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Transportation Dynamic Behaviour of Structural Break and Consumer Price Index

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Abstract; This paper studies the dynamic behaviour of transportation price in Peninsular Malaysia and Sabah from 2004 to 2015 using disaggregated monthly price data of consumer price index (CPI). For that, unit root tests and cointegration tests with structural breaks are 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 break points occurred in 2008, (ii) the variables cointegrate in the Johansen cointegration test which indicates that there is a long-run relationship and (iii) the Gregory and Hansen test also demonstrated some form of cointegration with structural break(s), especially in 2008. Overall, this study intends to match the structural break points with the comparable critical economic events.

Keywords: CPI; Structural Break; Economic Policy

I. INTRODUCTION

It is evident that any 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 cycle as they are often influenced by external shocks or regime changes in economic incidents like changes in economic policy, reforms in certain regulation, current international climate, and institutional developments. Accordingly, implementation of certain policies is heavily dependent on the course, strength, and reliability of the interrelation between goods and services utilization and prices. This paper intends to enrich the empirical literature on the stability between goods and services expenditure and prices in Malaysia by paying attention on specific target group, which in this case, is transportation.Despite economic development and composition vary for every country, most empirical studies proved that economic growth has a correlation with inflation.

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Nevertheless, details regarding economic growth are subject to differ over time and no empirical work has been performed to explore the possible variations and instability, particularly on the prices of "transportation" in Malaysia.

Given the case of study of price, [1] studied the integration of CPI inflation by looking at the core, energy, and food components. They tested the structural breaks in the interrelation between domestic inflation and comparable country-specific foreign inflation cycle for OECD countries using the monthly frequency. Beginning from the early 1990s, the comprehensive form of globalisation in composite inflation was largely derived by the intersection of the mean levels of the indispensable component. In particular, this was interlinked with the inflation aimed in most of their sample countries. In addition, short-run foreign energy inflation is usuallylead to the globalisation impact. On the other hand, [4] 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, [4] suggested that inflation is not a highly persistent process in general.[13] examined whether the assertion 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 structural break, they discovered that the speed of convergence with structural break was more rapid. Moreover, application of structural break resulted in a 64 % shorter than the half-life measure with a half-life of 3.9 years 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 aftermath on relative prices across US cities. On the other hand, [10] studied the concept of volatility and uncertainty in inflation using 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 identified, 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, bidirectional causality relationship was recognized in the series.In this research, the CPI data of Malaysia for the past 10 years which could be slightly influenced by economic events, reforms, or measurements were tested. Notably, structural changes in the data of CPI for several groups of goods and services may affect the findings of the stationary test.

Consecutively, [14] bivariate cointegration method was applied to test the cointegration relationship between the 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 were performed on each result. Apart from that, the structure of the paper is organised as follows: the next section explains the data incorporated, the third section shows the econometric method, the fourth section explains the empirical findings of both unit root tests and cointegration tests, and the fifth section concludes the research as well as relevant remarks.

II. 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 period t.
The 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. Due to data constraint, the aggregate data and disaggregated data for "transport" CPI in Peninsular Malaysia and Sabah were applied instead of the actual retail price.

III. METHODOLOGY AND EMPIRICAL FINDINGS

3.1 Unit Root Test Incorporating Structural Break

Generally, there are two kinds of unit root test. The first type is widely mentioned in the literature, comprising the augmented Dickey-Fuller (ADF) test founded by [6] and [22]. Notably, these tests have been judged because of their non-rejection nature towards the null hypothesis of a unit root against the alternative in the existence of structural breaks and low capacity for almost-integration processes. Contrary to the first type, the second type of test permits the incorporation of one break in the series. [26], hence (ZA) and [20] developed a new classification of unit root test that is able to incorporate an endogenous structural break including possible shift in regime. Nevertheless, these two tests have several differences; Perron's test has an additional time shock (or jump) dummy variable compared to ZA's test [17]. 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 [21]. Additionally, the Perron test indicates the break point at the absolute value of the t-statistic on the coefficient of the autoregressive variable or when there is transition in slope on the break term is maximised [2]. 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 choosing a break point intuitively[26]. This endogenous choosing 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) permits a single change in the level of the series, whereas the second model or Model B (3) permits a single change in the slope of the trend function. Third, Model C (4) incorporates the single changes in the level of the series and the trend function slope.

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

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

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

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 equivalent trend shift variable.

Formally,

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

and,

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

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 "transport" 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 fairly similar nature on both results.

Table 1: Unit Root Test with 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%	
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

(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 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%	
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

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

3.2 Johansen's Cointegration Test

Cointegration is a statistical property of an equation $(X1, X2, \ldots, Xk)$ of time series variables, which the series must be integrated of order *d*. If a linear combination of the equation is integrated of order less than$d$, then the equation will be regarded as cointegrated. [25]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) integrate these aspects by plotting the $I(1)$ variables into the $I(0)-$space. This enables researchers to extract out valid statistical inference, while containing theoretical elucidation.

Cointegration method was utilized to identify whether variables present a common stochastic trend [15]. Under [14] approach, the null hypothesis of no cointegration is tested against alternative hypothesis. In this study, the following two cointegration equations are adopted:

$$lnCPISabah = \alpha_1 + \beta_1 lnCPIPeninsular_t + u_{1t} \quad (7)$$

$$lnCPIPeninsular = \alpha_2 + \beta_2 lnCPISabah_t + u_{2t} \quad (8)$$

Next, estimation of the cointegrating relations was done by conducting Johansen's test. Consecutively, the ECM was applied as shown in Appendix C.

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%	
Transport	45.570	19.387	6.775	12.518	52.345	25.872	6.775	12.518	1

The first row in Table 3 corresponds to each group from the chosen VAR order. Beginning with the λ-max test results in the same table, the null hypothesis of $r = 0$ (no cointegration) was not rejected in preference of $r = 1$ (cointegration) 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 "transport" group was also not rejected. Apart from that, the Tr test results produced similar conclusion for these groups when (H_0: $r = 0$) was tested against the alternative hypothesis of H_a: $r \geq 1$[3]. Conversely, the calculated Tr statistics for "transport" was 52.345 and this points out the existence of one cointegrating relationship for the "transport" group between Peninsular Malaysia and Sabah. This may also reflect that consumer prices have disequilibrium relationship in both regions.

3.3 Gregory and Hansen Structural Break Test

In 1996, Gregory and Hansen provided an alternative estimation – the GH test – is based on the assumption of regime change with tests that provide a generalisation of the actual 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). [11] adjusted these alternative models in the cointegration ADF tests of [9], as well as the Z_t and Z_α tests of [23]. They estimated the values as per the equation below by assuming that the period of the change is unknown.

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

These residual-based tests for cointegration concentrate on obtaining an alternative hypothesis of one break in the cointegrating vector [11]. As the effectiveness of the [9] test is significantly minimize in the existence of a break in the cointegrating relationship, [11] extended the test to permit for breaks in either the "intercept" or the "intercept and trend" of the cointegrating relationship at an unspecified time. The GH test permits for testing the null of no cointegration of variables with $I(1)$ order in the existence of structural break in the cointegrating relationship due to the dismissal of cointegration with unknown break in the parameter.

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 %	
Transport	C	-8.507	2005M09	-97.535	2005M09	-8.537	2005M09	-5.13	-4.61	-4.34	Yes
	C/T	-8.889	2005M09	-102.95	2005M09	-8.920	2005M09	-5.45	-4.99	-4.72	Yes
	C/S	-9.186	2008M06	-107.47	2008M06	-9.219	2008M06	-5.47	-4.95	-4.68	Yes

(Note: The critical values are taken from Gregory and Hansen [1996])

The break points correlateto the point where the test statistic has the minimum value [24]. In this case, Table 4 shows that "transport" is cointegrated. Compared to the previous result which did not consider the presence of structural breaks, this result addressed the spurious aspect 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 endogenousl [19]. 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 existence 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 structural break incorporating ZA test and Perron test. Nevertheless, the outcome is slightly related to the previous findings.

For example, while "transport" is regarded as acointegrated group in Table 3, the results from the VEC (Appendix C) showed the presence 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 structural break. This is aligned with the cointegration of "transport" when the factor of structural break was incorporated into the test.

IV. DISCUSSION

The structural break tests indicated that most breaks happened in 2008. Thus, the discussion is categorised according to this different period.

4.1 Year 2008

The year 2008 can be characterised into two crucial parts of periods. In the first half of the year, global economies faced rapid inflationary constraintdue to the massive hike in prices of oil, food, and other commodities. This situation also intensified and escalate the disruption in the international financial markets and their negative effect on economic growth [8]. Advanced economies experienced reduced financial problems and hence, their investment funds shifted from mortgage securities and equities to commodities. This contributed to track high prices of oil and other commodities by the first half of the year followed by an increased cost-push inflationary coercion around the world [18].Global economic conditions experience a major transition in the second half of 2008 as the financial crisis diffuse into a systemic collapse. Subsequently, the escalation of the global financia turbulence and the emerging credit crunch had brought the major economies into a simultaneous recession since there were threats over inflationary force that emerged in the first half slide swiftly towards the menace of economic tightening [7]. As more open economies in Asia experienced export-led recessions by the end of the year, the spillover effects on the emerging economies were seen as more defined. On the other hand, growth in the other economies moderated sharply.

4.1.1 Overview of Inflation in 2008

"Food and non-alcoholic beverages" and "transport" groups have been recorded for 79.7 % of the total inflation in 2008. Extending to that, the "transport" group alone was averaged at 8.8%, which comprised of 25.9% of the whole inflation. Interestingly, even though there is a hike in global fuel prices, the domestic retail fuel prices were unchanged due to the action given by government such as subsidies. This had inevitably moderating the inflation of this group in the first half of the year Malaysian budget in 2009. Nevertheless, the inflation in this category had change its course due to the increase by 19.6 % due to the alteration to domestic retail fuel prices in June. The aftermath of the inflation was felt abruptly with a rapid hike to 7.7% in the same month by [5]. To counter this situation, and align with the fall in global fuel prices, the retail fuel prices had been revised for seven times, particularly between August and December in that year [5].

V. CONCLUSION

This paper studied the structural break issue in transportation prices between Peninsular Malaysia and Sabah from 2004 until 2015. For this study, unit root tests and the cointegration tests with structural breaks are employed. The purpose of this paper 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. Overall, in Malaysia, administered price mechanism was the key element that affected the transmission of inflation. The second group consists of items that need government authorization for price changes such as electricity tariff and public transport fares. The administered price mechanism functions to mitigate and delay the effect of supply shocks and external price developments on domestic prices. 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 [8]. 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 conductingthe GH structural break test that incorporated the structural break existence among the variables. Based on the findings, and similar to the Johansen test, the "transport" group was seen as cointegrated. The "transport" group cointegrationin the GH test can be related to the VEC result in Appendix C which shows that ECM coefficient value was positive. The short-run adjustment did not move towards the equilibrium relationship and thus, yielded divergence behaviour; this may suggest the structural break presence.

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28. APPENDICES

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

Variable	LCPITRANSSABAH	LCPITRANSPENS
Coint.Eq1 [ECM (t-1)]	0.239* [2.354]	0.625 [5.059]
D(LCPITRANSSABAH(-1))	-0.268 [-1.82995]	-0.069 [-0.38766]
C	0.000455 [0.384]	0.000241 [0.168]

[] indicates the t-stat value.