Sains Malaysiana 53(4)(2024): 953-967
http://doi.org/10.17576/jsm-2024-5304-17

Trend Behaviour of Malaysia Consumer Price Index: Evidence from National Database (2003-2022)

(Tren Tingkah Laku Indeks Harga Pengguna Malaysia: Bukti daripada Pangkalan Data Negara (2003-2022))

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Received: 15 August 2023/Accepted: 1 March 2024

ABSTRACT

The Consumer Price Index (CPI) is a general indicator used to measure price changes over time. The Malaysia CPI is published using a base year of 2010. This study aimed to identify the significant trend behavior in the Malaysia CPI series for the period 2003–2022. The main question of the paper is whether there exists any difference in trends between the main and overall CPI variables? If so, is the difference significant? If so, how strong or weak is the magnitude of its trend? This is analyzed empirically through five statistical analysis methods involving the serial correlation analysis, Mann–Kendall test, Mann–Kendall sequential test, Sen's-*T* test, and Sen's estimator. Overall, we conclude that there is a significant upward trend for 11 of the 13 variables, while two variables, which are Transportation and Communication, showed no significant monotonic trend. The results of this study provide insight into a better understanding of the behavioral trends of the CPI in Malaysia. This study can help policymakers to understand the importance of increasing expenditure into certain sectors in order to have better production and with this implementation, the trend of inflation rate can be better understood.

Keywords: Consumer price index; economic indicator; trend analysis

ABSTRAK

Indeks Harga Pengguna (CPI) ialah penunjuk umum yang digunakan untuk mengukur perubahan harga dari semasa ke semasa. CPI Malaysia diterbitkan menggunakan tahun asas 2010. Kajian ini bertujuan untuk mengenal pasti tingkah-laku arah aliran yang beerti dalam siri masa CPI Malaysia bagi tempoh 2003–2022. Persoalan utama kajian ini, adakah wujud sebarang perbezaan dalam arah aliran antara pemboleh ubah kumpulan utama dan keseluruhan CPI? Jika ya, adakah perbezaannya beerti? Jika ya, berapa kuat atau lemah magnitud arah alirannya? Ianya dianalisis secara empirik menerusi lima kaedah analisis statistik yang melibatkan analisis korelasi bersiri, ujian Mann–Kendall, ujian jujukan Mann–Kendall, ujian *T*-Sen dan penganggar Sen. Secara keseluruhan, kami simpulkan bahawa terdapat arah aliran meningkat yang ketara untuk 11 daripada 13 pemboleh ubah, manakala dua pemboleh ubah iaitu pengangkutan dan komunikasi tidak menunjukkan arah aliran ekanada yang ketara. Hasil kajian ini memberi gambaran dan pemahaman yang lebih baik tentang arah aliran tingkah laku CPI di Malaysia. Kajian ini membantu penggubal dasar memahami kepentingan meningkatkan perbelanjaan bagi sektor yang tertentu agar pengeluaran dapat dilaksanakan dengan lebih teratur supaya arah aliran kadar inflasi dapat difahami dengan lebih baik.

Kata kunci: Analisis arah aliran; indeks harga pengguna; penunjuk ekonomi

Introduction

The Consumer Price Index (CPI) can be used to measure the percentage change in purchase costs over time for a fixed basket of goods and services. As such, it can be employed to represent the average purchase pattern of a group of residents at a given time period. CPI can be used to calculate price changes over time and is very popular for measuring inflation rates around the world (Colombo 2013; Grytten 2020; Ongan, Işik & Özdemir 2017; Setyowati et al. 2019). In general, the CPI by

referring to the Laspeyres chain index method is based on internationally accepted standards and procedures (Dalén 1998). CPI weights reflect the importance of the household consumption of a set of consumer products at some period of time. Malaysia's CPI is published with a base year 2010 equal to 100. The items in the CPI basket of goods and services were classified into twelve groups based on the Classification of Household Goods and Services. There are three important steps used to calculate the CPI: calculating the cost of the CPI consumer basket at base year prices, calculating the cost of the CPI consumer basket at current year prices, and calculating the CPI for the base year and the current year.

Theoretically, CPI is an indicator for inflation. An increase in the price of goods generally indicates a corresponding increase in the CPI. According to Che Rose and Mutsamy (2020), a continuous increase in the price of goods causes a significant rise in the CPI and the rate of inflation. In this respect, the increased price of food (such as vegetables and chicken) is the direct effect of a lack of supply, which increases the cost of living. According to the Department of Statistics Malaysia (DOSM) (2022), an increase in the price of food was the biggest contributor to the overall weighted CPI for the year 2022. Thus, controlling the rate of inflation and achieving a stable economic state is important for all countries. According to Abdul Karim, Mod Asri and Wajdi (2006), a stable inflation rate is a sign of positive economic activity related to various aspects, such as efficient distribution of resources, strengthening of investment and consumption, incentive to save, strengthening of economic welfare, and the launching of national development programs. In the economic recovery phase, DOSM (2022) projected that the CPI in Malaysia would reach approximately 134.20 points in 2024.

The COVID-19 pandemic and the associated lockdown curfew caused a global economic downturn in certain sectors (Stiglitz & Guzman 2020) and Malaysia experienced moderate inflationary pressure due to low global oil prices (Maojun & Abdul Ghani 2020). According to the MIDF Amanah Investment Bank Bhd Research (2022), Malaysian inflation was predicted to be between 2.3% and 2.5% in 2023, if the status quo in the current fuel subsidy mechanism was maintained. However, the rate of inflation increased sharply at the end of September 2022 due to supply disruptions (particularly those of raw materials) in relation to Russia's invasion of Ukraine and the slow economic recovery following the COVID-19 pandemic. The increase in inflation experienced in the United States due to successive rate increases adopted by the Federal Reserve (FED) of the United States (US) also impact Malaysia's economy. However, the Public Investment Bank Bhd (PIVB) (2022) stated that increasing interest rates is an important step in curbing the continued increase in inflation in the US and inflation experienced in China is due to the zero-COVID-19 policy that caused the temporary closure of several important economic sectors.

The CPI generally measures the economic condition of a country as a whole with respect to inflation or deflation. For instance, the study by Che Rose and Mutsamy (2020) aimed to identify the impact of the increase in the price of goods on income and the level of survival, suggested measures to increase the savings of the population. Many other studies have used certain models to analyze the CPI in the United States or globally (de Haan & van den End 2018; Grinin & Korotayev 2018; Kitsul & Wright 2013). This paper will focus more on the effect or relationship of CPI sectors in Malaysia. Therefore, it is important to study the behavior of the price of goods as it increases, as this is uncertain and it causes CPI forecasts to change continually. In a similar vein, the pattern of consumer purchasing strategies has changed; for example, consumers might have become more careful about their expenditure, and they tend to spend only on daily necessities, such as food and shelter. This study focused on conducting a trend analysis of the Malaysia CPI based on the main variables listed in the Classification of Individual Consumption by Purpose from 2003 to 2022. Secondary data were obtained based on 12 main group variables: food and non-alcoholic beverages; alcoholic beverages and tobacco; clothing and footwear; housing, water, electricity, gas, and other fuels; decorations, appliances, and household maintenance; health; transportation; communication; services; education; restaurants and hotels; and miscellaneous goods and services. The overall variable refers to the index for all the variables of the main group combined. The study aimed to analyze behavior and identify trends in each of the main group variables and overall CPI in Malaysia. The statistical analysis methods used in this study were serial correlation, Mann–Kendall test, Sequential Mann–Kendall test, Sen's T test, and Sen's estimator.

THE IMPORTANCE OF TREND ANALYSIS ON CPI DATA

Trend analysis is important to describe about the CPI behavior over time. Particularly, in term of inflation

assessment, where trend analysis on CPI will provide an understanding corresponds to the direction and magnitude of inflation over time, providing insights into the general movement of prices for goods and services in an economy (Bryan, Cecchetti & O'Sullivan 2001; Clark & Garciga 2016). In fact, policymakers commonly refer to CPI trends in order to formulate and adjust monetary and fiscal policies (Eggertsson, Ferrero & Raffo 2014; Ferrero 2009). Thus, understanding inflation and CPI trends will guide decisions aimed at stabilizing prices and promoting economic stability. On the other hand, understanding CPI trends also helps the policy maker in adjusting fair wages that reflect changes in the cost of living (Gjelsvik, Nymoen & Sparrman 2020). Wage adjustments related to inflation is very important to sustain the real purchasing power of employees and strike a balance between economic conditions and business considerations. Trend analysis in CPI can provides an evaluation of changes in the cost of living over time for the purpose of providing information of individuals and businesses entity to understand how purchasing power is affected over time (Francis-Devine et al. 2022). Particularly for businesses entity, they commonly refer to CPI trend analysis to anticipate changes in consumer spending patterns (Kaplan & Schulhofer-Who 2017). This information is vital for pricing strategies, inventory management, and overall business planning. In fact, the information about CPI trends helps in identifying and managing inflation-related risks (Kitsul & Wright 2013; Konchitchki & Xie 2023). Based on the CPI trend behaviors, businesses entity and individuals can take proactive measures to mitigate the impact of potential future inflation. In summary, trend analysis for the CPI is crucial for assessing inflation, guiding policy decisions, understanding changes in the cost of living, and influencing wage adjustments.

MALAYSIA CPI DATA

This study used secondary CPI data provided by the Department of Statistics Malaysia (DOSM). The CPI national database was used because it is issued by the official source of the Malaysian government reported by DOSM. The data is accurate and easy to obtain. We expect the accuracy of the data from DOSM to be the same as the World Bank or other valid database platforms. In fact, national database offers local relevance, timeliness, policy formulation capabilities, custom indicators, data ownership, and historical context, providing a tailored and comprehensive understanding of a country's economic status compared to global databases like the World Bank. The data contain 13 variables comprising the total CPI index and 12 main sub-index group for the period of 2003-2022. Since this study was conducted to examine the annual trend of the CPI. Even though it is only 20 points of data, it represents 20 years of insight that is meaningful to evaluate as a medium-term trend for CPI behavior in Malaysia Table 1 shows the weights for the CPI sub-index variables with a base year of 2010. The formula for CPI computation is given as follows:

$$CPI = \frac{market\ basket\ cost\ in\ a\ given\ year}{market\ basket\ cost\ in\ the\ base\ year}, \qquad (1)$$

TABLE 1. Weighted Consumer Price Index (2010 = 100)

Basket of goods and services	Weighted (%)
Food and Non-Alcoholic Beverages (A)	29.5
Alcoholic Beverages and Tobacco (B)	2.4
Clothing and Shoes (C)	3.2
Housing, Water, Electricity, Gas and Other Fuels (D)	23.8
Decoration, Hardware and Household Maintenance (E)	4.1
Health (F)	1.9
Transportation (G)	14.6
Communication (H)	4.8
Recreational and Cultural Services (I)	4.8
Education (J)	1.3
Restaurant and Hotel (K)	2.9
Various Goods and Services (L)	6.7
Total	100

STATISTICAL METHODOLOGIES

This study conducted a time series analysis on 13 CPI variables shown in Table 1. As previously mentioned, the five statistical methods used to investigate trends in the CPI variables were: (1) Serial Correlation Effects; (2) Mann–Kendall Test; (3) Sequential Mann–Kendall Test; (4) Sen's T Test; and (5) Sen's estimator.

PEARSON SERIAL CORRELATION EFFECT

Serial correlation is a mixing effect that exists in time series data and it can affect the trends identified by the Mann–Kendall test. When data show a positive serial correlation value, a non-parametric test can suggest a significant trend in time series (Kulkarni & von Storch 1995). Therefore, Bayazit and Önöz (2007) suggested that 'pre-whitening' be conducted prior to using the Mann–Kendall test in a time series, to eliminate the effect of serial correlation. In this study, the time series data were analyzed to determine whether they contained a statistically significant trend ($x_1, x_2, \ldots, x_n$), and the lag-1 serial correlation coefficient (r_1) was first identified through the following equation.

$$r_1 = \frac{\frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - E\left(x_i\right)\right)\left(x_{i+1} - E\left(x_i\right)\right)}{\frac{1}{n}\sum_{i=1}^{n}\left(x_i - E\left(x_i\right)\right)^2}, \qquad (2)$$

where $E\left(x_i\right)$ is the mean of observed data. The significance of r_1 was then evaluated based on the following probability limit (Gocic & Trajkovic 2013):

$$r_1 = \begin{cases} \dfrac{-1 \pm 1.65\sqrt{n-2}}{n-1}, & \text{one-tailed test} \\ \dfrac{-1 \pm 1.96\sqrt{n-2}}{n-1}, & \text{two-tailed test} \end{cases} \qquad (3)$$

If the value of r_1 obtained was found to be insignificant at the 5% significance level, then the observed value of time series data can be used for the Mann–Kendall test without the pre-whitening process. However, if r_1 is found to be significant, the 'pre-whitened' time series needs to be obtained first, as $\left(x_2 - r_1 x_1, x_3 - r_1 x_2, \ldots, x_n - r_1 x_{n-1}\right)$, in prior to conducting the Mann–Kendall test.

MANN–KENDALL TREND TEST

The Mann–Kendall test is a technique used to evaluate trends in a time series (Kendall 1970; Mann 1945). The test has been widely used to test randomness against trends, especially in the fields of hydrology and climatology relating to temperature, rainfall, and trends (Tew et al. 2022) and prediction of COVID-19 (Shaharudin et al. 2021). This test is often used because it does not require data-related assumptions to be met. This test is a rank-based procedure, and it can be used even if the data variables are not normally distributed (Malik et al. 2020). In this study, the null hypothesis (H_0) was no trend is represented in the CPI data, which implies that the CPI data ($x_1, x_2, \ldots, x_n$) would be an independent and identically distributed. The alternative hypothesis H_1 for the two-sided test was that there would be a trend in the CPI and that the distribution of x_k and x_j would not be the same for all $k,j \leq n$ where $k \neq j$. The statistics for the Mann–Kendall test were determined from the S–statistic given as,

$$S = \sum_{k=1}^{n-1}\sum_{j=k+1}^{n} \operatorname{sgn}\left(x_j - x_k\right), \qquad (4)$$

where n is the number of time series observations, and the *sgn* function is determined as

$$\operatorname{sgn}\left(x_j - x_k\right) = \begin{cases} +1 & if \quad \left(x_j - x_k\right) > 0 \\ 0 & if \quad \left(x_j - x_k\right) = 0 \\ -1 & if \quad \left(x_j - x_k\right) < 0 \end{cases} \qquad (5)$$

Furthermore, the variance of the S-statistic is given as

$$Var\left(S\right) = \frac{\left[n\left(n-1\right)\left(2n+5\right) - \sum_{i=1}^{m} t_i\left(t_i-1\right)\left(2t_i+5\right)\right]}{18}, \qquad (6)$$

where m is the number of groups that can be detected in the dataset; and t_i is the number of data points in the i-th group. Based on the S-statistics, the Mann–Kendall statistics, which are known as the Z_s-statistic, were computed as follows

$$Z_s = \begin{cases} \dfrac{s-1}{\sqrt{Var\left(S\right)}}, & if \quad S > 0, \\ 0, & if \quad S = 0, \\ \dfrac{s+1}{\sqrt{Var\left(S\right)}}, & if \quad S < 0, \end{cases} \qquad (7)$$

where a positive Z_s-statistic value indicates upward trends in the observed data, and a negative value Z_s-statistic

indicates downward trends. In the two-way Mann–Kendall test for trend, H_0 is accepted if $|z| \leq z_{\alpha/2} = 1.96$ at the 0.05 significance level. Furthermore, a positive S value indicates an upward trend, and a negative S value indicates a downward trend. In this test we examined the trends of both the main group variables and the overall trend of the CPI.

SEQUENTIAL MANN–KENDALL TEST

The trend detection information provided by the Mann–Kendall method generally does not give a complete structure of the trend picture for the whole series. This is because there might be fluctuations in the trend over the whole period (Rahman, Yunsheng & Sultana 2016). Thus, to overcome this issue, the Mann–Kendall sequence test can be conducted to determine the starting point of the existence of a downward or upward trend or any changing point in the trend of a time series (Hirsch & Slack 1984; Moraes et al. 1998). Sequential values for $u(t)$ and $u'(t)$ were determined sequentially from the progressive analysis of the Mann–Kendall test to determine the change in the trend direction over time. In this respect, $u(t)$ is a standardized variable with a mean of zero and one standard deviation, and its sequential behavior fluctuates around the zero level. The value of $u(t)$ is equal to the z-value found from the first to the last data point. This test considers the relative value of all terms in the time series $x_1, x_2, \ldots, x_n$. The sequential Mann–Kendall test can be conducted using the following procedures (Zhao et al. 2015):

1. The magnitude of the mean x_j for the annual time series, $j = 1,\ldots,n$ is compared with the mean magnitude x_k, $k = 1,\ldots,n$. At each comparison, the number of cases where $x_j > x_k$ are determined and labeled as n_j.

2. The t-statistic is then calculated through the following equation

$$t_j = \sum_{1}^{j} n_j, \quad for \quad j = 2,3,\ldots,n \tag{8}$$

3. The mean and variance of this t-statistic are:

$$E(t) = \frac{n(n-1)}{4} \tag{9}$$

$$Var(t_j) = \frac{[j(j-1)(2j+5)]}{72}. \tag{10}$$

4. The sequence value for the statistic $u(t)$, which is defined as a forward sequence, can be obtained through the following equation:

$$u(t) = \frac{t_j - E(t)}{\sqrt{Var(t_j)}}, \tag{11}$$

SEN'S SLOPE AND TEST

Sen's-T test is a non-parametric test and a linear rank method in which the first procedure eliminates the block effects for each datum data point. The data are then summed over the blocks, and the test statistics are finally produced. This test is not affected by the effect of trend fluctuations (Sen 1968a). The test statistics are calculated as follow;

$$T = \left[\frac{12m^2}{n(n+1)\sum_{i,j}\left(R_{ij} - R_j\right)^2}\right]^{1/2} \left[\sum_{i=1}^{n}\left(i - \frac{n+1}{2}\right)\left(R_i - \frac{nm+1}{2}\right)\right]. \tag{12}$$

where n is the number of years; m is the number of blocks; and R is a ranks for differences of each data point corresponds to each block. Under the null hypothesis that there is no trend, the T-test statistic follows a standard normal distribution $N(0,1)$. If the value of T is larger than z_α=1.645 at the 0.05 significance level $(|T| > z_\alpha)$, then, the null hypothesis is rejected and there is strong evidence of a trend within the time series. A positive value of the T-test statistic indicates an upward trend, while a negative value of the T-test statistic indicates a downward trend.

Although the existence of trend behaviors and their direction can be determined from the Mann–Kendall test, the test does not show the magnitude of the trend. Therefore, the Sen's estimator was run to predict the magnitude of a trend in time series data. If there is a linear trend in the time series, then, the true slope (change per time unit) can be estimated using the simple non-parametric procedure developed by Sen (1968b) through the following equation:

$$Q_i = \frac{x_j - x_k}{j - k}, \quad for \quad i = 1,2,\ldots,N, \tag{13}$$

where x_j and x_k are the data value at time j and $k(j>k)$, respectively. The values of Q_i will be ranked increasingly and the median of Sen's slope estimator can be obtained as

$$Q_{med} = \begin{cases} Q_{\left[(N+1)/2\right]}, & \text{if } N \text{ is odd} \\ \dfrac{Q_{\left[(N/2)\right]} + Q_{\left[(N+2)/2\right]}}{2}, & \text{if } N \text{ is even} \end{cases} \quad (14)$$

The Q_{med} value indicates the steepness of the trend, while its sign indicates the data trend reflection. *100(1-α)%* confidence interval for Sen's slope can be determined as follow

$$C_\alpha = Z_{1-\alpha/2}\sqrt{Var(S)}, \quad (15)$$

where the upper and lower limits of the confidence interval are:

$$Q_{lower} = \frac{N - C_\alpha}{2}, \quad (16)$$

$$Q_{upper} = \frac{N + C_\alpha}{2}. \quad (17)$$

The confidence interval provides information about whether the median of the Sen slope is statistically different from zero and if the upper and lower limits have a similar sign (Gocic & Trajkovic 2013).

Results and Discussion

Figure 1 shows the trend for the total annual CPI data in the period 2003–2022. The figure clearly indicates that the CPI undergo a significant increasing trend in Malaysia. This scenario could be caused by parallel scenarios in the main sub-categories, which indicate increasing trends over the period. As shown in Figure 2, ten of the Malaysia CPI categories were found to show increasing trends, which are food and non-alcoholic beverages; alcoholic beverages and tobacco; housing; water; electricity, gas, and other fuels; decoration, hardware, and household maintenance; health; transportation; recreational and cultural services; education; restaurants and hotels; and various goods and other services. This indicate that an inflation affects the CPI by causing a general increase in the prices of goods and services, reflected in the CPI as higher costs for the representative basket of items, leading to a rise in the overall index value. Thus, this scenario may be caused by various factors, such as the increase in inflation, directly effects the price of most goods and products. The effect of the inflation rate implies the spillover effect, particularly on production cost, which directly effects an increase in price for consumers. On the other hand, the changing behaviors of supply and demand are also a main factor that influences the increase of the CPI index for those sub-categories in line with the increase in population. The amount of demand increases higher than the amount of supply, which generally leads to an increase in the price. Other important factors that influence the increase for those sub-categories of CPI in Malaysia are import cost and income level. Therefore, the increase in CPI is greatly affected when the national currency is weak especially if the cost of goods are controlled by foreign countries. Apart from this, economic growth and the increasing level of income of Malaysians also leads to a shift in consumer preferences toward higher-priced products.

Based on Figure 2, only two sub-categories which are clothes/shoes and communication sector showed decreasing trends of CPI over the period. This scenario also depends on various factors such as globalization and trade policies that are more friendly. In fact, Malaysia is a country that generally embraced globalization for the purpose to drive economic growth and development (Budhwar & Fadzil 2000). In a similar vein, Malaysia also has actively pursued policies to liberalize trade, attract foreign investment, and integrate into global supply chains (Arudchelvan & Wignaraja 2016; Tham & Loke 2011) that actively welcomes friendly and fair policy (Hj Ridzuan et al. 2021). Therefore, many textile and telecommunications industries have expanded their business in Malaysia. The growth rate of textile and clothing in Malaysia GDP reached 93.6% in 2021 with textile exports increase more that import is one of the reasons in decreasing trends in CPI (Farhana, Mahamude & Mica 2022). In a similar vein, an increase in competitive markets related to textile and telecommunications companies also caused the price of goods for this category to decrease over time. The cost of producing textile depends heavily on the country and there is a promising opportunity for renewable energies being used in Malaysia precisely solar energy to reduce the production cost (Farhana, Mahamude & Mica 2022). This scenario also leads to cost efficiencies which implies a lower price for consumers. In addition, another important factor that causes decreasing trends for textile industries is the emergence of online shopping platforms and also the improvements in terms of logistics and supply chain management systems in Malaysia. In particular, the emergence of online shopping platforms significantly improved the logistics and supply chain management system in Malaysia because online shopping

platforms facilitate streamline the distribution process by enabling direct-to-consumer shipments. Thus, it reduces the need for intermediaries and can lead to more efficient delivery routes (McKee et al. 2023).

Based on the trend behaviors of CPI categories in Figures 1 and 2, this study investigates the Malaysian CPI behaviors further to determine whether the trends indicated by each CPI sub-categories are significant or not.

Table 2 shows the results of the serial correlation effect based on the observed CPI time series data. The majority of the variables are seen to have a *p*-value of zero which indicates a strong evidence and concludes that all the variables have a significant linear relationship. In fact, the rho-value for each variable is significantly close to 1, which concludes that there is a linear relationship within the CPI time series data because they are correlated with the previous time lag.

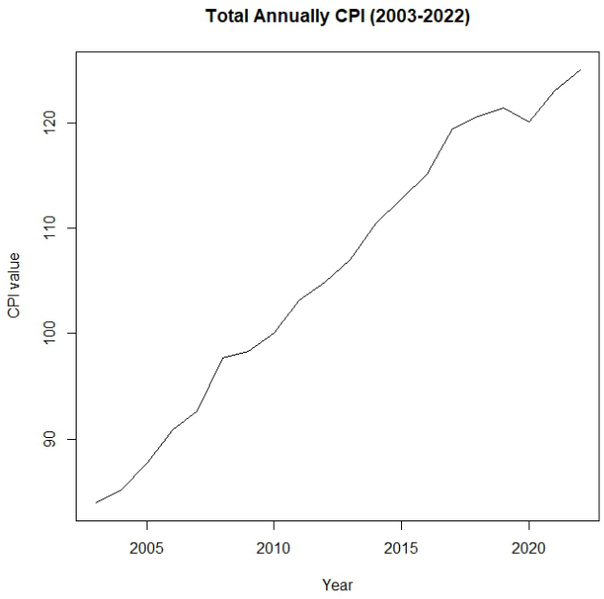

FIGURE 1. Total CPI trend for the years 2003–2022

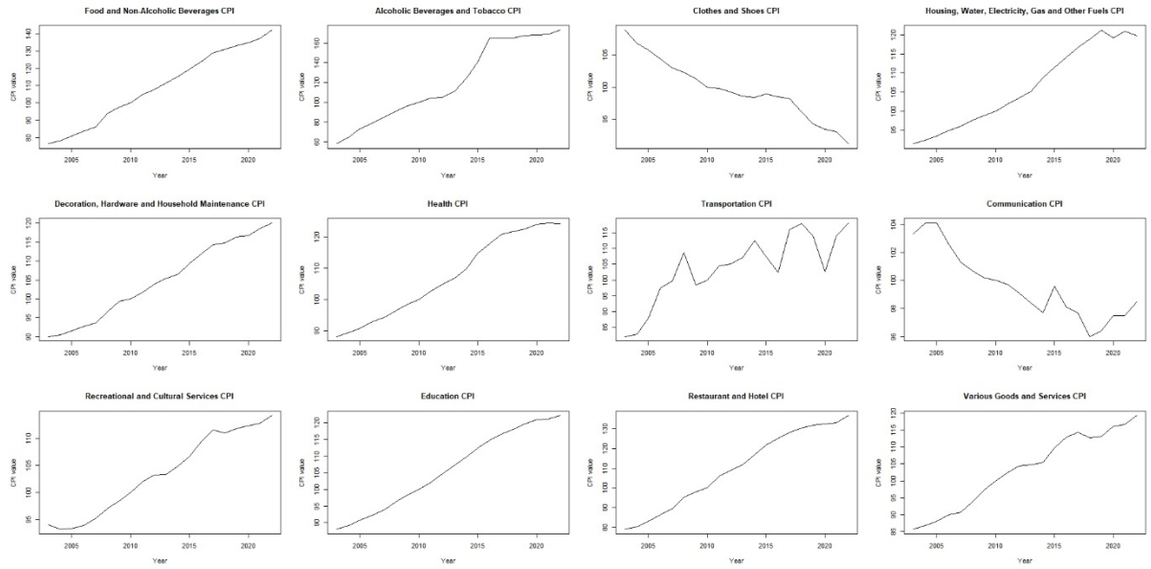

FIGURE 2. Trends of 12 main categories in the CPI index for the years 2003–2022

To support these results, autocorrelation (ACF) plots were compiled for the total CPI and its main sub-categories, and the results are shown in Figures 3 and 4, respectively. Each variable indicates a dependency behavior to its previous lag-time up to three years before. This scenario implies that a pre-whitening process should be conducted prior using the Mann–Kendall test to eliminate the effect of serial correlation found in the time series (Bayazit & Önöz 2007).

TABLE 2. Serial correlation effect

Variable	Rho value	z-statistic	*p*-value
Total CPI	0.9914	82.3855	0.0000
Food and non-alcoholic beverages	0.9929	99.6391	0.0000
Alcoholic beverages and tobacco	0.9876	58.1125	0.0000
Clothes and shoes	0.9901	70.3996	0.0000
Housing, water, electricity, gas and other fuels	0.9896	69.4046	0.0000
Decoration, hardware and household maintenance	0.9923	91.7945	0.0000
Health	0.9920	88.9168	0.0000
Transportation	0.8416	6.1200	0.0000
Communication	0.9231	12.9476	0.0000
Recreational and Cultural Services	0.9895	68.6971	0.0000
Education	0.9933	105.7363	0.0000
Restaurant and hotel	0.9925	94.0867	0.0000
Various goods and other services	0.9900	71.0802	0.0000

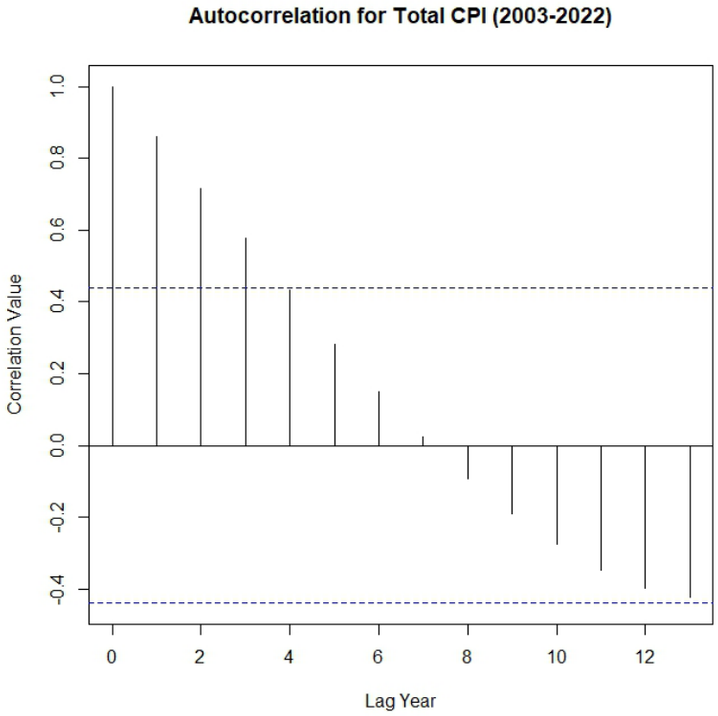

FIGURE 3. ACF plot for total CPI (2003–2022)

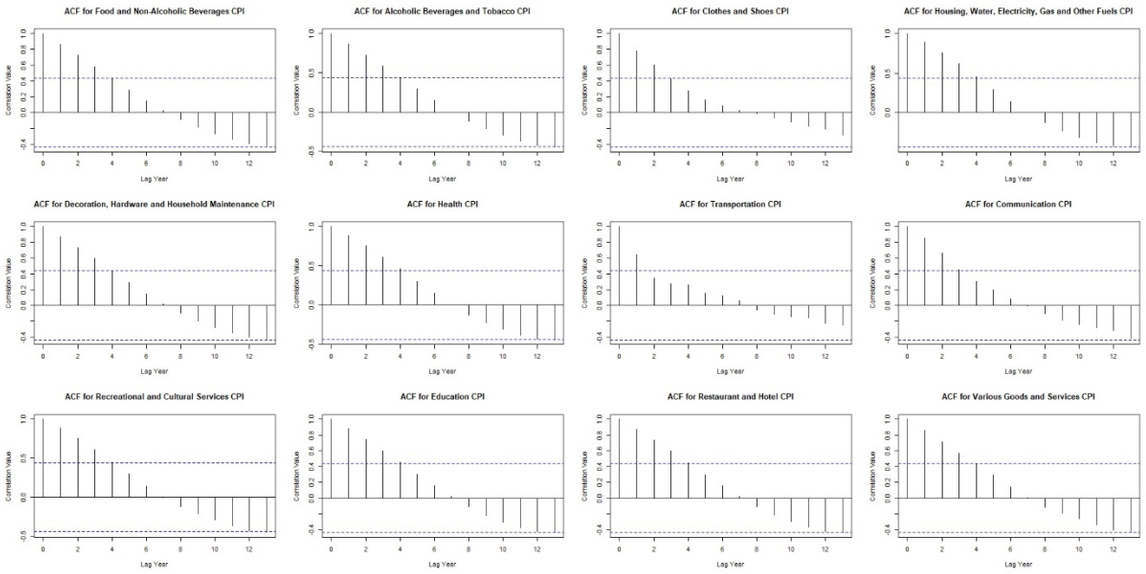

FIGURE 4. ACF plot for main sub-categories in CPI index (2003–2022)

Table 3 shows the results of the Mann–Kendall test following data pre-whitening. Based on Table 3, the variables 'transportation' and 'communication' show no significant trends with *p*-values of 0.2889 and 0.4487, respectively. This shows that the spending on 'transportation' and 'communication' sectors did not change much. 'Transportation' shows little positive since it is not necessary for individual to change transportation yearly and gasoline were subsidized by the government and low global oil price thus show no significant monotonic trends on the price of transportation (Ramli 2002). A different perspective was applied to 'communication variable as it includes telephone equipment and service. Even though the demand for equipment increases but the advancement in technology reduce the cost of management and operation and price of equipment imply no significant negative monotonic trends based on S-value (Sek et al. 2023). Only 'clothes and shoes' shows a significant downward trend corresponding to its negative S-value of −85 while all other variables show significant upward trends in relation to their positive S-values. Most of the variables that shows significant upward trends were affected from multiple reasons such as more import for these services such as 'food and non-alcoholic beverages', and in 'health' as import of medical equipment especially during COVID-19 as the general equipment were not enough. Other variables such as restaurant and hotel, services, and housing, water, electricity, gas and other fuels were secondary impacted especially by the 'food and non-alcoholic beverages'.

Table 4 shows the year in which the trend began to be detected in the annual CPI series, as determined using the sequential Mann–Kendall test, where the variables 'Transportation' and 'Communication' were excluded from analysis, due to the lack of significant trend in these series. The results of the successive Mann–Kendall test clearly show the significant change points for the 11 CPI variables. The sequence values for $u(t)$ and $u'(t)$ were both obtained from the Mann–Kendall rank correlation analysis. In the plots shown in Figures 5 and 6, $u(t)$ is represented by the solid line corresponding to a prograde series, while $u'(t)$ is represented by the dashed line corresponding to a retrograde series.

As shown in Figure 5, the change point in the 'total CPI' variable is in 2003, which is evident from the upward trend in the $u(t)$ curve that continues until 2022, while the $u'(t)$ curve shows a decreasing trend from 2003 to 2019. The intersection point of the two curves is the change point detected using the Mann–Kendall test. The change point of 3.970 detected in 2012 is statistically significant with *p*-value is 0.0015. Therefore, it can be concluded that the total CPI having a significant upward trend began in 2012 and continued until 2022.

TABLE 3. Mann-Kendall test after pre–whitening

Variable	*p*	Z-statistic	S-statistic	Tau value
Total CPI	0.001464*	3.1817	85	0.5556
Food and non-alcoholic beverages	0.000016*	4.3181	115	0.7516
Alcoholic beverages and tobacco	0.000652*	3.4090	91	0.5948
Clothes and shoes	0.001464*	-3.1817	-85	-0.5556
Housing, water, electricity, gas and other fuels	0.000031*	4.1665	111	0.7255
Decoration, hardware and household maintenance	0.000059*	4.0150	107	0.6993
Health	0.000112*	3.8635	103	0.6732
Transportation	0.288883	1.0606	29	0.1895
Communication	0.448718	-0.7576	-21	-0.1373
Services	0.001464*	3.1817	85	0.5556
Education	0.000022*	4.2423	113	0.7386
Restaurant and hotel	0.003132*	2.9545	79	0.5163
Various goods and other services	0.006388*	2.7272	73	0.4771

*significant at the 5% significance level

TABLE 4. Detection of change points using the Sequential Mann–Kendall test

Variable	Trend	Change Points (year)
Total CPI	Increasing	2012
Food and non-alcoholic beverages	Increasing	2013
Alcoholic beverages and tobacco	Increasing	2013
Clothes and shoes	Decreasing	2012
Housing, water, electricity, gas and other fuels	Increasing	2012
Decoration, hardware and household maintenance	Increasing	2013
Health	Increasing	2013
Transportation	Increasing	2013
Communication	Increasing	2010
Recreational and Cultural Services	Increasing	2012
Education	Increasing	2012

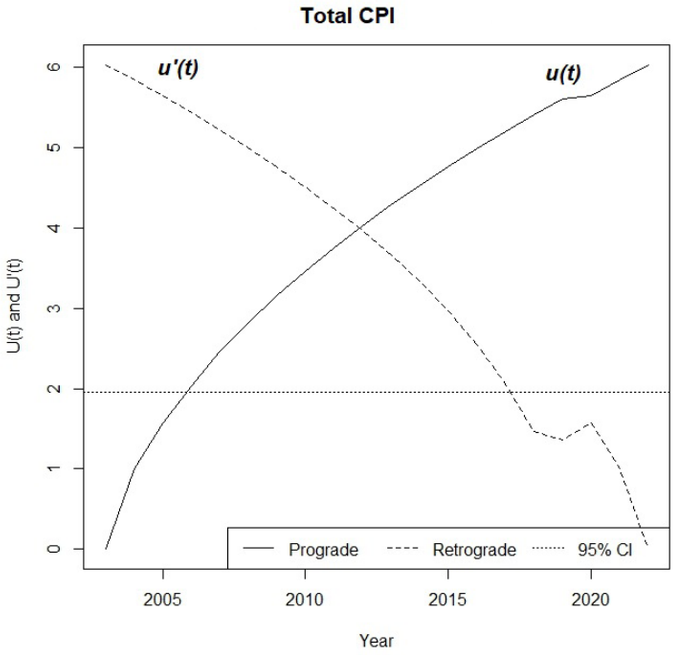

FIGURE 5. Change point plots based on Mann–Kendall sequential test for total CPI

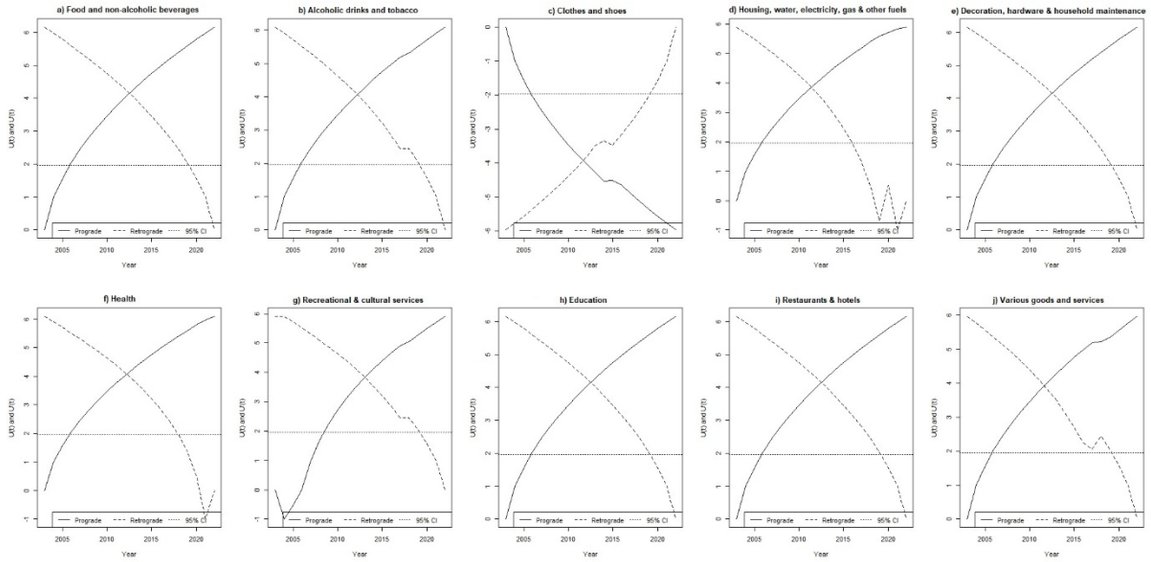

FIGURE 6. Change point plots for total main CPI sub-categories

The same analysis was then repeated for all of the sub-indices of the CPI variables. As shown in Figure 6, the $u(t)$ curve for all variables except 'clothes and shoes'. The $u'(t)$ curve for 'food and non-alcoholic beverages' shows a decreasing trend that began in 2003 and continued until 2022 (Figure 6(a)) with a change point occurred within the period of 2012 and 2013, where the $u(t)$ values are within 3.4641 and 4.7586, which are significant statistically with a p-value equal to 0.000016. Therefore, the variable 'food and non-alcoholic beverages' also shows a significant upward trend starting in 2012 and continuing to 2022. Next, the intersection between the $u(t)$ curve and the $u'(t)$ curve for 'alcoholic drinks and tobacco' in Figure 6(b) represents the change point detected in 2012 with a value of 4.0249 which shows a significant upward trend that began in 2012 and continued to 2022. However, the $u(t)$ curve point plot shows a decreasing trend for the variable 'clothes and shoes', in Figure 6(c), while the $u'(t)$ curve shows an increasing trend, with the intersection point detected in 2012 at −4.5257 is significant with a p-value of 0.0015 shows a significant downward trend that began in 2012 and continued until 2022.

For 'housing, water, electricity, gas, and other fuels', the change point of 4.5258 was detected in the year of 2012, in which Figure 6(d) shows a significant upward trend that began in 2012 and continued until 2022. Figure 6(e) shows the change point plot for the variable 'decoration, hardware, and household maintenance', where the intersection points occur within the years 2012 and 2013, and the change points detected within the range of 4.5257 and 4.7587 are statistically significant shows a significant upward trend from 2012 to 2022. Figure 6(f) shows the 'health' variable where the $u(t)$ curve and the $u'(t)$ curve cross each between 2012 and 2013 with change points at a range of 4.5257 and 4.7587 and a p-value equal to 0.0001. Therefore, the variable 'health' shows a significant upward trend that began in 2012 and continued until 2022. The change point plot for the variable 'recreational and cultural services' is where the $u(t)$ curve and the $u'(t)$ curve cross each other in 2012 with a change point with a $u(t)$ value of 3.7029 is detected, shows a significant upward trend from 2012. Figure 6(g) shows change point plots for the variable 'education', where the intersection point between the $u(t)$ curve and the $u'(t)$ curve shows intersecting points between 2012 and 2013, showing a significant upward trend that began in 2012 and continued until 2022. Figure 6(i) shows the change point plot detected for the variable 'restaurants and hotels' between two change points between 2012 and 2013 with values of 4.5257 and 4.7587 which are significant with a p-value of about 0.0031shows a significant upward trend beginning in 2012. Likewise, Figure 6(j) shows the plot of the change point for the variable 'various goods and services', where the $u(t)$ curve shows an upward trend while the $u'(t)$ curve shows a downward trend that began in 2003 and continued until 2022. The intersection point between $u(t)$and $u'(t)$ occurred in 2012, and the change point detected at 4.5257 is significant shows a significant upward trend starting in 2012.

To investigate further, Table 5 shows the Sen-T test results, which were found to agree with the other analyses conducted in this study. Based on Sen's-T test, it can be seen that all variables except 'clothes and shoes' and 'communication' show significant upward trends,

TABLE 5. Results on Sen-T test

Variable	T statistic	p-value
Total CPI	5.8076	6.34E-09
Food and non-alcoholic beverages	5.9475	2.72E-09
Alcoholic beverages and tobacco	5.8776	4.16E-09
Clothes and shoes	-5.7376	9.60E-09
Housing, water, electricity, gas and other fuels	5.8076	6.34E-09
Decoration, hardware and household maintenance	5.9475	2.72E-09
Health	5.9475	2.72E-09
Transportation	3.9884	6.65E-05
Communication	-5.0822	3.73E-07
Recreational and Cultural Services	5.6677	1.45E-08
Education	5.9475	2.72E-09
Restaurant and hotel	5.9475	2.72E-09
Various goods and other services	5.7376	9.60E-09

whereas 'clothes and shoes' with a *t*-statistic of −5.7376 and 'communication' with a *t*-statistic of −5.0822 show a significant decreasing trends. In addition, Table 6, explains the result of the change of each unit of time in a year for the direction of the detected trend. For the negative trend direction, the lowest gradient value was calculated for the variable 'clothing and shoes' with a value of −0.7333 years. All variables except 'clothes and shoes and communication show positive trends because the Q_{med} value obtained is positive, whereas 'clothes and shoes' and 'communication' show negative trend because the Q_{med} values obtained (−0.7333 and −0.4250) are negative.

TABLE 6. Results on Sen's estimator

Variable	
Total CPI	2.4125
Food and non-alcoholic beverages	3.6778
Alcoholic beverages and tobacco	6.4667
Clothes and shoes	-0.7333
Housing, water, electricity, gas and other fuels	1.8068
Decoration, hardware and household maintenance	1.7375
Health	2.1996
Transportation	1.6000
Communication	-0.4250
Recreational and Cultural Services	1.2857
Education	2.0600
Restaurant and hotel	3.4714
Various goods and other services	1.8800

Conclusion

This study used five different statistical methods to analyze the trend behavior CPI variables in Malaysia. The Mann–Kendall test, Sequential Mann–Kendall test, Sen's T test, and Sen's estimator were used to analyze the annual trend of CPI in Malaysia for the year 2003 until 2022, and the effect of serial correlation was also analyzed. The results of the study identified that ten out of 13 variables showed a significant upward trend. The variables such as 'clothing and shoes' showed a downward trend while 'transportation' and 'communication' showed no trend based on the Mann–Kendall test.

Sen's estimator identified that 11 out of the 13 variables showed a statistically significant upward trend. The results of the analysis found that a change point began in 2012 for 'total', 'alcoholic beverages and tobacco', 'housing, water, electricity, gas, and other fuels', and 'various goods and services', showed increasing trends, whereas 'clothing and shoes' showed a decreasing trend. An upward turning point was detected in 2013 for 'services', and 'food and non-alcoholic beverages', 'decoration, hardware, and household maintenance', 'health', 'education', whereas 'restaurants and hotels' showed two turning points in 2012 and 2013. This study found that almost all of the 12 main groups showed positive trends that caused an increase in the total CPI. The results of the Mann–Kendall test and Sen's T test were similar, and both gave the same results for variables that experienced a significant upward trend.

This study is useful for the government and policymakers to understand whether the sectors are local or global may determine the effectiveness of the policy. Most of the sectors show an upward trend expect 'clothing and shoes' that result in increase in inflation rate. This

might be based on the impact that Malaysia import more items that makes the cost of goods to be less controllable. Economists and policymakers can use this result to achieve price stability by looking into more details the sectors that we can produce on our own.

ACKNOWLEDGEMENTS

The authors are indebted to the Department of Statistics Malaysia for providing the Consumer Price Index (CPI) data. This research would not be possible without the sponsorship from the Universiti Kebangsaan Malaysia (Grant number GP-K020446).

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