-4.82	2008M10	-4.511	-5.34	-4.93	-4.58	2008M10
Recreation services, culture—Sabah	-3.883	-5.57	-5.08	-4.82	2010M11	-3.124	-5.34	-4.93	-4.58	2013M11
Recreation services, culture—Peninsular	-				-	-4.428	-5.34	-4.93	-4.58	2009M01
Miscellaneous goods, services—Sabah	-				-	-3.617	-5.34	-4.93	-4.58	2013M01
Miscellaneous goods, services—Peninsular	-				-	-4.610*	-5.34	-4.93	-4.58	2005M12

The values are based on the AIC information criterion estimation. *, **, and *** are referred to 10%, 5%, and 1% significance.

Table 2. Unit root test with a structural break (Perron)

Variable	Perron									
	Intercept and Trend	Critical Value			Year of Break	Intercept	Critical Value			Year of Break
		1%	5%	10%			1%	5%	10%	
All items—Sabah	-5.095	-6.32	-5.59	-5.29	2008M10	-2.788	-5.92	-5.23	-4.92	2008M10
All items—Peninsular	-4.786	-6.32	-5.59	-5.29	2008M08	-3.830	-5.92	-5.23	-4.92	2008M08
Food and non-alcoholic beverages—Sabah	-6.324***	-6.32	-5.59	-5.29	2010M12	-3.361	-5.92	-5.23	-4.92	2010M12
Food and non-alcoholic beverages—Peninsular	-4.206	-6.32	-5.59	-5.29	2008M06	-3.588	-5.92	-5.23	-4.92	2008M03
Alcoholic beverages and tobacco—Sabah	-4.686	-6.32	-5.59	-5.29	2010M09	-4.728	-5.92	-5.23	-4.92	2010M09
Alcoholic beverages and tobacco—Peninsular	-4.538	-6.32	-5.59	-5.29	2010M09	-4.448	-5.92	-5.23	-4.92	2010M09
Clothing and footwear—Sabah	-4.695	-6.32	-5.59	-5.29	2009M12	-2.699	-5.92	-5.23	-4.92	2007M12
Clothing and footwear—Peninsular	-4.603	-6.32	-5.59	-5.29	2008M11	-4.614	-5.92	-5.23	-4.92	2008M11
Housing, water, electricity, gas, and other fuels—Sabah	-4.813	-6.32	-5.59	-5.29	2012M12	-5.410**	-5.92	-5.23	-4.92	2013M12
Housing, water, electricity, gas, and other fuels—Peninsular	-3.586	-6.32	-5.59	-5.29	2013M12	-4.009	-5.92	-5.23	-4.92	2013M12
Furnishings, household equipment, and routine household maintenance—Sabah	-4.756	-6.32	-5.59	-5.29	2010M11	-3.329	-5.92	-5.23	-4.92	2012M12
Furnishings, household equipment, and routine household maintenance—Peninsular	-5.195	-6.32	-5.59	-5.29	2012M02	-3.667	-5.92	-5.23	-4.92	2013M12
Health—Sabah	-3.634	-6.32	-5.59	-5.29	2007M01	-3.667	-5.92	-5.23	-4.92	2013M12

(Continued)

Table 2. (Continued)

Variable	Perron									
	Intercept and Trend	Critical Value			Year of Break	Intercept	Critical Value			Year of Break
		1%	5%	10%			1%	5%	10%	
Health—Peninsular	−3.816	−6.32	−5.59	−5.29	2007M12	−3.533	−5.92	−5.23	−4.92	2013M12
Transport—Sabah	−5.929**	−6.32	−5.59	−5.29	2008M08	−3.681	−5.92	−5.23	−4.92	2008M08
Transport—Peninsular	−6.610***	−6.32	−5.59	−5.29	2008M09	−4.248	−5.92	−5.23	−4.92	2008M07
Recreation services and culture—Sabah	−3.877	−6.32	−5.59	−5.29	2011M04	−3.170	−5.92	−5.23	−4.92	2013M11
Recreation services and culture—Peninsular	−4.480	−6.32	−5.59	−5.29	2008M12	−4.427	−5.92	−5.23	−4.92	2008M12
Miscellaneous goods and services—Sabah	−3.865	−6.32	−5.59	−5.29	2005M11	−3.578	−5.92	−5.23	−4.92	2012M12
Miscellaneous goods and services—Peninsular	−5.358*	−6.32	−5.59	−5.29	2005M11	−4.667	−5.92	−5.23	−4.92	2005M11

The values are based on the AIC information criterion estimation. *, **, and *** are referred to 10%, 5%, and 1% significance.

For example, D. Harvey et al. (2013) found a significant break point in ZA test in 1929 for real GNP, nominal GNP, real per capita GNP, industrial production, and employment of the Nelson-Plosser dataset. In the same research, the Perron test identified the break point for the same series in 1928. Cakan and Ozmen (2002) investigated the integration properties of Turkish velocity series by employing the ZA test and Perron test and they discovered that the two tests produced very similar break points. In studying the relationship between energy consumption and GDP for Turkey, Altinay and Karagol (2004) reported that the break points found in the Perron test lagged exactly 1 year from those obtained via the ZA test. Similarly, most break points shown in Tables 1 and 2 occurred closely in both tests. With the exception of certain significant distinctions in break points, the unit root tests' results in this research is deemed as consistent and adequately fit to be considered robust.

As shown in Tables 1 and 2, the unit root tests determined that break points occurred most frequently in 2008, followed by 2010 and 2013. Notably, the year 2008 recorded a major break point for all groups except for "housing, water, electricity, gas, and other fuels", "furnishings, household equipment, and routine household maintenance", and "miscellaneous goods and services". Using these results, this study proceeds to test whether these groups of prices are cointegrated using Johansen's (1988) test and Gregory and Hansen's (1996) test with a structural break.

Johansen (1988, 1995), Juselius (2006), and Harris (1995) proposed a method which requires estimating a vector error correction (VEC) model in order to determine the cointegration. The VEC is a VAR with a long-run relationship showing how variables return to the equilibrium after suffering a shock. In order to obtain the optimal VEC model, the lag was selected automatically using Akaike's information criterion (AIC). Calculation of the estimates of the autoregressive parameters with minimum AIC suggests a lag length order for every model (refer to Appendix B). Moreover, the Johansen maximum likelihood method provides both trace and maximum eigenvalue statistics to detect the existence of a cointegrating vector which indicates cointegrating relation (Risso et al., 2013).

3.2. Johansen's cointegration test

Cointegration means that a linear combination of different order 1 – integrated variables $I(1)$ is stationary ($I(0)$). Yavuz (2014) added that cointegration carries several important implications including the existence of a long-run relationship between two or more non-stationary time series. Furthermore, error correction models (ECM) incorporate these aspects by mapping the $I(1)$ variables into the $I(0)$ – space. This enables researchers to draw the valid statistical inference, while preserving theoretical interpretability.

Johansen's (1995) cointegration technique was employed to determine whether variables share a common stochastic trend. Under Johansen's (1988) approach, the null hypothesis of no cointegration is tested against the alternative hypothesis. In this study, the following two cointegration equations are adopted:

$$\ln CPI_{Sabah} = \alpha_1 + \beta_1 \ln CPI_{Peninsular} + u_{1t} \quad (7)$$

$$\ln CPI_{Peninsular} = \alpha_2 + \beta_2 \ln CPI_{Sabah} + u_{2t} \quad (8)$$

Next, estimation of the cointegrating relations was obtained by applying Johansen's system estimator. Consecutively, the ECM was applied as shown in Appendix C.

The first row in Table 3 corresponds to each group from the preferred VAR order. Starting with the λ -max test results in the same table, the null hypothesis of $r = 0$ (no cointegration) was not rejected in favour of $r = 1$ (cointegration) in all groups except for "transport". The "transport" group was cointegrated and the calculated test statistics was 45.570. Additionally, the null hypothesis of

maximum one cointegrating vector ($H_0: r \leq 1$) for all other groups was not rejected. Apart from that, the Tr test results produced a similar conclusion for these groups when ($H_0: r = 0$) was tested against the alternative hypothesis of $H_a: r \geq 1$ (Bahmani-Oskooee et al., 2016). Conversely, the calculated Tr statistics for “transport” was 52.345 and this indicates the presence of one cointegrating relationship for the “transport” group over all other groups between Peninsular Malaysia and Sabah. This may also reflect that consumer prices have disequilibrium relationship in both regions.

Similarly, for other groups where the null hypothesis of no cointegration was accepted, the results may imply a discrepancy between domestic trade in Peninsular Malaysia and Sabah. This depicts a potential imbalance in the economic activities among these regions. In summary, these findings suggest a lack of long-run equilibrium relationship between Peninsular Malaysia and Sabah. However, this may also be the effect of possible structural changes in the cointegrating vector (Beyer et al., 2009).

3.3. Gregory and Hansen structural break test

In 1996, Gregory and Hansen provided an alternative estimation—the GH test—based on the notion of regime change with tests that provide a generalisation of the usual residual-based cointegration test. The GH test comprises three alternative models that enables an endogenous structural break to be included in the cointegration vector: (i) a level shift (model C), (ii) a level shift with a trend (model C/T), and (iii) a regime shift that allows the slope vector to shift as well (model C/S). Gregory and Hansen (1996) adjusted these alternative models in the cointegration ADF tests of Engle and Granger (1987), as well as the Z_t and Z_α tests of Phillips and Ouliaris (1990). They estimated the values as per the equation below by assuming that the date of the change is unknown.

$$ADF^* = \inf_{\lambda \in J} ADF, Z_{t^*} = \inf_{\lambda \in J} Z_t, Z_{\alpha^*} = \inf_{\lambda \in J} Z_\alpha \quad (9)$$

These residual-based tests for cointegration concentrate on deriving an alternative hypothesis of one break in the cointegrating vector (Gregory & Hansen, 1996). As the effectiveness of the Engle and Granger (1987) test is substantially reduced in the presence of a break in the cointegrating relationship, Gregory and Hansen (1996) extended the test to allow for breaks in either the “intercept” or the “intercept and trend” of the cointegrating relationship at an unknown time. Given the rejection of cointegration with an unknown break in the parameter, the GH test allows testing the null of no cointegration of variables with $I(1)$ order in the presence of a structural break in the cointegrating relationship.

Villanueva (2007) explained that the break points correspond to the point where the test statistic has the smallest value. Table 4 suggests that few groups in the series were cointegrated, namely “transport”, “recreation services and culture”, and “miscellaneous goods and services”. Compared to the previous result which did not take into account the existence of structural breaks, this result addressed the spurious appearance of cointegration between two independent unit root processes. Therefore, it is more substantial to the study as it considers the possibilities of having all groups being co-moved, while considering the consequences of breaks throughout the period endogenously (Nejad et al., 2016).

From the results, all three tests of ADF, Z_α , and Z_t implied long-run relationship between CPI of Sabah and Peninsular Malaysia in the presence of structural breaks. Most of the endogenously determined break dates with significant cointegration relationships coincided with the global economic crisis in 2008. This is parallel to the previous unit root test with a structural break using the ZA test and Perron test.

Generally, all groups were considered as cointegrated, especially “alcoholic beverages and tobacco” and “transport” groups. This outcome is slightly related to the previous findings,

Table 3. Johansen's cointegration test

Model	λ_{max}					Trace				Cointegrating Vector
	$r = 0$	C.V at 5%	$r = 1$	C.V at 5%	$r = 0$	C.V at 5%	$r = 1$	C.V at 5%		
All items	8.878	19.387	4.009	12.518	12.887	25.872	4.009	12.518	No	
Food and non-alcoholic beverages	7.952	14.264	3.249	3.8415	11.201	15.494	3.249	3.8415	No	
Alcoholic beverages and tobacco	11.511	19.387	8.878	12.518	20.389	25.872	8.878	12.518	No	
Clothing and footwear	10.755	19.387	4.077	12.518	14.831	25.872	4.077	12.518	No	
Housing, water, electricity, gas, and other fuels	10.347	19.387	1.999	12.518	12.346	25.872	1.999	12.518	No	
Furnishings, household equipment, and routine household maintenance	12.262	19.387	7.923	12.518	20.185	25.872	7.923	12.518	No	
Health	11.478	19.387	5.428	12.518	16.907	25.872	5.429	12.518	No	
Transport	45.570	19.387	6.775	12.518	52.345	25.872	6.775	12.518	1	
Recreation services and culture	12.138	19.387	3.978	12.518	16.117	25.872	3.978	12.518	No	
Miscellaneous goods and services	14.309	19.387	6.304	12.518	20.613	25.872	6.304	12.518	No	

Table 4. GH cointegration test

Model	ADF*	Estimated Break Point	Z_t^*	Estimated Break Point	Z_{α}^*	Estimated Break Point	Critical Value Based on ADF* Statistics			Reject Null of No Cointegration
							1 %	5 %	10 %	
All items	C	2007M01	-34.688	2007M01	-4.488	2007M01	-5.13	-4.61	-4.34	No
	C/T	2006M01	-33.874	2005M12	-4.363	2005M12	-5.45	-4.99	-4.72	No
	C/S	2007M09	-41.281	2007M09	-4.993	2007M09	-5.47	-4.95	-4.68	Yes at 10 %
Food and non-alcoholic beverages	C	2010M10	-27.288	2010M10	-3.869	2010M11	-5.13	-4.61	-4.34	No
	C/T	2007M05	-34.891	2007M04	-4.382	2007M04	-5.45	-4.99	-4.72	No
	C/S	2010M11	-37.539	2008M02	-4.607	2008M02	-5.47	-4.95	-4.68	No
Alcoholic beverages and tobacco	C	2008M10	-58.513	2008M07	-6.277	2008M07	-5.13	-4.61	-4.34	Yes
	C/T	2008M10	-66.629	2008M09	-6.872	2008M09	-5.45	-4.99	-4.72	Yes
	C/S	2008M05	-59.753	2008M07	-6.384	2008M07	-5.47	-4.95	-4.68	No
Clothing and footwear	C	2014M01	-31.946	2014M01	-4.692	2014M01	-5.13	-4.61	-4.34	No
	C/T	2006M08	-46.977	2006M09	-5.772	2006M09	-5.45	-4.99	-4.72	No
	C/S	2009M12	-70.937	2009M11	-7.519	2009M11	-5.47	-4.95	-4.68	No
Housing, water, electricity, gas, and other fuels	C	2009M05	-33.469	2009M05	-4.332	2009M05	-5.13	-4.61	-4.34	No
	C/T	2009M05	-35.454	2009M05	-4.526	2009M05	-5.45	-4.99	-4.72	No
	C/S	2009M09	-35.545	2009M09	-4.424	2009M09	-5.47	-4.95	-4.68	No
Furnishings, household equipment, and routine household maintenance	C	2012M10	-24.112	2012M09	-3.878	2012M09	-5.13	-4.61	-4.34	No
	C/T	2012M10	-23.297	2012M09	-3.693	2012M09	-5.45	-4.99	-4.72	No
	C/S	2012M10	-22.840	2012M09	-3.671	2012M09	-5.47	-4.95	-4.68	No
Health	C	2013M01	-16.794	2013M02	-3.020	2013M02	-5.13	-4.61	-4.34	No
	C/T	2012M10	-27.850	2012M10	-3.853	2012M10	-5.45	-4.99	-4.72	No
	C/S	2012M11	-16.597	2012M10	-3.060	2012M10	-5.47	-4.95	-4.68	No

(Continued)

Table 4. (Continued)

Model	ADF*	Estimated Break Point	Z_t^*	Estimated Break Point	Z_{α}^*	Estimated Break Point	Critical Value Based on ADF* Statistics			Reject Null of No Cointegration
							1 %	5 %	10 %	
Transport	C	2005M09	-97.535	2005M09	-8.537	2005M09	-5.13	-4.61	-4.34	Yes
	C/T	2005M09	-102.95	2005M09	-8.920	2005M09	-5.45	-4.99	-4.72	Yes
	C/S	2008M06	-107.47	2008M06	-9.219	2008M06	-5.47	-4.95	-4.68	Yes
Recreation services and culture	C	2013M10	-18.377	2013M09	-3.036	2013M09	-5.13	-4.61	-4.34	No
	C/T	2014M01	-18.745	2013M09	-3.073	2013M09	-5.45	-4.99	-4.72	No
	C/S	2009M11	-41.803	2009M10	-4.896	2009M10	-5.47	-4.95	-4.68	Yes at 5 %
Miscellaneous goods and services	C	2005M10	-32.473	2005M10	-4.310	2005M10	-5.13	-4.61	-4.34	Yes at 10 %
	C/T	2013M02	-30.214	2013M02	-4.115	2013M02	-5.45	-4.99	-4.72	No
	C/S	2006M04	-34.540	2006M04	-4.424	2006M04	-5.47	-4.95	-4.68	No

Note: The critical values are taken from Gregory & Hansen, 1996.

particularly for the “transport” group. For example, while “transport” is regarded as the only cointegrated group in Table 3, the results from the VEC (Appendix C) showed the existence of a long-run causality for the same group. Nonetheless, a divergent behaviour as the short-run adjustment mechanism will not move towards the equilibrium relationship when shocks to the system were sustained because ECM coefficients posit with positive values. Consequently, the divergent nature of the short-run adjustment may indicate the existence of a structural break. This is aligned with the cointegration of “transport” when the factor of structural break was incorporated into the test.

As for “alcoholic beverages and tobacco”, Malaysia’s alcohol production centres are located in East Malaysia as it has a higher non-Muslim population. Although alcohol is heavily taxed and the price of alcoholic drinks in Malaysia is high, the federal territory of Kuala Lumpur reported the highest alcohol consumption in the country, followed by Sarawak and Sabah.² Furthermore, the price of tobacco was co-moved due to the implementation of the Malaysian minimum price law (MPL) on prices of licit and illicit cigarette brands in 2011 and its widespread consumption in Peninsular Malaysia and Sabah.

Apart from the “alcoholic beverages and tobacco” and “transport” groups, other groups that depicted cointegration with break can be regarded as isolated. Groups cointegrated at only the C/S model such as “recreation services and culture” and “all items”, and groups cointegrated at only the C model like “miscellaneous goods and services” do not have adequate strength to be linked as completely cointegrated. As the results of the GH test show lesser cointegrated groups, the affected year of break was lower compared to the ZA test and Perron test. Using the break points obtained in the ZA test, Perron test, and GH test, the causes and events leading to their occurrences are discussed in the following section.

3.4. Non-linear ARDL

Apart from the structural cointegration, this paper also intends to look at the non-linear cointegration between the CPIs of Sabah and Peninsular Malaysia. For that, the non-linear autoregressive distributed lag (NARDL) model developed by Shin et al. (2014) is incorporated to investigate the cointegrating relations and its asymmetrical interactions between the variables. This model is an extension of the linear ARDL model (Pesaran & Shin, 1998; Pesaran et al., 2001). The performance of the ARDL models is very strong for small sample size and does not require all variables to have the same integration order (Kocaarslan et al., 2020; Pesaran & Shin, 1998; Pesaran et al., 2001; Shin et al., 2014). Unlike other test like VECM, the integration orders of the variables could be a mixture of $I(0)$ and $I(1)$. Therefore, it is able to discern between short- and long-term effects of all CPI groups between Sabah and Peninsular Malaysia, as well as the asymmetric relations. Due to its practicality and characteristics, it is realistic to imbibe NARDL model to address the concern of non-linearity cointegration in this study. Following the study of Shin et al. (2014), the model of non-linear long-run cointegrating regression is developed.

$$y_t = \beta^+ x_t^+ + \beta^- x_t^- + u_t \quad (10)$$

with y_t refers to CPIs of Sabah and x_t refer to CPIs of Peninsular Malaysia. β^+ and β^- are the associated long-run parameters. x_t is a $k \times 1$ vector of regressors, which enters the model asymmetrically and is defined as $x_t = x_0 + x_t^+ + x_t^-$, where x_0 represents the initial value. The NARDL model utilizes the decomposition of the predetermined explanatory variables into their positive and negative partial sums for increases and decreases, respectively.

$$x_t^+ = \sum_{i=1}^t \Delta x_i^+ = \sum_{i=1}^t \max(\Delta x_i, 0) \quad (11)$$

$$x_t^- = \sum_{i=1}^t \Delta x_i^- = \sum_{i=1}^t \min(\Delta x_i, 0) \quad (12)$$

Equation (10) can be extended to model the long- and short-run asymmetries within the NARDL framework. The error correction representation of the NARDL model is shown as below:

$$\begin{aligned} \Delta CPIofSabah_t = & \chi CPIofSabah_{t-1} + \omega_1^+ CPIofPENS_{t-1}^+ + \omega_1^- CPIofPENS_{t-1}^- + \mu \\ & + \sum_{i=1}^{p-1} \tau \Delta CPIofSabah_{t-i} + \sum_{i=0}^{q-1} \varphi_1^+ \Delta CPIofPENS_{t-i}^+ \\ & + \sum_{i=0}^{q-1} \varphi_1^- \Delta CPIofPENS_{t-i}^- + \varepsilon_t \end{aligned} \quad (13)$$

The above-shown equations to investigate asymmetric interactions and cointegration relation between the variables of CPI between both regions. It is noted that CPI of Sabah and CPI of Peninsular Malaysia are both stated as dependent and independent variables for all groups. The Δ denotes the first difference of the variables. The coefficients and τ and ω_j represent the long-run coefficients of the model, while τ and φ_j refer to the short-run coefficients for the variables with $j = 2, 3, 4$.

Initially, following the bounds-testing procedure (Pesaran & Shin, 1998; Shin et al., 2014), the F-statistic is used to test the null hypothesis of no non-linear cointegration that $\chi = \omega_1^+ = \omega_1^- = 0$. Then, the standard Wald test is used to test the short- and long-run symmetries (Shin et al., 2014). To investigate the presence of long-run nonlinearities, the null hypothesis of long-run symmetry is tested as $\beta^+ = \beta^-$, where $\beta^+ = -\omega_j^+ / \chi$ and $\beta^- = -\omega_j^- / \chi$ with $j = 2, 3, \text{ and } 4$. The results are presented in the following.

Tables 5-13 report the results of Equation (13) for each of the group. The findings suggest that the CPIs of Sabah is significantly and asymmetrically affected by the fluctuations in CPIs in Peninsular Malaysia in the long-run. Most of the groups recorded the asymmetrical interaction at the similar rate, except for three groups, notably Housing, Water, Electricity, Gas, and Other Fuels,

Table 5. NARDL for food and non-alcoholic beverages

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
C	0.136172	0.108017	1.260651	0.2097
LFOODSABAH(-1)	-0.029236	0.023376	-1.250645	0.2133
LFOODPENS_P(-1)	0.026793	0.034560	0.775268	0.4396
LFOODPENS_N(-1)	0.035647	0.045078	0.790781	0.4305

Table 6. NARDL for alcoholic beverages and tobacco

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
C	0.740972	0.244742	3.027561	0.0030
LALCOHOLSABAH(-1)	-0.157635	0.052098	-3.025730	0.0030
LALCOHOLPENS_P(-1)	0.165089	0.056233	2.935783	0.0039
LALCOHOLPENS_N(-1)	0.135341	0.050029	2.705273	0.0077

Table 7. NARDL for clothing and footwear

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
C	0.149838	0.126651	1.183085	0.2390
LCLOTHINGSABAH(-1)	-0.033741	0.028023	-1.204050	0.2308
LCLOTHINGPENS_P(-1)	0.121726	0.080372	1.514537	0.1323
LCLOTHINGPENS_N(-1)	0.082487	0.050466	1.634518	0.1046

Table 8. NARDL for housing, water, electricity, gas, and other fuels

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
C	0.249124	0.107589	2.315514	0.0221
LHOUSINGSABAH(-1)	-0.054141	0.023408	-2.312891	0.0222
LHOUSINGPENS_P(-1)	0.052449	0.018145	2.890492	0.0045
LHOUSINGPENS_N(-1)	0.789227	0.287020	2.749726	0.0068

Table 9. NARDL for furnishings, household equipment, and routine household maintenance

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
C	0.227177	0.129844	1.749619	0.0824
LFURNSABAH(-1)	-0.050156	0.028393	-1.766478	0.0796
LFURNPENS_P(-1)	0.051185	0.038811	1.318802	0.1895
LFURNPENS_N(-1)	-0.036699	0.100802	-0.364066	0.7164

Table 10. NARDL for health

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
C	0.077394	0.063897	1.211241	0.2279
LHEALTHSABAH(-1)	-0.016920	0.013832	-1.223269	0.2234
LHEALTHPENS_P(-1)	0.019242	0.018032	1.067142	0.2878
LHEALTHPENS_N(-1)	-0.180666	0.161055	-1.121767	0.2640

Table 11. NARDL for transport

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
C	1.409416	0.270698	5.206603	0.0000
LTRANSABAH(-1)	-0.297969	0.057294	-5.200747	0.0000
LTRANSPENS_P(-1)	0.360233	0.071224	5.057748	0.0000
LTRANSPENS_N(-1)	0.355687	0.069351	5.128797	0.0000

Table 12. NARDL for recreation services and culture

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
C	0.093641	0.090806	1.031221	0.3043
LRECSABAH(-1)	-0.020788	0.019657	-1.057522	0.2921
LRECPENS_P(-1)	-0.002862	0.025058	-0.114221	0.9092
LRECPENS_N(-1)	-0.490231	0.442865	-1.106952	0.2703

Table 13. NARDL for miscellaneous goods and services

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
C	0.575750	0.200223	2.875550	0.0047
LMISCESABAH(-1)	-0.124818	0.043405	-2.875691	0.0047
LMISCEPENS_P(-1)	0.111052	0.042597	2.607045	0.0102
LMISCEPENS_N(-1)	0.102283	0.041511	2.464025	0.0150

Health and Recreation Services and Culture. This is due to the fact that for these groups the decline in CPIs of Peninsular Malaysia significantly decrease the CPIs of Sabah more than the effect of the increasing rate of CPIs in Peninsular Malaysia towards the CPIs in Sabah. Apart from that, similar with the results of Johansen's Cointegration Test, all groups are found as non-cointegrated except for Transport (Table 14); while the Wald test in Table 15 shows the asymmetric interactions of all groups, with all recorded with symmetrical in the long-run impact, except for Alcoholic Beverages and Tobacco. In short, the results of NARDL are providing an alternative measure for CPIs of both

Table 14. Non-linear cointegration

Groups	Wald Test (F-Statistic)	df	Probability
Food and non-alcoholic beverages	1.351174	(3, 130)	0.2607
Alcoholic beverages and tobacco	3.232653	(3, 133)	0.0245
Clothing and footwear	1.042817	(3, 129)	0.3760
Housing, water, electricity, gas, and other fuels	3.230938	(3, 135)	0.0245
Furnishings, household equipment, and routine household maintenance	2.976720	(3, 136)	0.0339
Health	2.831343	(3, 135)	0.0408
Transport	9.463355*	(3, 134)	0.0000
Recreation services and culture	1.648093	(3, 137)	0.1812
Miscellaneous goods and services	2.826089	(3, 136)	0.0410

Refer to Pesaran et al. (2001), only for Transport, the calculated F-statistics is larger than the critical value of $I(1)$ of 7.84 at 1% significance level. Hence, there is strong evidence of cointegration at 1% significance level.

Table 15. Symmetrical test

Groups	Wald Test (F-Statistic)	df	Probability
Food and non-alcoholic beverages	0.394424	(1, 130)	0.5311
Alcoholic beverages and tobacco	12.08954	(1, 133)	0.0007*
Clothing and footwear	0.587361	(1, 129)	0.4448
Housing, water, electricity, gas, and other fuels	5.645705	(1, 135)	0.0189
Furnishings, household equipment, and routine household maintenance	0.693212	(1, 136)	0.4065
Health	0.747173	(1, 135)	0.3889
Transport	1.340539	(1, 134)	0.2490
Recreation services and culture	1.216053	(1, 137)	0.2721
Miscellaneous goods and services	3.279363	(1, 136)	0.0724

*denotes p -value < 0.05.

Peninsular Malaysia and Sabah compared to the previous tests abovementioned. In the following sections, the economic and policy implications of the study are discussed in detail.

4. Discussion

This part will discuss the results obtained from both linear and non-linear tests. First, the structural break tests indicated that most breaks happened in 2008, 2012, and 2013. Thus, the discussion is categorised according to these different periods. Second, the non-linear tests explain the asymmetrical interaction from all groups, with a few recorded substantial difference for the partial sums for increases and decreases, namely, Housing, Water, Electricity, Gas, and Other Fuels, Health and Recreation Services and Culture.

4.1. Year 2008

The year 2008 can be characterised into two distinct periods. In the first half of the year, global economies faced intense inflationary pressures amidst a sharp increase in prices of oil, food, and other commodities. This also intensified and spread the turmoil in the international financial markets and their negative impact on economic growth (Elekdag et al., 2012). Advanced economies experienced reduced financial problems and hence, their investment funds shifted from mortgage securities and equities to commodities. This contributed to record high prices of oil and other commodities by the middle of the year and subsequently, increased cost-push inflationary pressures around the world (Menon, 2008).

Global economic conditions experienced a major reversal in the second half of 2008 as the financial crisis developed into a systemic failure of the financial system. Concerns over inflationary pressures that prevailed in the first half shifted rapidly towards the threat of economic contraction as the intensification of the global financial turmoil and the ensuing credit crunch led the advanced economies into a synchronised recession (Dimitriou & Simos, 2013). The spillover effects on the emerging economies were evident towards the end of the year as the more open economies in Asia experienced export-led recessions. Notably, growth in the other economies moderated sharply. The sharp deterioration in global financial and economic conditions triggered a rapid correction in commodity prices. Along with rapidly contracting demand conditions, this resulted in a large reduction of the inflationary pressures sweeping across the global economy (C. W. S. Chen et al., 2009).

The economic spillover crisis caused the activities of a majority of corporations and entities in Malaysia to be slowed down due to several austerity measures taken by the government and banks (Doraisami, n.d.). Although economic activities in Asia, especially India and China, remained favourable, the support on domestic demand in these countries had been slightly affected due to inflationary pressures (Nag & Mukherjee, 2012).

4.1.1. Overview of inflation in 2008

The inflation was increasing in the first five months of 2008 following the steady increase in global food and fuel prices that reached new highs at mid-year. Subsequently, the inflation rate rose sharply in the third quarter following the 40.4% adjustment to retail fuel prices in June. By July, inflation peaked at 8.5% (Central Bank of Malaysia, 2009). Consecutively, the reducing global food prices and bursting of the commodity bubble led to the rapid correction in the global commodity prices across the board. In the fourth quarter, the prices of domestic food and fuel declined, while the inflation averaged at 5.4% across the year (Central Bank of Malaysia, 2009).

The main contributors to inflation in 2008 were the “food and non-alcoholic beverages” and “transport” groups which comprised 79.7% of the overall rise in domestic prices during the year. Inflation in the “food and non-alcoholic beverages” category averaged 8.8% in 2008 and contributed 52.2% to the overall inflation in that year. Ibrahim (2015) explained that the increase in food prices was universal and contributed by higher global food prices, although all food sub-components recorded a faster price increase compared to the previous year. On average, the

domestic price of rice rose by 25.3% in 2008 as poor harvests caused supply shortages in major rice-exporting countries and prompted major stockpiling activities to ensure food security (Vijayan et al., 2014). Overall, the effect of global prices on domestic food prices was moderated by government price controls. Nevertheless, food items that were not subjected to price controls reflected the direct higher production costs and global prices to the consumers (Ayupp, 2013).

In the “transport” category, inflation averaged 8.8% in 2008 and contributed 25.9% to domestic inflation. Despite the surge in global fuel prices, inflation in this category remained relatively moderate in the first half of the year as domestic retail fuel prices were unchanged with government subsidies (Malaysian Budget, 2009). Nonetheless, the 40.4% adjustment to domestic retail fuel prices in June led the inflation in this category to increase sharply to 19.6%. The impact on headline inflation was immediate with an increase to 7.7% in the same month (Central Bank of Malaysia, 2009). Nevertheless, in line with the fall in global fuel prices, the government revised retail fuel prices down seven times between August and December. By the end of the year, the fuel prices were lower than their pre-June adjustment levels (Central Bank of Malaysia, 2009).

Table 16 summarizes the global industries that was affected in the year 2008. These include various sectors such as oil/fuel, housing, energy prices, as well as food prices.

4.2. Year 2012

The year 2012 continued to be challenging as the recovery of several advanced economies was constrained by the unresolved fiscal, financial, and structural concerns. The resulting low global growth affected international trade and subsequently, had adverse spillover effects on domestic activities in the emerging economies (Psaraftis et al., 2013). With the exception of crude oil prices that had remained elevated, the prices of other commodities were lower due to the weak global demand and constant supply (Akter & Basher, 2014). This led to more subdued inflationary pressures.

In response to the uncertain and volatile external environment, many countries pursued further monetary easing to support growth. According to Schenkelberg and Watzka (2013), the growth momentum in the advanced economies was uneven. After the economic restructuring, domestic demand had been a prominent growth factor in Malaysia (Ministry of Finance, 2012). Essentially, the growth was sustained by the strong private consumption and the emerging private investment (Ministry of Finance, 2012). The sources of economic growth had also become more diversified and balanced across economic sectors and trade partners.

4.2.1. Overview of inflation in 2012

The moderation of inflation during 2012 was driven mainly by supply factors (Malaysian Budget, 2012). The external price pressures were modest in 2012 due to moderate increase in global energy prices and lower global food prices. Even though global crude oil prices were affected by the geopolitical tensions in the Middle East and North Africa, average oil prices for the year remained stable with only minor increase from the previous year (Central Bank of Malaysia, 2013). The modest increase in global crude oil prices reflected an excess supply of oil caused by higher production and lower global demand.

Apart from that, the moderation in inflation was widespread and was observed across most CPI categories. Only two CPI categories recorded a break in 2012, namely “furnishings, household equipment, and routine household maintenance”, and “health”. Despite the uncertainties in the external environment, consumption activity remained strong during 2012 due to favourable income growth, low inflation environment, and supportive financing conditions (Malaysian Budget, 2012). Low income and middle-income households also received further monetary support from the government.

Table 16. Sectors affected in 2008

No	Sector	Sub-sector	Explanation	References
1	Oil/fuel	Stock price	Prior to the financial crisis, stock returns are slightly (negatively) affected by oil prices and by the USD/Euro. For the subsample of mid-2009 onwards, however, stock returns are positively affected by oil prices and a weaker USD/Euro. As with inflation expectations, U.S. stocks responding positively to expectations of recovery worldwide	(Mollick & Assefa, 2013)
		Stock price	Impact of the US financial crisis in September 2008 on the dynamic linkages between these stock prices. The international transmission of stock prices between the BRICs and the United States weakened in both the mean and variance on account of the 2008–09 US financial crisis.	(Xu & Hamori, 2012)
		Investor sentiment	Effects of oil price on Chinese investor sentiment are time-varying and in most cases are negative. Moreover, the negative effect is large in the latest year of 2017, followed by the global financial crisis of 2008, yet small for the steady economic period in 2012, and minimal for the China's oil product pricing reform in 2013.	(He, 2020)
		Russian economy	Oil prices are pro-cyclical and lead the business cycles. Considering the response to oil price shocks, positive shocks in oil prices give a positive and statistically significant impact on almost all types of Russian economic activity. Taking into account possible structural changes led by the economic crisis in Russia in 2008–2009, a negative response to a positive shock is found in oil prices in eight months both for main economic activities and mining. We find the domestic oil prices do Granger cause main economic activity, industrial production and manufacturing which is consistent with the cyclical properties.	(Balashova & Serletis, 2020)
		Oil price shocks	The structural shocks of oil price fluctuations are categorized into four types: oil supply shocks, global demand shocks, domestic demand shocks and oil-specific demand shocks. The time-varying effects of these oil price shocks on China's inflation at the import, production and consumption stages were tested using monthly data from January 1999 to December 2016. The analysis of the variance decomposition shows that the effects of oil price shocks on China's inflation at each stage are incomplete and decrease along the price chain. The increase in oil prices driven by oil-specific demand shocks is the most important cause of China's inflation at the import and production stages during the full sample period, while China's inflation at the consumption stage is mainly affected by domestic demand shocks. Inflationary effects of oil price shocks have been dramatically weaker since the international financial crisis compared with before the crisis.	(J. Chen et al., 2020)

(Continued)

No	Sector	Sub-sector	Explanation	References
		Declining oil price	Causes of the extreme oil price plummets through supply and demand factors of price determinants. The autoregressive models with exogenous variables reflect real demand, speculative activities explain the causes of the extreme oil price plummets through the supply and demand factors of price determinants. During the first period of oil price decline, real demand reduction seemed to play a more prominent role compared with the other factors. Meanwhile, some supply factors, measured by U.S. shale oil production, combined with real and speculative demand factors, played an important role during the period of second oil price drop.	(M. S. Kim, 2018)
		Oil price shocks and yield spreads	Time-varying correlation between oil price shocks and the 10-year sovereign yield spread of core and periphery countries in the EMU, by employing a scalar-BEKK framework. The correlations between sovereign yield spreads and oil price shocks are time-varying and are influenced by specific economic and geopolitical events that took place during the study period. Even though the correlation patterns are constantly low or zero prior to the Great Recession, a change is revealed in the post-2008 period, when correlations become moderate and more volatile.	(Filippidis et al., 2020)
		Volatility spillover between oil and other commodity prices	Changing impact of oil price shocks on a bouquet of metal and agro prices and their implications for investment decisions, during different oil price regimes, separated by structural breaks. Oil is the highest contributor to the volatility of agro and metal commodities. The agro commodities are net receivers except for soybeans, wheat and sugar. The strong volatility connect between oil price and agro commodities like sugar, corn, and wheat is consistent with the demand for biofuels.	(Guhathakurta et al., 2020)
		Oil price volatility on ethanol, gasoline, and sugar price forecasts	Long-term and short-term effects of oil prices on ethanol, gasoline, and sugar price forecasts. The results indicate that: (i) there are long-term effects of the oil price forecast on the forecasts of the other three prices; (ii) in the short term, the ethanol and gasoline price forecasts were more sensitive to changes in future oil prices than the sugar price forecast; and (iii) the future volatility of the price of sugar is less than the future volatility of the other two prices.	(Carpio, 2019)

(Continued)

Table 16. (Continued)

No	Sector	Sub-sector	Explanation	References
		Biofuel and other supply and demand factors on food price	<p>After March 2008, grain prices declined by 50% while biofuel production continued to increase. It is not possible to reconcile claims that biofuel production was the major factor driving food price increases in 2007–2008 with the decrease in food prices and increase in biofuel production since mid-2008.</p> <p>Grain prices in 2008 were not caused by increased biofuel production, but were actually the result of a speculative bubble related to high petroleum prices, a weak US dollar, and increased volatility due to commodity index fund investments.</p> <p>Factors: increased demand, decreased supply, and increased production costs driven by higher energy and fertilizer costs.</p> <p>Biofuel production had a modest (3–30%) contribution to the increase in commodity food prices observed up to mid-2008.</p> <p>The development of second-generation biofuels (e.g., cellulosic ethanol) which use non-food residual biomass or non-food crops should mitigate any future impact of biofuel production on food prices.</p>	(Mueller et al., 2011)
2	Housing	Housing price	<p>Impact of the 2008 financial crisis on housing prices at difference price levels in China and Taiwan.</p> <p>The empirical results indicate that in Taiwan the housing prices were more affected by the financial crisis when the prices of real estate were high, but in China the housing prices were less affected by the crisis when the prices were high.</p>	(Kang & Liu, 2014)
		J-REIT	<p>Fundamental value of the J-REIT price from impact of the 2008 financial crisis and the 2011 Japan earthquake between May 2003 and December 2014.</p> <p>Fundamental value of the J-REIT is determined only by the real estate price in the long-run. Short-run deviations from the fundamental value of the J-REIT price occur during the 2008 crisis and the 2011 earthquake because the trading volume by foreigners exceeded 50%.</p> <p>The deviations from the fundamental value were less persistent during 2008 and 2011 because the 2011 earthquake caused Japanese investors to focus on earthquake risk while foreigners departed from investing in the J-REIT market</p>	

(Continued)

No	Sector	Sub-sector	Explanation	References
3	Energy prices	Stock return	Before the 2008 global financial crisis, energy prices exerted a moderate negative effect on future stock returns and their effects have become strongly positive afterwards.	(J. H. Kim et al., 2019)
		Electricity	Compares the market power of Hungarian electricity traders during the partially liberalised transitional market model from 2004 to 2008 and the fully liberalised period lasting since 2008. Based on asymmetric price transmission (APT) theory to measure the market power of traders in the electricity market. Different regulation regimes lead to different patterns of asymmetry in price transmission and the results underline that the market position of electricity traders have improved since the introduction of the liberalised market model.	(Szöke et al., 2019)
		Biofuel policy	Due to the crop-biofuel price linkages that took hold in 2007 caused by biofuel policies, developing countries' policy responses had little impact on world prices in 2008 and maximum impact in reducing domestic price in developing countries. The incidence of those developing countries with policy responses were mostly in reducing domestic prices while those countries that did not respond (including all developed countries) faced high world prices locked onto crude oil prices and unaffected by policy responses.	(De Gorter & Drabik, 2016)
4	Food prices	Food price shocks	The variability of food prices is defined by relating it to the detection of extreme values and change points in the decomposed time series of food price indices (change-point analysis). Between the middle of 2007 and 2008, crop failures caused by drought and low levels of global stocks	(Malesios et al., 2020)

4.3. Year 2013

Finally, the year 2013 marked a year of transition for the world economy. The normalisation of monetary conditions in the advanced economies improved global economic conditions (Salisu & Fasanya, 2013). Nevertheless, the international financial markets still suffered from increased volatility. The global economy expanded at a modest pace amid an uneven growth environment across economies. Accordingly, global inflation slowed as a result of the moderate demand conditions in many economies and lower non-energy commodity prices.

In the advanced economies, growth continued to improve gradually but at a modest pace of recovery as policy uncertainties and structural constraints continued to affect overall demand (Kavussanos et al., 2014). Similarly, growth in emerging economies moderated because domestic demand was affected by the prolonged weakness in external demand. The policy measures introduced to manage domestic vulnerabilities in a number of emerging economies also affected their growth. Towards the second half of the year, the market expected monetary accommodation in the United States to reduce and this led to large capital flow reversals from the emerging economies (Khazanah Nasional Berhad, 2013).

4.3.1. Overview of inflation in 2013

Despite the increased supply and lower demand growth from key emerging economies, commodity prices continued to moderate from the peak recorded in early 2011. Department of Statistics (2013) reported that record production of grains, primarily corn and rice, along with higher stocks dampened food prices. Apart from that, oil prices were sustained at 2012 average levels. During the first half of 2013, oil prices fell as the result of slow growth in major oil importing economies in Asia and the geopolitical turmoil in the Middle East. Nonetheless, Brent crude oil price rose to a six-month high of 118 USD per barrel in August then stabilised at the end of the year to average 109 USD per barrel in 2013 (Central Bank of Malaysia, 2014).

During this period, the emerging economies experienced sharp reversals of capital flows. The policy spillovers and contagion effects were the major risks faced by these emerging economies in this year of transition. These developments affected the emerging economies in varying extents (C. Lee & Fukunaga, 2014). Nevertheless, the earlier reforms and policy implementations enabled most of these economies to manage the volatile and uncertain condition more effectively.

The inflation in 2013 was moderate at 2.1%; the average inflation was low at 1.7% in the first 8 months of the year before increasing to 2.9% in the remaining 4 months (Department of Statistics, 2013). The higher inflation in the latter part of the year was contributed by the upward adjustments to administered prices and weather-related domestic supply shortages. Despite the strong growth in private consumption and sustained wage growth during the year, adequate productive capacity in the economy balanced the demand pressures. Hence, core inflation which is an indicator of demand-driven pressures, moderated to 1.8% in that year (Central Bank of Malaysia, 2014).

Notably, inflation during the year was driven mainly by “food and non-alcoholic beverages” due to domestic cost and supply factors. Higher cost of poultry feed in the early part of 2013 and disruptions in domestic food supply due to adverse weather conditions such as flood in the east coast of Peninsular Malaysia were the main factors that led to higher food inflation (Central Bank of Malaysia, 2014). Apart from that, average inflation of 1.7% in the “housing, water, electricity, gas, and other fuels” category reflected higher rental for housing, particularly for apartments, condominiums, and properties in urban areas (Department of Statistics, 2013).

4.4. Asymmetrical interaction

The substantial partial asymmetrical interaction has been shown for three groups which include Housing, Water, Electricity, Gas, and Other Fuels; Health as well as Recreation Services and Culture. This could be due to the fact that most of materials used in these groups are imported, particularly from the Peninsular Malaysia. Since the period covered for this study is covered under the implementation of Cabotage Policy³, it is realistic to relate the price of Sabah as being “hampered by the shortcoming” linked to the policy (Ruslan et al., 2019). Nonetheless, by assuming that there is “cabotage-free”, the effect of partial interaction would be evident since no restriction of trade activities will be imposed to manufacturers, importers and exporters.

On the other hand, strong state intervention in the involved groups with limited private sector participation could also be one of the factors. Strong state involvement in housing provision, for example, requires a large financial allocation from the federal government, if not market (Shuid, 2016). Strong state involvement in housing provision requires a large financial allocation from the federal government and, if not limited and carefully focused, may not be financially sustainable in the long term.

In terms of construction cost, for most Federal and State governments affordable housing programmes, the construction cost is relatively the same as private sector housing due to the similar price of construction materials and land cost. With declining size of state owned lands, most government agencies involved with affordable housing programmes at the Federal or State

level have to purchase the land the market price (Shuid, 2016). Therefore, Federal government has to subsidize at least 20% of the construction cost in order to sell the unit 20% below the market price for similar type and size of unit by the private sector to make it affordable for the middle-income people to spend no more than 30% of their average household income for their monthly home mortgage repayment (Shuid, 2016).

To address that, the federal government needed to move aggressively to initiate a substantial expansion of affordable housing to address the housing need of the people immediately. However, federally subsidized, government provided, housing for the middle class should not become a permanent approach. In the long run, the federal government should return the responsibility to provide middle-class affordable housing to the private sector.

5. Conclusion

This paper studied the structural break issue in consumer prices between Peninsular Malaysia and Sabah from 2004 until 2015. Nine aggregates and few disaggregated categories of goods and services were employed for linear tests with structural breaks as well as non-linear test. This paper's purpose was mainly to evaluate data of CPI in Malaysia in terms of structural break after the country experienced several economic incidents and policy alterations, leading to a few conclusions drawn from the empirical tests.

Most of the structural changes occurred in 2008—the period of global financial crisis with steep oil prices which indirectly translated into the increased food prices and other commodities. Moreover, instability of the financial sector in the United States and the worsening economic condition in Europe had threatened the global economic growth (Elekdag et al., 2012). The study also investigated the cointegration of prices by examining the long-run relationships among the variables using Johansen's cointegration test. The result suggested no long-term relationship among all variables except for the “transport” group.

Consecutively, the lack of long-run relationship in the Johansen test was compensated by conducting the GH structural break test that incorporated the structural break existence among the variables. Similar to the Johansen test, the “transport” and “alcoholic beverages and tobacco” groups were discovered to be cointegrated. The “transport” group cointegration in the GH test may relate to the VEC result in Appendix C which shows that the ECM coefficient value was positive. The short-run adjustment did not move towards the equilibrium relationship and thus, yielded divergence behavior; this may suggest the structural break presence.

Among all, the non-linear test of NARDL supplement the outcome of linear tests by providing the asymmetrical interactions between the CPIs of Sabah and Peninsular Malaysia. Three groups have been identified as having a substantial imbalance for its partial sums. This indicated that the decrease of CPIs of Peninsular Malaysia further plummeting the CPIs of Sabah, should there be any circumstances that lead to the condition.

In sum, the administered price mechanism in Malaysia was the key element that affected the transmission of inflation. The prices of several essential goods were administered by the government as changes in the prices of these goods have a significant impact on the cost-of-living for the low income and middle-income groups (Ministry of Finance, 2012). Generally, the price administered items are divided into two types. The first group comprises items listed under the Price Control Act (1946); the government determines the retail prices for these goods such as fuel and sugar (Ministry of Finance, 2012). The second group consists of items that require government approval for price changes such as electricity tariff and public transport fares (Ministry of Finance, 2012). The administered price mechanism functions to mitigate and delay the impact of supply shocks and external price developments on domestic prices. Apart from that, the prices could also be affected by external factors such as global economic uncertainty, implementation of the new policy as well as dynamic domestic situations existed throughout time.

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Notes

1. The World Factbook of the CIA (accessed on 6 March 2017).
2. The Star, 11 May 2013: "Sabah is 3rd highest in alcohol consumption".
3. Implemented from 1 January 1980 until 1 June 2017.

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Appendix A Unit root tests without structural breaks

Variable	ADF		PP		KPSS	
	Levels	First Differences	Levels	First Differences	Levels	First Differences
All items—Sabah	-1.991	-9.312***	-1.991	-11.016***	0.174**	0.057
All items—Peninsular	-1.465	-10.205***	-1.273	-10.101***	0.256***	0.108
Food, non-alcoholic beverages—Sabah	-1.088	-13.183***	-1.029	-13.183***	0.336***	0.068
Food, non-alcoholic beverages—Peninsular	-1.737	-3.087	-1.909	-13.429***	0.341***	0.059
Alcoholic beverages, tobacco—Sabah	-2.962	-12.110***	-3.085	-12.112***	0.129***	0.037
Alcoholic beverages, tobacco—Peninsular	-2.962	-12.110***	-3.085	-12.112***	0.149***	0.043
Clothing, footwear—Sabah	-1.421	-2.040	-1.275	-15.908***	0.299***	0.113
Clothing, footwear—Peninsular	-1.667	-1.910	-2.587	-19.053***	0.201***	0.118
Housing, water, electricity, gas, other fuels—Sabah	-0.215	-2.590	-1.325	-13.081***	0.304***	0.063
Housing, water, electricity, gas, other fuels—Peninsular	-1.336	-1.904	-2.181	-13.291***	0.220***	0.064
Furnishings, household equipment, routine household maintenance—Sabah	0.047	-2.833	-1.120	-13.750***	0.353***	0.054
Furnishings, household equipment, routine household maintenance—Peninsular	1.446	-0.910	-0.443	-13.494***	0.336***	0.084
Health—Sabah	-1.549	-2.086	-2.273	-13.483***	0.285***	0.054
Health—Peninsular	-2.297	-1.966	-2.959	-13.500***	0.151**	0.079
Transport—Sabah	-2.586	-9.935***	-2.309	-9.767***	0.182**	0.095
Transport—Peninsular	-3.241*	-4.919***	-2.695	-11.203***	0.173**	0.103
Recreation services, culture—Sabah	0.230	-2.997	-1.210	-12.932***	0.366***	0.044
Recreation services, culture—Peninsular	-2.856	-2.478	-3.028	-13.069***	0.145*	0.138*
Miscellaneous goods, services—Sabah	-3.723**	-11.831***	-2.360	-11.833***	0.198**	0.0441
Miscellaneous goods, services—Peninsular	-2.947	-3.268*	-2.830	-13.428***	0.231***	0.051

The values are based on the AIC information criterion estimation. *, **, and *** are referred to 10%, 5% and 1% significance.

Appendix B Optimal lag order selection criteria

Model	Lag	AIC
All items	2	-17.01
Food and non-alcoholic beverages	1	-14.23
Alcoholic beverages and tobacco	2	-12.44
Clothing and footwear	2	-15.44
Housing, water, electricity, gas, and other fuels	1	-14.99
Furnishings, household equipment, and routine household maintenance	1	-14.72
Health	1	-14.73
Transport	2	-12.25
Recreation services and culture	1	-13.57
Miscellaneous goods and services	1	-16.04

Appendix C VEC table

Dependent Variable: LCPITRANSPORTSABAH			
Variable	Coefficient	Std. error	t-stat
C	-1.260	-	-
LCPITRANSPENS ($t - 1$)	1.267	0.0419	30.256



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