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EXAMINING THE NEXUS OF INFLATION-GROWTH: THE CASE OF MALAYSIA

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Abstract: The theory of the Phillips curve posits a trade-off nexus between inflation and growth where high inflation stimulates higher economic growth by reducing the unemployment rate. The nexus has been debated without coming to a consensus. Hence, this study extends the examination of the two-way nexus by using Markov-switching dynamic regression (MS-DR) for the case of Malaysia for the period from 1960 to 2019. The study also seeks to identify other determinants that contribute to economic growth in Malaysia. The results detected the existence of a trade-off relationship in the two-way gross domestic product (GDP)-inflation nexus when GDP is at a low regime and inflation is at a high regime respectively. This implies that the effort of policymakers to achieve low inflation and high GDP cannot be achieved together, as the achievement of one target would come at the expense of the other target. Hence, high inflation rates and low GDP levels are not desired economic regimes. Moreover, the output gap does not influence the inflation rate, but inflation might affect the output gap and GDP. Government expenditure and gross capital formation are the main factors that contribute to higher GDP. The policymaker should monitor price stability and stimulates economic growth through monetary and fiscal policy actions.

Keywords: Inflation, output growth, trade-off, Phillips curve, Malaysia.

Introduction

There has been discussion over the association between inflation and economic growth for a long time. The inflation-growth relationship acts as a fundamental aspect underlying economic approaches as it shows the way and the influence of inflation on the economy. The comprehension of this linkage also delivers guidelines for policy decisions and vital information on monetary policy formation. The aims of macroeconomic policy are high economic growth and low inflation. However, the debate on the coexistence of this relationship remains open. Difference perspectives of thought provide diverse evidence on the nature and causes of inflation. As claimed by Temple (2000), there is a considerable collection of theoretical and empirical research on the nature and existence of an inflation-growth linkage.

Price stabilisation is an essential policy goal for any central bank, and it may be attained by managing the inflation rate. Moreover, central banks seek to undertake monetary policy by keeping inflation as low as possible. However, the Phillips curve theory assumes a negative link between inflation and unemployment, which means that a higher inflation rate is linked to lower unemployment level and vice versa. As high economic growth generates more jobs, hence lower unemployment, this theory also implies a positive link between inflation and economic growth, which means that a higher inflation level is associated with higher economic growth and vice versa. Hence achieving a low inflation rate is only attainable when the unemployment rate is high or economic growth is low. It leads to a dilemma for the central bank since lower inflation and higher growth and lower unemployment cannot be achieved at the same time. This means that reduced inflation comes at the expense of higher economic growth.

Besides the theoretical debates, the presence of the nonlinear inflation-growth connection can also be examined in empirical studies. Given the previous theories and debates, this study continues the investigation of the two-way inflation-growth and inflation-output gap nexus in the context of Malaysia through a nonlinear two-regime Markov-switching (MS) model, from 1960 to 2019 with the quarterly datasets. Some of the other factors that are believed will affect the relationship will also be included in this study to test their impacts on the nexus. Low inflation and sustainable economic growth are the main features of Malaysia's economy in recent years. Inflation will affect the economy of a country in various ways, either positively or negatively. For example, Mallik and Chowdhury (2001) discovered a positive inflation-growth association. Despite the presence of a negative inflation-growth relationship is confirmed in numerous previous studies, the cause-and-effect relationship between them is controversial.

With its successful economic and social development, Malaysia is now forging ahead to become a developed nation. Malaysia is also known as an upper-middle-income country. It is crucial to identify the exact relationship of the determinants with economic growth and inflation in the case of Malaysia for a better understanding of a nation's economy. However, the sources of study on the nexus between inflation-growth in the case of Malaysia are quite limited. Therefore, this study examines the effect of inflation on economic growth in Malaysia, along with other determinants such as gross capital formation, population ages, broad money and government expenditure. Thus, it would be interesting if we can analyse the exact linkage between inflation and economic growth in Malaysia appropriately in this study. It might provide a clearer view of the economic condition in Malaysia for future researchers.

Moreover, previous studies employed various methodologies in the study of the nexus of inflation-growth, mainly focused on the linear regression approach. This leads to inaccurate results if the real relationship is nonlinear. However, rather than focusing on the linear model, we examine the relationship using a nonlinear model, which is the MS model. The nonlinear formats can show the asymmetric effects of explanatory variables on the dependent factor. Additionally, the MS model enables results to be interpreted under high versus low regimes, the probability transition across regimes and also the expected duration in each regime. Furthermore, this study includes a few economic regressors to be examined in the nexus of inflation-growth which is seldom found in previous studies. This enables in–depth information to be revealed on the inflation-growth link. This study will also provide a comparison between four economic equations to reveal the existence of other control variables on the connection between inflation and growth.

Five sections follow the introduction section. Specifically, the next section delivers a background study of the economy in Malaysia concerning the economic history during the previous years which is related to the inflation-growth nexus. This is followed by a brief discussion of previous studies with different approaches by precursory researchers. Then, there is a detailed explanation of the data and methodology employed in this study. It is followed by the results and discussions. Finally, there is a concluding remark on this whole study.

Background Study of Malaysia

Malaysia is one of the Association of Southeast Asian Nations (Asean) most advanced nations. In Southeast Asia, Malaysia's economy is the fifth largest in terms of GDP (International Monetary Fund, 2022). In Malaysia, 1973 and 1974 were exceptional years in the history of inflationary experiences. In 1973, inflation increased in both the domestic and international markets. In the early 1970s, Malaysia had a single-digit value of inflation at merely 2%, with GDP growing at the rate of nearly 7%. Throughout the second half of the 1970s, the GDP growth rate stayed constant, while the inflation rate rose to 4%. The significant increase in oil prices was the primary cause of the acceleration of global inflation in the 1973to 1974 period. Therefore, Malaysian consumer prices started to soar, peaking at 10.62% by the end of 1973. In 1974, the increase in oil price by more than 230% added powerful fuel to the inflation rate, resulting in a record high inflation rate of 17.32%. After one year, the Malaysian economy entered a recession, with the GDP growing only 0.8% in 1975, contrasting with the 8.3% in 1973 and 11.7% in 1974. The inflation rate declined to 4.5% in 1975.

Due to external factors, Malaysia had a second phase of high prices during in 1980 and 1981. Oil prices grew by 47% in 1979 and 66% in 1981. Industrial raw materials and investment products prices rose considerably as well. Thus, the inflation rate in 1981 increased to 9.62% as much as 6.02% as compared with 3.6% in 1979. Furthermore, the GDP declined to 6.9% in 1981 while the GDP in 1979 was at 9.3%. The growth of the Malaysian economy was at a critical crossroads in 1985 as the inflation rate kept decreasing from 1982 to 1986. The economic performance slumped into its greatest recession in 1985 and 1986, which recorded -1.1% and 1.1% growth rates, respectively.

Even though the inflation rate increased, on average to 3.9% only during the period from 1991 to 1996, the GDP growth rate increased continuously and achieved 9.6%. Malaysia has been implementing a managed floating exchange rate following the Asian Financial Crisis in 1997and 1998. Prices of goods and services, fuel prices and interest rates have all risen since the financial crisis erupted. Strong foreign demand because of the Malaysian Ringgit's (RM) over 40% depreciation has put Malaysia under tremendous inflationary pressure. However, the government immediately fixed the country's currency to the US dollar at US$1to RM3.80 on September 2, 1998and it controlled some of the effects of the inflation in Malaysia.

Following the Asian financial crisis, there was a severe negative growth rate, at was -7.35%, in late 1998. Notwithstanding, Malaysia had the fastest recovery rate among Asian countries in 1999. Malaysia's inflation rate was exceptionally low in the early 2000s because of supply and demand pressures in the 1990s. Nevertheless, the rate of inflation climbed up in 2005 and achieved a high p% of 5.4 in 2008. Malaysia was also dealing with an inflation rate that had risen from 2.1 % to 3.1% in 2014. The rate of inflation was predicted to be 2.4% by the end of the quarter in the following years, based on Trading Economics global macro models and expectations (Laporan Ekonomi 2012/2013).

After the implementation of the goods and service tax (GST) by the Malaysian government in 2015, the Malaysian people opine that this implementation had a negative impact on society and provoked inflation because Malaysia is highly reliant on domestic consumption. As such, the consumer domestic market shrunk due to the goods and services tax (GST) and resulting inflation. It may also cause a negative impact on investment in Malaysia.

Literature Review

Theoretical Review

The link between inflation and economic growth is significant in macroeconomics and monetary policy analysis. Although the inflation-growth connection has been widely examined, its precise nature remains unclear. The results of the direct association are not consistently found in the existing studies (Akinsola & Odhiambo, 2017). The achievement of strong and sustained output growth and ideal inflation are the ultimate targets of macroeconomic policymakers as they are required to monitor the inflation's complicated behaviour and composition of output (Blanchard *et al.*, 2010).

Some economic theories have significant contributions to the association between inflation and economic growth, namely Classical, Keynesian, Neo-Classical, Neo-Keynesian and Endogenous growth theories.

Classical growth theory is an economic theory represented by economists during the Industrial Revolution. According to this theory, a higher population growth retards economic growth. The economists suggested that overpopulation has an adverse effect on gross domestic product (GDP) due to higher demand and limited resources. Although the association between inflation and output growth is not precisely expressed in this theory, the linkage is indirectly proposed to be negative.

Keynesian theory by John Maynard Keynes is a theory that shows the way of aggregate demand or total spending in the economy can powerfully impact economic output and inflation. From the perspective of the Keynesian view, supply is not assumed to meet the demand if only prices are adequately flexible. However, it is influenced by a variety of factors such as employment and inflation. Instead, fiscal intervention can help stabilise economic output and inflation by affecting aggregate demand.

Neo-classical growth theory explains how a stable economic growth rate is achieved by a group of three motivating factors, namely labour, capital and technology. This theory, often acknowledged as the exogenous growth model, was established by Robert Solow and Trevor Swan in 1956. It has been used as a long-run economic growth, where the long-run growth rate depends on technological advancement and population growth rate, both of which are assumed to be exogenous. This theory argues that technological innovations play an immeasurable role in the growth of the economy, while an economy has finite resources of capital and labour.

The neo-Keynesian theory established and corresponds to the Keynesian theory's apparent theoretical problem. A comprehensible concept of aggregate supply, in which price and wage rigidities may be justified, is aimed to be constructed by new Keynesian theorists (Snowdon and Vane, 2005). The neo-Keynesian theory emphasises more on economic growth and stability than full employment.

Endogenous growth theory, which argues that economic development is created by internal processes, is entangled in the conventional and firming microeconomic underpinnings of neoclassical economics. This theory contrasts with neo-classical theory, where endogenous growth economists claim that productivity improvements may be directly related to more rapid innovation and additional investments in human capital. Accordingly, productivity can be improved when attractive incentives for businesses and individuals are offered and innovation initiatives are implemented.

However, these theories draw different inferences on the reaction of growth to inflation. Regarding the link between inflation and economic growth, Orphanides & Solow (1990) believed that there are three likely outcomes, which are positive, negative and no relationship. The association between inflation and growth is assumed to be nonlinear by Fisher (1993), who was the first person to investigate this relationship. With a growth accounting context, Fisher identified the major pathways by which inflation inhibits growth. He discovered that inflation diminishes investment, hinders the productivity growth rate and ultimately hampers economic growth. His findings support the common wisdom that a steady macroeconomic environment is associated with a practically low inflation rate and a minimal budget deficit is beneficial to long-term economic growth.

Empirical Review

Most studies related to the effect of inflation on growth are seen to be at the economy-wide macro. The use of GDP aggregate statistics has been analysed in two different ways. Cross-sectional regressions and panel data estimations applied in numerous research papers (e.g., López-Villavicencio and Mignon (2011), Crespo Cuaresma & Silgoner (2014), Muzaffar & Junankar (2014), among others) found a nonlinear inflation-growth association. Secondly, the influence of inflation on growth differs among nations, based on the research using time-series data and VARs, for example, Rapach (2003). Depending on the country, inflation may either accelerate or hinder economic growth. Some studies found that inflation harms economic growth, for instance, Kirşanli (2022), Olamide *et al.* (2022) and Atigala *et al*. (2022). Other studies had mixed results. For instance, Tenzin (2019) examined the nexus between economic growth, inflation and unemployment using data from Bhutan. The study revealed a negative link between inflation and unemployment in the short-run but a positive link was detected in the long-run, implying a positive link between economic growth and inflation in the short-run and long-run respectively. On the other hand, Niken *et al.* (2023) focused the examination in Ethiopia and found the negative impact of inflation and unemployment on economic growth in both the short- and long run. In turn, economic growth and unemployment have negative impacts on inflation in the long run. It is unclear if inflation and growth can coexist or whether there will be a trade-off between reducing inflation and obtaining better economic growth.

Recent research notably examines nonlinearity in the inflation-growth relationship. For example, Munir *et al.* (2009) used an endogenous threshold autoregressive (TAR) model to study the correlation between inflation and economic development in the Malaysian economy between 1970 and 2005. They discovered a threshold of 3.89% for the impact of inflation on economic growth. The inflation rate beyond this cut-off point had an adverse impact on economic growth, while an inflation rate below it had a favourable impact. Baglan & Yoldas (2014) applied a flexible semi-parametric panel data model for developing countries to examine if there is a threshold effect between inflation and growth. For the whole duration of the analysis, they discovered that the inflation threshold was 12%. Additionally, it was shown that inflation rates above this limit would have a potentially adverse effect on economic development. Mondjeli Mwa Ndjokou & Tsopmo (2017) applied a panel smooth transition regression (PSTR) model to examine the nexus between inflation and economic growth for six African countries. The results revealed an optimal inflation rate of 4.3% for the region. Below this rate, an increase in inflation enhances growth, while above this rate, the increase in inflation causes a decline in economic growth.

Economic growth has a dynamic structure by nature. As a result, Kremer *et al.* (2013)'s proposal to build the dynamic panel threshold model is preferable to the static panel threshold model by Hansen (1999). The threshold models developed by Hansen (2000) and Caner and Hansen (2004) can be used to solve dynamic problems but they both rely on cross-sectional research. Moreover, panel models offer greater advantages as more information is provided, multicollinearity is reduced, and country differences are also controlled. The gap in the econometrics literature could be filled by Kremer *et al.* (2013)'s dynamic panel threshold model. Boujelbene (2021) applied a dynamic panel threshold regression to examine the nexus in North African countries. The result revealed the existence of a nonlinear relationship between inflation and economic growth. When CPI inflation is above a threshold value, it has a negative impact on economic growth, but its impact is insignificant below this threshold level.

Moving on, the difference between the actual and potential output is known as the output gap and it is often adopted as an indicator of the economic cycle. In a business cycle, most economists and policymakers desire to recognise whether the current output is greater or less than its potential. Jahan and Mahmud (2013) explained that the output gap can change either in positive or negative directions. When the demand is very high and the actual output is larger than the potential output, the direction can be positive. As such, the factories and workers need to run well over their most efficient capacity to fulfil that demand. By contrast, when there is an extra capacity or slack in the economy because of insufficient demand, there might be a negative direction as actual output is lower than the quantity an economy could generate at full capacity.

The output gap can also be described as the level of inflationary pressure in the economy. Prices tend to increase when the demand for products and services exceeds the capacity of the economy to produce them. On the other hand, when demand is weak which is the inflation rate coming in lower than expected, it tends to push prices down. Therefore, if the actual output drops below the potential output over time, prices will start to decrease which reflects a weak demand.

By using a Markov regime-switching model, Valadkhani (2014) examined how the output gap affected inflation from the first quarter in 1970 to the third quarter of 2013 in Canada, the United Kingdom and the United States. The study found a positive but varying impact of the output gap on inflation. Some studies focused on the asymmetric/nonlinear effects of output gaps on inflation, where economists agree that the output gap can influence inflation in the short run with asymmetric or nonlinear means. Several studies also offered reliable proof that increasing the output gap may have greater inflationary than decreasing the output gap is disinflationary (Clark *et al.*, 2001; Clements & Sensier, 2003).

Data

This study investigates the association between inflation and economic growth in Malaysia. All of the data was collected from the World Bank, particularly the World Development Indicators. This study focuses on Malaysia, from 1960 to 2019. The key purpose of this study is to examine the connection between inflation versus output growth proxied by GDP growth and output gap. Hence, these three variables are treated as dependent variables but might appear as independent variables to each other. The output gap is constructed as the actual GDP minus the potential GDP, proxied by the HP filter of GDP. The other variables are treated as control variables (GCF, POP_AGE, GOV, MONEY). The details and descriptions of the variables are summarised in Table 1. As the data might be short to conduct the estimation, the annual data are converted into the quarterly frequency through a linear interpolation method. In the following sections, the explanations of data will be based on quarterly data, as the converted data was used for estimation.

Table 1: The list of variables.

Variable	Description	Unit of measurement	Remark
GDP	GDP per capita growth	Annual%	
GAP	Output gap which is the difference between actual GDP and potential GDP	Annual%	GAP=GDP-HPTREND01 where HPTREND01 is generated by Hodrick-Prescott Filter in EViews 10
INF	Inflation rate	Annual% change in CPI	
GCF	Gross capital formation	Annual%	
POP_AGE	Population ages 15-64	% of the total population	
GOV	General government final consumption expenditure	% of GDP	
MONEY	Broad money	% of GDP	

Methodology

One of the research gaps is the examination of the nexus of inflation and economic growth is based on a linear modelling approach, whereas in the real-life situation, the relationship between economic variables might vary over time. Hence, to capture the switching of the nexus, the nonlinear model approach of Markov-switching regression is utilised in this study. The flow of analyses is as follows. The preliminary tests, to wit the unit root tests, are conducted to confirm the characteristics of the variables used in this study. This step is crucial to ensure that all variables used are stationary. The variables that are not stationary are transformed into stationary series by first differencing. After studying the variables and verifying the characteristics exhibited by the variables, we proceed to model estimation. There are four equations/models to be estimated (GDP equation, output gap equation, inflation-GDP equation and inflation-output gap equation). The two-regime MS dynamic regression (MS-DR) is used in this study. The study considers time-invariant and time-varying of transition functions. Lastly, we proceed to interpretation and comparison of the results obtained. There are four models included in the study as follows:

Model 1: GDP = F(INF, GDP(-1 to -4), DGCF, DPOP_AGE, DGOV) (1)

Model 2: GAP = F(INF, GAP(-1 to -4), DGCF, DPOP_AGE, DGOV) (2)

Model 3: INF = F(GAP, INF(-1 to -4), DMONEY) (3)

Model 4: INF = F(GDP, INF(-1 to -4), DMONEY) (4)

The four models include the dynamic effects, which are captured by the lags one to four, indicated by (-1 to -4) of dependent variables. Four lags are included as the data are quarterly (i.e., 4 quarters = 1 year). The four models are formed by referring to economic theories. Model 1 (GDP growth) is supported by growth theories. The GDP is proxied by the aggregate production function which is determined by physical capital, human capital and productivity or technology process. Physical capital is represented by DGCF, human capital is represented by population aged 15-64 (DPOP_AGE). Government expenditure (DGOV) is included as the policy factor that might also affect economic performance. Inflation is included to capture if there exists any trade-off linkage between economic growth and inflation. Next, Model 2 is formed by replacing GDP growth with an output gap. Following the monetary policy literature, the policymaker tends to target on price stability and growth stability which are proxied by inflation variability and output gap. Some studies examined the trade-off relationship between inflation versus the output gap.

Models 3 and 4 are formed by referring to the Phillips curve theory. Inflation is influenced by previous inflation rates, expectations of future inflation by economic agents and the output gap. The coefficient on the output gap measures price flexibility. In particular, the higher flexible the prices, the larger the coefficient value. Inflation is also considered a useful macroeconomic indication of the government's economic management. Although some studies found that inflation exhibits threshold effects on economic growth, empirical evidence strongly supports a negative association between inflation and growth. According to Keynesian economics, inflation may be triggered by factors besides money expansion in the short run, specifically those that cause ongoing demand shocks in an economy. The originality of this study is the utilisation of MS models in identifying the drivers of inflation in both the long and short runs.

MS models capture the asymmetrical behaviour observed between two or more regimes/ states. It is useful to examine the behaviour of a variable, such as GDP, in which the series might exhibit switching behaviour over a finite number of overlooked states, enabling the process to develop diversely in each phase. The transitions are modelled to follow a Markov process. The transition duration and the period between state changes are assumed to be randomised. The basic MS models include MS autoregression (MS-AR) and MS-DR based on views by Doornik (2013). The MS-AR model has a more gradual adjustment, which is suitable for the most stable series, with an autoregressive element created by the difference between the lagged endogenous variable and the average estimated for the endogenous variable in the regime. As the autoregressive element only involves the endogenous variable, the MS-DR model responds to the new regime instantly with a more noticeable shift.

In this study, the MS-DR model is chosen as a modelling technique to recognise the change in regimes, the duration and the transition probability across regimes. Doornik (2013) also added that the MS-DR model that comprises a structural element is crucial for analysing the time series with the mean and variance value alternations. The MS-DR model presented by Hamilton (1989) is founded on the assumption that the evolution of may be described by states or regimes. The following is the two-regime MS regression model:

Regime I: $Y_t = \mu_1 + \varphi Y_{t-1} + \varepsilon_t$ (5)

Regime II: $Y_t = \mu_2 + \varphi Y_{t-1} + \varepsilon_t$ (6)

where Y_t denotes the dependent variable, μ_1 and μ_2 indicate the intercepts in the respective regimes, φ represents the autoregressive coefficient and ε_t is the error at time *t*.

If the shift of the regime is acknowledged, the two-regime MS model is as follows:

$$Y_t = S_t\mu_1 + (1 - S_t)\mu_2 + \varphi Y_{t-1} + \varepsilon_t \quad (7)$$

where denotes the regime. It equals to one if the process is in Regime I and two if it is in Regime II. In most circumstances, nevertheless, it is impossible to perceive in which regime the process is presently in, and thus unidentified. In MS regression models, the regime follows a Markov chain. The following is the model with k regime-dependent intercepts:

$$Y_t = \mu_1 + \varphi Y_{t-1} + \varepsilon_t \quad (8)$$

where for regimes. In general, the MS-DR model is written as:

$$Y_t = \mu_{st} + X'\alpha + Z'\beta_{st} + \varepsilon_{st} \quad (9)$$

where X' indicates a vector of (state-independent) exogenous or independent variables with state-invariant coefficients α, Z' denotes a vector of (state-dependent) exogenous or independent variables with state-dependent coefficients β_{st}; the error term is normally distributed with mean 0 and state-dependent variance σ^2_{st}. The lags of the dependent variable, Y_t could be specified either as state-dependent, Z' or state-independent, X' variable.

The original model allows only to be regime-shifted with lag one of specified. In this study, the original MS-DS model is extended to two forms with the dynamic effects specified in 4 lags of as quarterly data applied. The two forms of models are as below:

Model (a): $Y_t = \mu_{st} + X'\alpha + \varepsilon_{st}$ (10)

Model (b): $Y_t = \mu_{st} + Z'\gamma\beta_{st} + \varepsilon_{st}$ (11)

where St = 1, 2 regimes. In Model (a), all regressors (lags of Y_t, control variables and exogenous variables) are state-invariant. In Model (b), all regressors (lags of Y_t, control variables and exogenous variables) are state-dependent. Exogenous variables refer to the GDP-INF and GAP-INF nexus variables, while control variables are other variables covering GCF, GOV, POP_AGE and MONEY.

A Markov chain is supposed to be time-invariant when the condition stancenal probability $(x_{n+1}|x_n)$ is independent f n, for instane, $Pr(x_{n+1} = b|X_1 = a)$ for all $a, b \in \chi$ and the n = 1, 2, ... If $\{X_i\}$ is a Markov chain, is known as the state at time n. A time-invariant Markov chain is characterised by its initial state and a probability transition matrix.

The MS model's fixed transition probability is extended to include time-varying transition probabilities. This extension has provided other beneficial regime-switching models and resulted in numerous exciting research due to its intuitive appeal. In a time-varying transition probability (TVTP) MS model, transition probabilities are permitted to differ with information variables, such as economic strength, fundamental deviations from real values, and other principal indicators of change. These expansions can be found in a variety of disciplines.

In short, the terms DGCF, DPOP_AGE, DGOV and DMONEY indicate the variables after performing the first difference on variables GCF, POP_AGE, GOV and MONEY respectively. The variables other than GDP, GAP and INF are used in the first differenced state since they are only stationary after the first differencing conducted. Each equation has two specifications named (a) and (b), where Model (a) indicates that all regressors are specified as switching variables, while in Model (b), all of them are non-switching variables. Each specification has two versions, namely time invariant (TI) and time-varying (TV). The model specification is summarised in Table 2.

There are four equations in our study, which are denoted as Models 1, 2, 3 and 4. Model 1 is GDP as the dependent variable, Model 2 is GAP as the dependent variable while the dependent variable in Model 3 and Model 4 is INF. For each model, time-invariant and time-varying versions are examined where the time-invariant model is denoted as TI and the time-varying model is denoted as TV. Moreover, each equation has two specifications. One is all regressors and control variables are included in the switching variables while another one is only mean and variance are included in switching variables when all regressors and control variables are non-switching variables. The notation for Model 1 in the time-invariant version with all regressors and control variables are switching variables is Model 1(a)_TI, while Model 3(b)_TV represents Model 3 in the time-varying version with all regressors and control variables are non-switching variables.

Results and Discussion

Before conducting the estimation, unit root tests are performed to check on the stationarity of each variable. The unit root tests performed include Augmented Dickey-Fuller (ADF), Kwiatkowski-Phillips-Schmidt-Shin (KPSS) and breakpoint unit root test. The results of unit root tests are summarised in Table 3. The null hypothesis for ADF and breakpoint unit root tests is the series is not stationary while that of KPSS is the series is stationary. Hence the rejection of ADF and breakpoint unit root tests means the series is stationary while that of KPSS is the series is not stationary.

The results of the majority of tests show that all variables are not stationary at level, except GAP and INF. Hence, all variables are tested with first differenced except GAP and INF to further check if they are stationary after first differenced. The results in differenced terms reveal that these variables are stationary after first differenced. Thus, the variables in the stationary form will be used in the model estimation, i.e., GAP, INF and others in the first differenced term (DGCF, DGOV, DMONEY and DPOP_AGE) with 'D' indicating the first differenced. Note that for the first differenced of POP_AGE, the variable is stationary after first differencing only when using lag 112 with the t-statistic value of –7.1310 and rejecting the null hypothesis of the series is not stationary at even 1%.

Next, model selections are first conducted. The model performances are evaluated in terms of model-fitting (i.e., Schwarz info criterion (SC), Akaike info criterion (AIC) and log-likelihood) and forecast performances (i.e., root mean squared error (RMSE), mean absolute error (MAE) and mean absolute percentage error (MAPE)). The best model should minimise the SC, AIC, RMSE, MAE and MAPE but maximises the log-likelihood value. The outcomes are displayed in Table 4. Model 1(a)_TI, Model 2(b)_TV, Model 3(b)_TV and Model 4(a)_TI is selected to be the best model among the four models in different types, respectively, as they satisfy most of the selection criteria.

Table 2: Model specification

Model	Dependent Variable	Non-switching Variable	Switching Variable	Markov's Option
1(a)_TI	GDP	-	Mean (μ_{st}), σ^2_{st}, INF, GDP(-1 to -4), DGCF, DPOP_AGE, DGOV	Time-invariant
1(b)_TI	GDP	INF, GDP(-1 to -4), DGCF, DPOP_AGE, DGOV	Mean (μ_{st}), σ^2_{st}	Time-invariant
1(a)_TV	GDP	-	Mean (μ_{st}), σ^2_{st}, INF, GDP(-1 to -4), DGCF, DPOP_AGE, DGOV	Time-varying
1(b)_TV	GDP	INF, GDP(-1 to -4), DGCF, DPOP_AGE, DGOV	Mean (μ_{st}), σ^2_{st}	Time-varying
2(a)_TI	GAP	-	Mean (μ_{st}), σ^2_{st}, INF, GAP(-1 to -4), DGCF, DPOP_AGE, DGOV	Time-invariant
2(b)_TI	GAP	INF, GAP(-1 to -4), DGCF, DPOP_AGE, DGOV	Mean (μ_{st}), σ^2_{st}	Time-invariant
2(a)_TV	GAP	-	Mean (μ_{st}), σ^2_{st}, INF, GAP(-1 to -4), DGCF, DPOP_AGE, DGOV	Time-varying
2(b)_TV	GAP	INF, GAP(-1 to -4), DGCF, DPOP_AGE, DGOV	Mean (μ_{st}), σ^2_{st}	Time-varying
3(a)_TI	INF	-	Mean (μ_{st}), σ^2_{st}, GAP, INF(-1 to -4), DMONEY	Time-invariant
3(b)_TI	INF	GAP, INF(-1 to -4), DMONEY	Mean (μ_{st}), σ^2_{st}	Time-invariant
3(a)_TV	INF	-	Mean (μ_{st}), σ^2_{st}, GAP, INF(-1 to -4), DMONEY	Time-varying
3(b)_TV	INF	GAP, INF(-1 to -4), DMONEY	Mean (μ_{st}), σ^2_{st}	Time-varying
4(a)_TI	INF	-	Mean (μ_{st}), σ^2_{st}, GAP, INF(-1 to -4), DMONEY	Time-invariant
4(b)_TI	INF	GDP, INF(-1 to -4), DMONEY	Mean (μ_{st}), σ^2_{st}	Time-invariant
4(a)_TV	INF	-	Mean (μ_{st}), σ^2_{st}, GAP, INF(-1 to -4), DMONEY	Time-varying
4(b)_TV	INF	GDP, INF(-1 to –4), DMONEY	Mean (μ_{st}), σ^2_{st}	Time-varying

Table 3: Results of unit root tests

Variable	Test Statistics (Level Variable)			Test Statistics (Different Term)		
	ADF	**KPSS**	**Break-point**	**ADF**	**KPSS**	**Break-point**
GDP	-3.2773**	0.6130**	-4.8676**	-6.3075***	0.08729	-
GAP	-6.5346***	0.01081	-6.4957***	-	-	-
INF	-3.4444**	0.1832	-4.3951*	-5.7669***	-	-
GCF	-2.5114	0.4852**	-3.4702	-3.9549***	0.1855	-7.0803***
GOV	-1.5569	1.3428***	-4.8056**	-4.9498***	0.1609	-9.4839***
MONEY	-1.6013	1.8053***	-2.9828	-4.6608***	0.07926	-8.4567***
POP_AGE	-1.8221	1.9200***	-3.0774	0.0257**	0.2713	-3.9397

Table 4: Model selection

Model	SC	AIC	Log-likelihood	RMSE	MAE	MAPE
1(a)_TI	**2.2921**	**1.9692**	**-210.3703**	5.8202	4.5619	274.6021
1(b)_TI	2.4037	2.1982	-245.3884	**4.5899**	**3.4746**	133.2797
1(a)_TV	2.3656	2.0134	-213.5767	5.0728	4.0303	267.2423
1(b)_TV	2.4364	2.2016	-243.7901	5.0009	3.7684	**115.7839**
2(a)_TI	**2.0262**	**1.7033**	-178.9884	33.1593	21.2140	12978.35
2(b)_TI	2.2323	2.0268	-225.1631	**2.7407**	1.9448	309.1689
2(a)_TV	2.0582	1.7059	**-177.2991**	18.8030	12.9020	6935.931
2(b)_TV	2.2688	2.0339	-224.0027	**2.7407**	**1.9383**	**298.2227**
3(a)_TI	1.5409	1.2767	-132.6529	3.0831	1.9575	**362.3001**
3(b)_TI	**1.4658**	1.2897	-140.1842	4.15E+08	1.35E+08	1.44E+10
3(a)_TV	1.5514	**1.2578**	**-128.4250**	6.1934	4.4991	825.1100
3(b)_TV	1.6871	1.4816	-160.8314	**2.8606**	**1.8432**	419.4981
4(a)_TI	**1.4366**	**1.1725**	-120.3498	3.0711	1.9122	**335.6774**
4(b)_TI	1.5469	1.3708	-149.7552	**2.6810**	**1.7072**	369.1661
4(a)_TV	1.4716	1.1781	**-119.0148**	3.2101	2.1811	428.7127
4(b)_TV	1.5889	1.3834	-149.2460	2.6880	1.7225	386.3795

In the following subsections, the discussions of MS estimation results will focus on the best model. In particular, the results are discussed based on (1) average inflation and the output gap, (2) estimated nexus and (3) the impacts of control variables. It is followed by the results and discussions for transition probability and expected duration for the four models.

Results of MS-DR Models

Table 5 summarises the results from MS estimation, where Regime I denote the period with upward trending and is interpreted as a high regime, while Regime II indicates a period with downward trending and implies a low regime. The regimes refer to GDP, GAP and INF to move between high versus low states respectively in Models 1, 2, 3 and 4. The coefficient of , is the estimated average inflation (INF), output gap (GAP) and GDP growth (GDP) for the respective models.

To examine the expected mean value in both high and low regimes, the coefficient of constant (estimated) in the MS model is observed. For

Table 5: The estimated coefficients of the four best models

Variable	Model 1(a)_TI	Model 2(b)_TV	Model 3(b)_TV	Model 4(a)_TI
		Regime I		
μ_{st}	0.3153***	0.0596	0.2253	0.6887***
X	-0.0117	-	-	-0.0638**
DGCF	0.1946***	-	-	-
DPOP_AGE	1.9749	-	-	-
DGOV	0.9028***	-	-	-
DMONEY	-	-	-	-0.0366
		Regime II		
μ_{st}	0.2598	-0.2196	0.1542***	-0.0201
X	0.0959*	-	-	0.0273***
DGCF	0.04894***	-	-	-
DPOP_AGE	-0.1510	-	-	-
DGOV	0.0651	-	-	-
DMONEY	-	-	-	0.0056
		Non-regime		
X	-	-0.0106	-0.0003	-
DGCF	-	0.1143***	-	-
DPOP_AGE	-	-1.1102*	-	-
DGOV	-	0.4313***	-	-
DMONEY	-	-	-0.0043	-

Note: X represents INF for Models 1 and 2, whereas for Models 3 and 4, X denotes GAP and GDP, respectively.

the nexus GDP-INF (Model 1), the coefficient for the high GDP growth regime (Regime I) is significantly higher than that of the low GDP growth regime (Regime II) in the specification of all regressors and control variables are included as switching variables for time-invariant version. This implies that the expected mean value of inflation is higher in a high GDP growth regime. Besides, only the coefficient of the high GDP growth regime is statistically significant at even a 1% level. Model 2 is a generalisation of Model 1 by allowing the replacement of the dependent variable, using an output gap (GAP). The estimated average of inflation in Regime I is higher than that in Regime II but all estimated averages are not statistically significant. By observing the relationship between INF and GAP, the estimated mean in Model 3(b), where all regressors and control variables are non-switching variables in the time-varying model, is only significant at Regime II. For Model 4, the estimated mean in Regime I is higher than that in Regime II with only the former being statistically significant.

The estimated coefficient of the variable X in all four relationships (Table 5) represents the estimated nexus between GDP-INF, GAP-INF, INF-GAP and INF-GDP. In the GDP-INF nexus (Model 1), the positive value of the estimated coefficient of INF indicates a trade-off in the nexus as an increase in INF leads to an increase in GDP, implying that the efforts of policymakers to achieve low inflation and high GDP cannot be achieved together. The achievement of high GDP is compensated by the loss of high inflation. Similarly, the nexus of INF-GDP (Model 4) is found to have a positive estimated coefficient of GDP indicating the trade-off relationship as an increase in GDP leads to the increase of

INF too. In the GAP-INF nexus (Model 2), the negative estimated coefficient of INF implies a trade-off relationship as an increase in INF leads to a lower GAP, that is, the target to achieve a low output gap and low inflation could not be achieved simultaneously. This is similar to the nexus of INF-GAP (Model 3), a negative estimated coefficient of GAP indicates the trade-off relationship as an increase in GAP leads to drop-in inflation.

The results show that in Models 2 and 3, the non-regime specification models report no significant estimated X's coefficient, which fails to detect any nexus in the two equations. In Model 2 (GAP-INF), there is no significant nexus detected, implying that inflation does not trigger significant changes in the output gap. Similarly, the output gap also does not provoke any significant changes in inflation as reported in Model 3. On the other hand, the regime-switching specification models have detected the existence of the nexus, particularly in Model 4. For the GDP-INF nexus (Model 1), there is a non-significant or weak linkage in both regimes.

The estimated coefficients of control variables are also summarised in Table 5. The positive sign of the coefficient of the control variable means that there is a positive impact of the control variable on either inflation, GDP or output gap, and vice versa. The results show that in Model 1 (GDP-INF nexus) and Model 2 (GAP-INF nexus), the labour represented by the population aged 15-60 (DPOP_AGE) does not contribute significantly to fostering economic growth nor reduce the output gap in the regime-switching and non-regime switching specification models. In contrast, government expenditure (DGOV) contributes to higher GDP (which is good) and a higher output gap which is not preferred. This means that DGOV stimulates market activities, higher demand and spending, which leads to higher GDP, but at the same, it also causes to a higher output gap, in which the actual output is much higher than the potential or targeted output level. Meanwhile, the increase in gross capital formation (DGCF) leads to an increase in both GDP and GAP. In other words, DGCF provides sources of capital through saving and fixed assets, which could be transformed into higher investment, and production to boost economic growth. Conversely, DGCF improves the GAP with a lower difference between actual versus potential output. Both DGOV and DGCF are found to be more influential in high regimes. This is because an increase in government spending and capital formation directly impacts the increase in demand for goods and services, which can increase output and employment, leading to higher GDP and the output gap. In Models 3 and 4, the results show that money supply (DMONEY) has an insignificant influence on inflation in all specification models.

Results of Transition Probabilities and Expected Durations

The results of transition probability and expected duration in Table 6 can be used to study the pattern and behaviour of inflation. Transition probabilities P11 and P22 specify the likelihood of staying in Regime I (high regime) and Regime II (low regime), respectively. Meanwhile, P21 and P12 are defined as the probability of transitions between two regimes.

The result of Model 1(a)_TI shows that transition probabilities are substantially state-dependent, with a comparatively larger likelihood of remaining in the high GDP growth regime. In specific, it has a 76.16% of probability maintaining its high GDP growth regime compared to a 42.33% probability in the low GDP growth regime. Under the high and low GDP growth regimes, the corresponding expected durations are 4.19 and 1.73 quarters, respectively. It is found that moving from Regime I to Regime II has a probability of 23.84%, whereas shifting out of Regime II is much easier, which has a chance of 57.67% each quarter.

Similarly, Model 2(b)_TV has a relatively greater likelihood of remaining in the high output gap regime compared to remaining in the low output gap regime. It is found to have an 81.58% probability to maintain the high output gap regime and also a 72.22% of probability to shift from low to high output gap regimes. This indicates that variables in the model are more persistent to remain or transit to Regime I, which is the high output gap regime. The expected duration at Regime I is 5.64 quarters, which is higher than the expected duration at Regime II of 1.41 quarters.

Meanwhile, the result of Model 3 shows a comparatively higher chance of staying in the low inflation regime instead. Model 3(b)_TV, which is determined as the best model, has a 73.82% of probability retaining at Regime II and also a 42.30% probability to shift from Regime I to Regime II. Therefore, the variables in the model have higher persistence to remain or transit to Regime II, which is the low inflation regime. The corresponding expected duration in Regime II is 4.16 quarters, which is higher than in Regime I 3.47 quarters.

INF-GDP equation (Model 4) shows results similar to INF-GAP (Model 3), whereby the INF-GDP equation has a comparatively greater probability of staying in the low inflation regime. Model 4(a)_TI, which is determined as the best model, has a 72.02% of probability retaining at Regime II and also a 53.80% probability to shift from Regime I to Regime II. The expected duration in Regime II is 3.57 quarters which is higher than in Regime I, 1.86 quarters.

For easier economic interpretation of different regimes, the plots of transition probabilities for the four best models are illustrated in Figure 1, Figure 2, Figure 3 and Figure 4 for the respective equations/models. Both Figure 1 and Figure 4 display a constant trend in the transition probabilities throughout the whole period as the selected best model for Model 1 and Model 4 are based on time-invariant specification. Hence, they have constant Markov transition probabilities. It can be observed that GDP (Model 1) has a comparatively greater chance of remaining in the high GDP growth regime as transition probabilities of P11 and P21 are with higher values. On the other hand, inflation (Model 4) has a comparatively greater likelihood of staying in the low inflation regime as the transition probabilities tend to have larger values to remain at Regime II.

From Figure 2 and Figure 3, it can be seen that there are some fluctuations or non-linear trends in the transition probabilities since the best models of Models 2 and 3 are based on time-varying specifications instead. Figure 2 shows that around the late 1960s and 1970s, there is a spike in transition probability P22 indicating a higher probability to retain the low output gap regime during this period. There is also a drop in transition probability P21 during this period whereby the probability of shifting away from the low output gap regime to the high output gap regime is lower. Meanwhile, it is observed from Figure 3 that there is a decrease in transition probability P22 around the 1970s and also at the beginning of 1997. This indicates that there is a lower probability of retaining the low inflation regime. Therefore, it is noticed that the high inflation regime and low output gap regime occur in two different periods. The first starts in

Table 6: Transition probability and expected duration for the four best models.

Variable	Model 1(a)_TI	Model 2(b)_TV	Model 3(b)_TV	Model 4(a)_TI
Transition Probability				
P11	0.7616	0.8158	0.5770	0.4620
P22	0.4233	0.2778	0.7382	0.7202
P21	0.5767	0.7222	0.2618	0.2798
P12	0.2384	0.1842	0.4230	0.5380
Expected Duration				
I	4.1938	5.6432	3.4661	1.8589
II	1.7339	1.4111	4.1593	3.5738

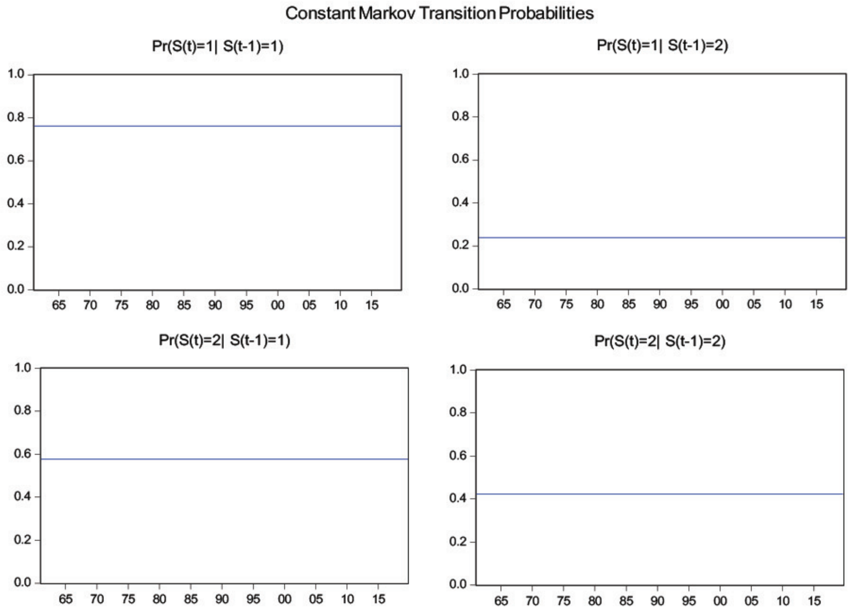

Figure 1: The plot of transition probabilities for Model 1 – GDP equation

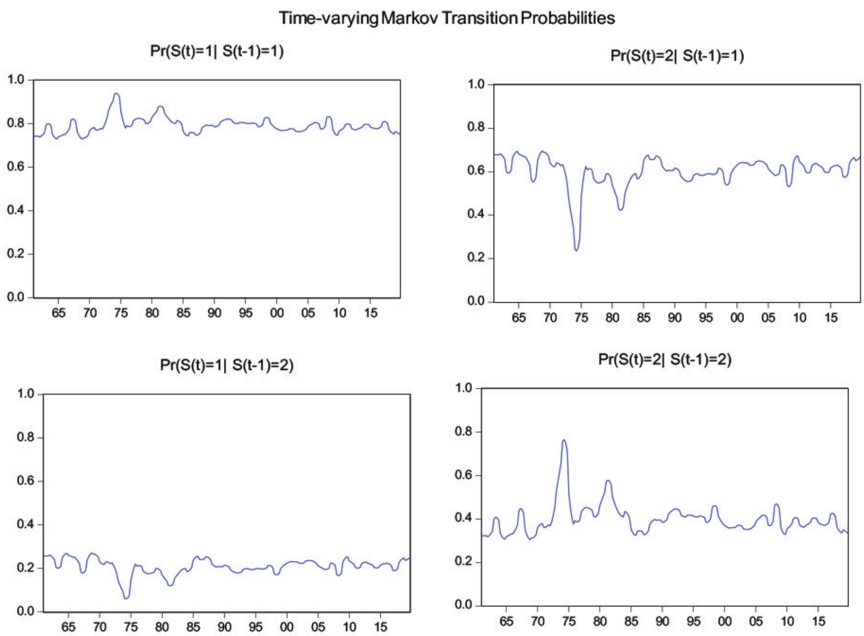

Figure 2: The plot of transition probabilities for Model 2 – GAP equation

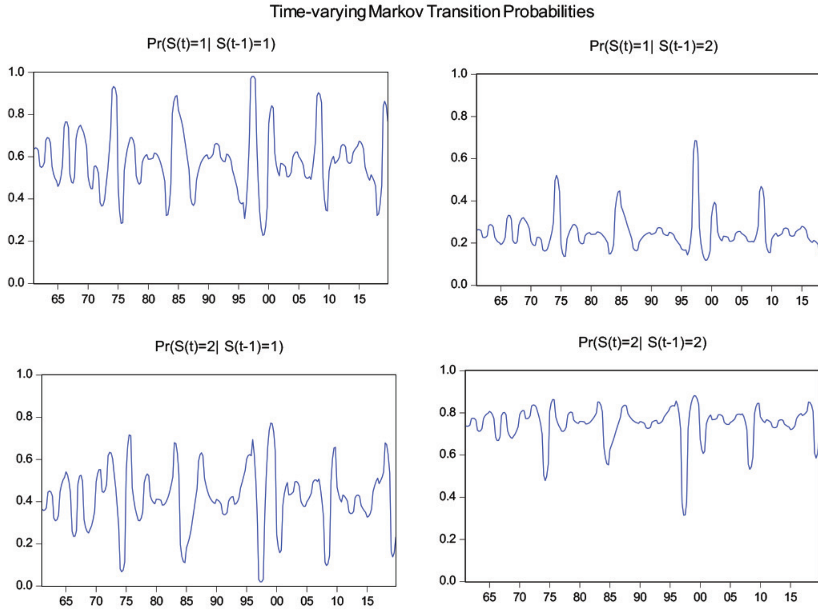

Figure 3: The plot of transition probabilities for Model 3 – INF-GAP equation

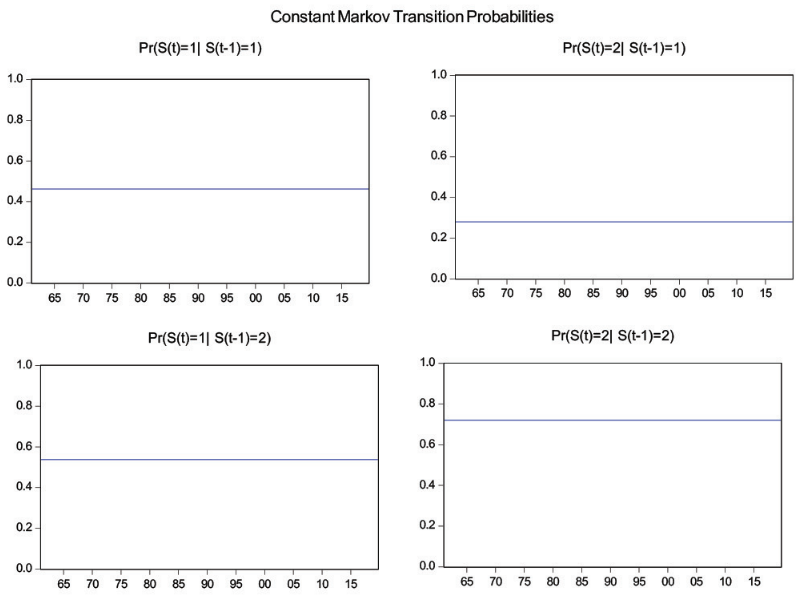

Figure 4: The plot of transition probabilities for Model 4 – INF-GDP equation

the late 1960s, and 1970s, which coincides with the Great Inflation. The second distinct period, beginning almost in the year 1997, which caused by the Asian Financial Crisis. Yet, considering the more unpredictable nature of inflation during the late 1960s, 1970s, high-inflation 1980s, and post-2008 period, the exhibited behaviour of the transition probabilities is expected. The estimated probabilities nearly correspond to the actual progress of the inflation rate around the years 1970-1980. The high inflation regime and low output gap regime closely match the period of the country's greatest inflation rates. Therefore, there exists a good match between what the model predicts and the actual path of inflation across the whole period of interest.

Conclusion

The key objective of this research is to investigate the two-way inflation-growth and inflation-output gap linkages in Malaysia over the period 1960 to 2019. This study applies MS models to examine the non-linear two-way nexus of inflation growth under a two-regime model (high regime versus low regime). The findings imply that a two-regime specification may reasonably represent Malaysia's inflation rate, GDP growth, and output gap since the early 1960s, with regime shifts happening in the early 1970s and 1990s. The regime-switching regression models are more advantageous as they can detect nexus with different relationships found in high versus low regimes compared to the linear regression which fails to detect the majority of the nexus due to its limitation.

Besides, the increase in government expenditure and gross capital formation are determined as factors contributing to higher GDP and higher output gaps. This shows that government spending is found to stimulate market activities, creating higher demand and spending which leads to the development of the overall economy. Moreover, the increase in economic growth is stimulated by the increase in gross capital formation, because a high rate of household savings may accumulate funds to generate capital goods faster, which leads to an increase in national income levels. However, the higher output gap is not preferred because the overly high demand forces businesses and employees to work beyond their optimal efficiency level to fulfil the demand level. This often causes inflation in an economy since both labour costs and the prices of products rise in accordance with rising demand.

Overall, the results from the MS models show that a trade-off relationship exists in the two-way GDP-INF nexus signifying that a rise in INF results in an increase in GDP or vice versa, implying that the effort of policymakers to achieve low inflation and high GDP could not be achieved together. The achievement of high GDP is compensated by the loss of high inflation. Meanwhile, the two-way GAP-INF nexus exists as a trade-off relationship too whereby the target to achieve a low output gap and low inflation could not be achieved simultaneously. Alternatively, the regime-switching specification models imply that the output gap might trigger changes in inflation instead. A low output gap is preferred as the objective of policymakers is to achieve both low inflation and a low output gap. However, the nexus between GDP-INF does not show any significant relationship.

This study found the primary drivers that are positively linked with economic growth are gross capital formation and government expenditure. These findings have significant policy implications and recommendations for Malaysia. The higher the economy's capital formation, the quicker it can raise its aggregate revenue. More goods and services produced can contribute to higher national income levels. A country should create investments and savings through household savings or via government policy to acquire extra capital. Therefore, policymakers should design a policy package or plan to attract foreign investment and capital inflows.

Proactive actions and policies should also be taken to increase capital mobility. With higher capital mobility, it will enable trade changes between countries to happen more easily. It will also enable citizens from other countries to invest more in the countries. This is also one of the methods of increasing the investment of a country. Thus, there is a need to foster economic growth through encouraging capital inflow, capital market development and FDI by harmonising foreign investment regulations and creating an economic and social environment conducive to foreign investments. Fiscal policy can also be adopted by governments to bridge the output gap. For instance, expansionary fiscal policy, boots the aggregate demand by rising government spending or reducing taxes can be implemented to bridge a negative output gap. Contrarily, when the output gap is positive, a contractionary or "tight" fiscal policy is executed to cut down the demand and battle inflation via reduced spending and/or higher taxes.

The results show the tendency to have a trade-off relationship in GDP-INF and INF-GDP when GDP is in a low regime and when INF is in a high regime. Hence, high inflation and low GDP regimes are not a good economic level. Also, GAP does not influence inflation level but inflation might affect GAP and GDP. Hence, stabilising inflation and price level is crucial. The government should take the initiative to stabilise the price level especially the prices of daily necessity goods such as rice, meat, petrol, gas etc. The results show that both GDP and GAP tend to have a higher possibility to stay in the high regime while inflation tends to stay longer in the low regime which is good. It implies that inflation is expected to maintain in the low regime. Policy actions such as price control schemes, subsidies etc. could be helpful to monitor price levels.

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