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The Causal Effects of Economic Uncertainty on Monetary Policy: Evidence from 10 Selected Countries

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Abstract

The uncertainty may play a prominent role in influencing the process of decision making by the policymakers.Many empirical studies on the central bank's monetary policy response on economic uncertainty does not focus on the explicit comprehensive measure of economic uncertainty, rather it focuses on individual economic uncertainty measure. To overcome this shortcoming, the objective of the study is to examine the causal relationship between monetary policy and economic uncertainty variables. This study extends the Taylor Rule function by introducing two external variables, namely, exchange rate and terms of trade based on a sample of 10 countries, namely, four developed(i.e., Australia, Canada, Japan and United States), and six developing countries (i.e., Indonesia, Malaysia, Philippines, Singapore, South Korea and Thailand). To test the stationarity of the variables, this paper employs the unit root test (i.e., Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test) to determine whether the variables are in the order of integrated zero, I(0) or in the order of integrated one, I(1) in order to avoid spurious regressions. Using the Granger causality test and Toda-Yamamoto causality test, the expected finding suggests that the policy makers may find a route for the implication of the monetary policy that could help to attain better economic outcomes and improve economic performances.

Keywords: Economic uncertainty, Taylor Rule, Unit root tests, Granger causality test, Toda-Yamamotocausality test

1. Introduction

Economic uncertainty refers to unpredicted events in the future economy. Uncertainty was first described in the seminal work of Knight (1921) that includes both 'risk' and 'uncertainty'; inducing that the context of economic uncertainty in this paper can be better describeby the Knightian uncertainty. Theeconomic uncertainty can be a challenge to central bank's monetary policy decision makingfor better economic outcomes. Because economic uncertainty can potentially influence the economic performances that stem from the insufficient information on future economic events, indicating that the monetary policy can be less responsive due to the cautiousness effect of uncertainty (Montes, 2010; Aastviet, 2017).On the other hand, Greenspan (2003) stressed that the uncertaintymay play a prominent role in influencing the process of decision making by the policymakers. Therefore, a question arises whether the study on the economic uncertainty may help to improve the understanding of the central bank's monetary policy response.

Many empirical studies on the central bank's monetary policy response on economic uncertaintydoes not focus on the explicit comprehensive measure of economic uncertainty, rather it focuses on individual economic uncertainty measure, for instance, interest rate, output, inflation, exchange rate and terms of trade; according to Gan (2014), the definition of economic uncertainty should include the interest rate uncertainty, output uncertainty, inflation uncertainty and exchange rate uncertainty (*note* that this paper uses a broader definition of uncertainty that includes fluctuation, volatility and shock). For instance, with respect to the interest rate uncertainty,Istrefi and Mouabbi (2017) examined the changes of economic performance and interest rate through vector autoregression (VAR) approach, in which, the results suggested that interest rate uncertainty may have negative influence on the economic performance. Interest rate could be acknowledged as an important instrument in conducting the monetary policy because by adjusting the interest rate,conventional variables could be stabilised, for a better economic performance (Hetzel, 2000). Evans (1984) stated that interest rate volatility and output may be related, in which, the unanticipated interest rate volatility cause the output to decrease. Creal and Wu (2014) found that the economic uncertainty and real economy may have inverse movements where the uncertainty negatively influences the economy causing the interest rate to increase and correspondingly increases inflation.

With respect to the output uncertainty on economic events, Smets (2002) measured the uncertainty using the output gap on the monetary policy rules based on the US economy. Orphanides (2001) suggested that the presence of gap in the output variable may be a challenge in policy implementationthat may influence economic performance differently. In the context of increasing inflation, central bank's increases the interest rate, hence, this reaction causes the output gap to increase (Grigoli et al., 2015).Mishkin (2002) suggested that by knowing and adjusting the movement of output via monetary policy could help the policymakers control inflation. Failing to do so may result in the instability of the economic activity, in which the real-time data of output could lead to an inaccuracy in estimation for the monetary policy to react to the changes of the output (Orphanides, 1998). Orphanides and Norden (2002) suggested that the output gap appeared to be less reliable in real time because this may raise certain problems for the policymakers in fine-tuning the policy to stabilise the economic fluctuation. Moreover, output gap and inflation rate gap may be correlated, the increasing output gap in the monetary policy may serve as a signal of anoverheating economy and this may put pressure on the inflation causing the policymakers to increase the interest rate to cool down the overheated economy (Billi, 2012).

With respect to the inflation uncertainty on the economic event, Ali and Mehdi (2015) suggested that policymakers should control inflation uncertainty to avoid a decrease of economic activity that may have a negative effect on the economic performance. Drakos and Kouretas (2015) reviewed that the presence of inflation uncertainty may indicate a continuous increase in inflation; the inflation could be influenced by the expansion or deflation monetary policy which causes a period of recession. Glas and Hartmann (2016) explained that the presence of inflation uncertainty in the economy may potentially influence the outcomes of the monetary policy. The implication from the presence of inflation uncertainty could be seen through the context when economicagents delay their decision making regarding investments or savings leading to a sluggish market performance due to the increasing of volatility on prices and risk (Friedman, 1977; Baillie et al, 1996; Bloom, 2009). In contrast, Lahiri and Sheng (2010) described that a good monetary policy is by having low levels of inflation a stable inflation uncertainty. Moreover, inflation is correlated with the adjustment of the monetary policy, where inflation may negatively influence the economy;therefore the central bank is required to control the monetary policy to keep the inflation low and steady (Cioran, 2014).

With respect to the exchange rate uncertainty on the economic event, Taylor (2001) stated that exchange rate may be part of the arbitrage equation that reflects domestic and foreign interest rate through the expected exchange rate. Ruzima and Boachie (2017) suggested the use of exchange rate volatility to stand in proxy of uncertainty, in which, the uncertainties are estimated through the ARCH-based model. Ariccia (1999) explained that if the exchange rate uncertainty does not decrease, the risk of reducing foreign activity may increase which cause the foreign market to reallocate their production domestically. Despite the uncertainty about economic events, de Oliveira (2014) stated that the movement of exchange rate could be reviewed as a source of uncertainty for the policymakers in gauging a better policy during the decision making process. Bianchi and Deschamps (2017) indicated that by forecasting the movements of exchange rate might bring great response to the expected future inflation, in which, showing that the presence of exchange rate may help in keeping the inflation and output close to the target level and might could influence the interest rate.

With respect to the terms of trade on the economic events, by using the multi-sector New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model, Hove et al (2015) examined the influence of terms of trade towards monetary policy; they found that the role of terms of trade is important to the policymakers in making decision because terms of trade may have the potential to indirectly influence the inflation and exchange rate. Fatima (2010) stated that the terms of trade could be worse when the exchange rate starts to depreciate causing the prices of export goods to decrease and the cost of import goods to increase. Baxter and Kouparitsas (2000) briefly explained the fluctuations in terms of trade may simply happendue to the variation of exported and imported goods, in which, the value of export and import good fluctuate individually cause the ratio of export and import to continuously differ. On the other hand, fluctuations in terms of trade may influence the investment performances because of the expected returns from export-oriented industries that may affects investors views, resulting in a negative effect towards exchange rate (Rodríguez et al, 2017). Svensson (1985)examined the influenced of terms of trade, exchange rate and interest rate based on two countries; he found that increasing the interest rate temporarily may not have much effect compared to permanent increase which may have stronger effect in influencing the terms of trade to decrease that could have effect in conducting the monetary policy.

This paper is motivated by the fact that economic uncertaintymay influence the monetary policy decision, hence, influencing the economic outcomes.Ben-Haim and Demertzis (2016) stated that economic uncertainty can be reflected as an unforeseen future economic event leading to indecisive decisions and indirectly influence the economic performance. Economic uncertainty that is considerably high may have an unfavourable effect on the economic performance that may induce greater recession and sluggish recovery of the economy, which in turn causes the policymakers to take immediate action(IMF, 2008; 2012). Increasing economic uncertaintycan prompt the economic agents to delay their decision making process and to anticipate for clearer information, hence, resulting in a poor responsiveness towards the changes in the real economic activity including monetary policy (Bernanke, 1983; Dixit andPindyck, 1994). Moore (2016) stated that economic uncertainty could have unexpectedly make changes in monetary policy, because market participants are pressured in predicting the direction of monetary policy when the uncertainty is high. Caggiano et al. (2017) explained that a sudden height up in uncertainty shows a negative response in consumption, investment and output inducing a tightening in real activity. Hence, the policymakers may consider to postpone the decision making process for the future economic performances in the presence of uncertainty (Evans et al, 2015; Seneca, 2016). As suggested by Bernanke (2010), economic uncertainties issues needed to be fine-tuned.

The aim of this paper is to examine the causal relationship between monetary policy and economic uncertainty variables, namely interest rate gap, output gap, inflation gap, exchange rate gap and terms of trade gap, such that the causal relationship results canprovide a route for the monetary policymakers to make better decisions in improving the economic performances and achieving better economic outcomes; *note* that the economic uncertainty variables are measured in the gap form (see Section 2 for gap variable discussion)[1]. To relax the study, this paper uses the Taylor Rule that can serve as a standard guideline economic performance measure and could be adjusted to include economic uncertainty through gap form where the difference between the actual and potential value implies uncertainty.[2]In doing so, we may promote a better policy decision-making process and help the central bank to achieve their goals by filtering the unnecessary uncertainty in obtaining a more substantial information regarding the policy making (Shuetrim and Thompson, 1999).

The rest of the paper is arranged as follow. The following section will introduce the theoretical model and the methodology used in this paper. The discussion of thedata and empirical results will be discussed followed by the conclusion of the study.

2. Theoretical Model

In this paper, Taylor Rule is used as a model to examine the relationship of the economic uncertainty and monetary policy. Taylor (1993) proposed the Taylor rule (TR) as one of the central bank's instrument and the model may be written in general form as following:

$$r_g = f(y_g, \pi_g) \tag{1}$$

where, $r_g$is the interest rate, y_g is the output gap and π_g is the inflation gap. To serve the purpose of this study, Equation 1 is extended to encompass with the other two external variables in gap form, namely, exchange rate gap and terms of trade gap.

The introduction of this extended TR model by including two external variables (i.e., the exchange rates and the terms of trade) is examined by using the specifications of the standard model of Taylor Rule.Among other researchers, this standard model function is used by Ball (1999), Gan and Kwek (2010)and Kuper (2018). This paper re-specifies the general form to include the external variables and can be presented as follows:

$$r_g = f(y_g, \pi_g, e_g, tot_g) \tag{2}$$

where, r_g is the interest rate gap—the difference between current real interest rates (r_t) and real interest rates at potential one (r_t^*); y_g represents output gap—the difference between actual output (y_t) and potential output (y_t^*); π_g denotes the inflation gap—the deviation of the inflation rate (π_t) from its target value (π_t^*); e_g representsexchange rate gap—the difference of the current real exchange rate (e_t) from the real exchange rate at potential output (e_t^*); tot_gdenotes the terms of trade gap—the quarterly rate of change of the terms of trade. The theoretical model to relax the study in this paper is as follows:

$$r_{g_t} = \alpha_3 y_{g_{t-1}} + \gamma_2 \pi_{g_{t-1}} - \propto_3 e_{g_{t-1}} - \lambda_3 tot_{g_{t-1}} + \varpi_t \tag{3}$$

where, the variables in the equation are expressed as follows: $r_g$is the interest rate, y_g is the output gap, π_g is the inflation gap, $e_g$is the exchange rate gap and tot_g is the terms of trade gap. Parameters α_1, α_2, α_3, γ_1, γ_2, λ_1, λ_2 and β_2 are positive and the parameters$\propto_1$, $\propto_2$, $\propto_3$, β_1 and λ_3 are negative. The ε_t, μ_t, η_t, ϖ_t and ς_t are the error terms.

From Equation 3, the theoretic relationship for output gap and inflation gap show positive signs, which indicate that the central bank adjust the interest rate by increasing the interest rate to stabilise the output gap and inflation rate gap. In the context of output gap, Grigoli et al. (2015) stated

[1] Ben-Haim et al. (2017) suggested that the presence of uncertainty in the variables could be estimated by the gap approach.
[2]Refer to Gan (2014) paper for a further discussion on the economic uncertainty index.

that the increasing of output may indirectly affected the price of goods to increase leading to inflation and resulting the central bank to increase the interest rate to control the output gap. As from the context of inflation rate gap, Cukierman and Meltzer (1986) stated that the increasing of inflation may be related with the changes in the output which result the central bank to increase the interest rate in order to balance out the output and inflation. On the other hand, the theoretic relationship forexchange rate gap and terms of trade gap show negative signs, which indicate that the central bank could reduce the interest rate to stabilise the exchange rate and improve the terms of trade. Specifically, the inclusion of the exchange rate gap implies that the depreciation of the currency would likely influence the upcoming trading performance of a country making the central bank try to stabilise the exchange rate by reducing the interest rate (Furman and Stiglitz, 1998). As for the inclusion of the terms of trade gap, the changes in the terms of trade may have influence the demand and supply of the economy, which a worsen terms of trade can be fine-tuned via monetary policy easing by the central bank (Ghate et al., 2016).

3. Methodology

The methodology apply in this paper namely the unit root test (i.e., Augmented Dickey-Fuller test and Phillips-Perron test), Granger causality and Toda-Yamamoto causality test will be discussed in this section. The stationarity of the variable will be tested by using the unit root test which consists of two tests, namely, Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test. The causality relationship between the monetary policy and its determinants are examined by using the Granger causality test and Toda-Yamamoto causality test.

3.1 Unit Root Tests

Unit root test plays an important role for this study because unit root test is necessary to test the stationarity of the variables in order to decide whether to use the predicting models in differences or levels in practice (Dickey et al. 1986). Unit root test is carried out to avoid the spurious regression analysis which could harm any economic decision and policy recommendations. Occurrence of any spurious regression analysis may lead to a fail results of the search (Granger and Newbold, 1974). The equation for the simple auto-regression model can be illustrated as follows:

$$Y_t = \rho Y_{t-1} + \delta Y_{t-1} + \varepsilon_t \tag{4}$$

where, Y_t represents dependent variable, ρ represents the parameter that needed to be examined, ε_t represents error term and δY_{t-1} represents the exogenous regression.

3.1.1 Augmented Dickey-Fuller (ADF) Test

In the unit root test, there are two types of test that could be conducted to analyse the stationarity of the variables. Therefore, ADF test and PP test are conducted and explained as follows. ADF test is a more comprehensive test compared to the standard Dickey-Fuller (DF) test (Dickey and Fuller, 1979) in which this ADF test is able to test for higher order of auto-regression that could be more suitable for this paper. The null hypothesis and the alternative hypothesis is similar to the DF test which can be written as:

H_0 : The series is not stationary (There is unit root)

H_1 : The series is stationary (There is no unit root)

This paper employs the Akaike information criterion (AIC) because AIC may strengthen the properties of the test (Cheung and Lai, 1995). Hence, this model is called Augmented Dickey-Fuller (ADF) test and this model can be illustrated as following:

$$\Delta Y_t = \alpha_1 + \alpha_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Y_{t-i} + \varepsilon_t \tag{5}$$

where, ΔY_t represents the first-order difference of the series y_t, α_1 and α_2 represents parameters, m represents the lags used by the dependent variable and ε_t is the error term. This series involved the number of lagged difference terms is to ensure that the error term is serially uncorrelated in Equation 9.

3.1.2 Phillips-Perron (PP) Test

Phillips-Perron (PP) test is a test with modification from the Dickey-Fuller (DF) t-statistics, in which, Phillips and Perron (1988) proposed a method that do not include lagged difference terms in controlling the serial correlation. The hypothesis for null and alternative hypothesis for PP test is the same ADF test where the null hypothesis is a unit root exists and the alternative hypothesis is there is no unit root. Thus, this general model of PP test could be briefly explained and assume as following:

$$\tilde{t}_\beta = t_\beta(\delta_0/\gamma_0)^{1/2} - \frac{T(\gamma_0-\delta_0)(\varepsilon(\tilde{\beta}))}{2\gamma_0^{1/2}\mu} \tag{6}$$

where, β represents the estimate, t_β represents the t-ratio of β, $\varepsilon(\tilde{\beta})$ represents the coefficient of standard error, δ_0 denotes the consistent estimate of the error variance, γ_0 denotes the estimator of the residual spectrum at the frequency of zero, $\varepsilon(\tilde{\beta})$ represents the standard error of the coefficient and μ denotes the standard error of the test regression. Choi (1992) argues the result obtained from PP test may show a more robust outcome compared with the results obtained from ADF.

3.2 Toda-Yamamoto Causality Test

In this paper, Toda-Yamamoto (1995) causality test is used to examinethe causal relationship between monetary policy and economic uncertainty variables,including both conventional variables (i.e., interest rate gap and output gap) and external variables (i.e., exchange rate gap and terms of trade gap). This test is carried out from the modified Wald test (MWald) and in Seemingly Unrelated Regression (SUR) models (Rambaldi and Doran, 1996) which requires an estimation of the augmented vector autoregression (VAR). The augmented VAR model could be $(k + d_{max})$, where k represents the optimal lag length and d_{max} is the maximum order of integration. According to Hacker and Hatemi (2006), this test may able to be carried out without considering whether the series is in the same integration order. The optimal lag length is chosen by using the Akaike Information Criterion (AIC), assuming that the lag length chosen is $k = 4$. This shows that the estimation for the VAR model should be VAR (5) because $d_{max} = 1$. Then the VAR model of Toda and Yamamoto causality could be estimated as follows:

$$\begin{bmatrix} r_{g_t} \\ y_{g_t} \\ \pi_{g_t} \\ e_{g_t} \\ tot_{g_t} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} + \begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} & \alpha_{14} & \alpha_{15} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} & \alpha_{24} & \alpha_{25} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} & \alpha_{34} & \alpha_{35} \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & \alpha_{44} & \alpha_{45} \\ \alpha_{51} & \alpha_{52} & \alpha_{53} & \alpha_{54} & \alpha_{55} \end{bmatrix} \begin{bmatrix} r_{g_{t-1}} \\ y_{g_{t-1}} \\ \pi_{g_{t-1}} \\ e_{g_{t-1}} \\ tot_{g_{t-1}} \end{bmatrix} + \begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} & \alpha_{14} & \alpha_{15} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} & \alpha_{24} & \alpha_{25} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} & \alpha_{34} & \alpha_{35} \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & \alpha_{44} & \alpha_{45} \\ \alpha_{51} & \alpha_{52} & \alpha_{53} & \alpha_{54} & \alpha_{55} \end{bmatrix} \begin{bmatrix} r_{g_{t-2}} \\ y_{g_{t-2}} \\ \pi_{g_{t-2}} \\ e_{g_{t-2}} \\ tot_{g_{t-2}} \end{bmatrix} + \begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} & \alpha_{14} & \alpha_{15} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} & \alpha_{24} & \alpha_{25} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} & \alpha_{34} & \alpha_{35} \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & \alpha_{44} & \alpha_{45} \\ \alpha_{51} & \alpha_{52} & \alpha_{53} & \alpha_{54} & \alpha_{55} \end{bmatrix} \begin{bmatrix} r_{g_{t-3}} \\ y_{g_{t-3}} \\ \pi_{g_{t-3}} \\ e_{g_{t-3}} \\ tot_{g_{t-3}} \end{bmatrix} + \begin{bmatrix} \varepsilon_{r_{g_t}} \\ y_{g_t} \\ \pi_{g_t} \\ e_{g_t} \\ tot_{g_t} \end{bmatrix} \tag{7}$$

wherer_{g_t} represents interest rate, y_{g_t} denotes output gap, π_{g_t} denotes inflation gap, e_{g_t} denotes exchange rate gap and tot_{g_t} denotes terms of trade gap. Assuming to test one of the null hypothesis which is the output gap does not Granger cause interest rate, $H_0 = \alpha_{12} = 0$, where the coefficient of

α_{12} is the restricted lag value for output gap in the model. The alternative hypothesis on interest rate does not Granger cause output gap is similar to the first approach which $H_0 = \alpha_{11} = 0$, where the coefficient of α_{11} is the restricted lag for the interest rate in the model. By using the above mentionedprocedure, the significance statistics of the MWald statistics in the Toda-Yamamoto causality test imply that the null hypothesis of the non-Granger causality for bothoutput gap to interest rate gap, and interest rate gap to output gap, are rejected; in other words, output gapcauses interest rate gap, and vice-versa.

3.3 Granger Causality Test

In addition to the Toda-Yamamoto (1995) causality test, this study furthers the test to the Granger causality, in which examines the causal relationship between monetary policy and economic uncertainty variables, including both conventional variables (i.e., interest rate gap and output gap) and external variables (i.e., exchange rate gap and terms of trade gap).By using this method, we could be able to examine the relationship of two or more variables and to view on how the variables react to each other (Granger, 1969). Assuming that there are two stationary time series with zero means included in this study, namely y_t and x_t which can be seen in a series of x_t does not Granger cause y_t and y_t does not Granger cause x_t, where, the simple causal model can adapted from (Granger, 1969) and illustrated as follows;

$$x_t = \sum_{i=1}^{k} a_i \, x_{t-i} + \sum_{i=1}^{k} b_i \, y_{t-i} + u_t \qquad (8)$$

$$y_t = \sum_{i=1}^{k} c_i \, x_{t-i} + \sum_{i=1}^{k} \beta_i \, y_{t-i} + e_t \qquad (9)$$

whereu_t and e_t are considered to be uncorrelated white-noise series, k means lag length of the data which can be infinity but to some extent when comes to practice.

4. Data

The samples of this study focused in developed and developing countries only. This research uses sample of four selected developed countries, namely, Australia, Canada, Japan and United States (US), and six selected developing countries, namely, Indonesia, Malaysia, Philippines, Singapore, South Korea and Thailand. The data are collected and analysed according to the model created. Data collected for this research are quarterly data from year 1995 quarter one until year 2016 quarter four. As for the exchange rate variable, it is presented by using the real effective exchange rates index. Monetary policy variable, namely interest rates is used for the Australia, Canada, Indonesia, Japan, Malaysia, Philippines Singapore, South Korea, Thailand and US country. The output variable that is applied in this study is known as Gross Domestic Product (GDP). Additional to that, terms of trade gap variable from this study implies to the external shocks. The data sources obtained from Datastream, namely, the International Monetary Fund (IMF) and International Financial Statistics (IFS). The features are as follows:

- Interest rate: The quarterly series of money market rates (MMR) obtained from the IFS is used to serve as interest rates.
- Real exchange rate: The real effective exchange rate (REER) is used as real exchange rate. The quarterly series of the REER is taken from IFS and IMF.
- Gross Domestic Product: The quarterly series of the nominal gross domestic product (NGDP) is collected from IFS. The real term of this variable is obtained by using the value of NGDP divided by the consumer price index (CPI).
- Consumer price index: The quarterly series of consumer price index (CPI) data is obtained from IFS. Inflation rate is obtained from the first difference of the log of the CPI level.
- Terms of trade: The series of terms of trade (TOT) is obtained from IFS and IMF on a quarterly basis.

The interest rate, r_{g_t} time series is computed by the differences between the current real interest rate and the potential real interest rate which is calculated as a percentage point change. The output gap, y_{g_t} is the differences of the real output from the potential output, in which, the output gap is the difference of the logged time series of the real output and the potential output, which is then multiplied by 100. The time series of inflation gap,π_{g_t} is obtained from the differences between current inflation and the potential inflation. Time series for the exchange rates gap, e_{g_t} is obtained from the differences between the logged time series of REER and the potential REER which is calculated as a percentage point change in the exchange rate. The potential interest rate, potential output, potential inflation and the potential exchange rate are calculated by using the Hodrick-Prescott (HP) filter with the smoothing parameter, λ which is set equal to 1600 and the potential level mentioned referred to the equilibrium level; the HP filter developed by Hodrick and Prescott (1997) can be used to ease the process in analysing the movements or fluctuations in the economic activity (Gerdrup et al. 2013). Hamilton (2017) argues that HP filter may have the potential in predicting the future as the HP filter are a function constructed based from future realizations. The HP filter also applied in other researches, for exampleCalderón et al. (2004), Grigoli et al. (2015) and, Ahmad and Brown (2017). The time series of terms of tradegap,tot_{g_t} is measured by the quarterly rate of the change of the TOT.

5. Results Discussions

This section discusses the result for all the analysis that have been carried out, namely, unit root test (i.e., Augmented Dickey-Fuller Test ad Phillips-Perron Test) and causality test (i.e., Granger causality and Toda-Yamamoto causality test).

5.1 Unit Root Test Result

The result for the unit root tests, i.e., the ADF test and the PP test for both developed and developing countries are presented in Table 1 and Table 2, respectively; both developed and developing countries are Australia, Canada, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Thailand and United States.The variables are tested via level and first difference by using the ADF and the PP tests; in the table, the examined variables are the interest rate (r_{g_t}), output gap (y_{g_t}), the inflation gap (π_{g_t}), the exchange rate gap (e_{g_t}) and terms of trade gap (tot_{g_t}). From Table 1 and Table 2, the results reveal that all of the variablesfor both developed and developing countries, namely interest rate, output gap, inflation rate gap, exchange rate gap, and terms of trade gap, are stationary, i.e., integrated of order zero, $I(0)$.

Table 1: Unit Root Test on ADF Test

Variables	Level	Probability	First Difference	Probability	Decision
Australia					
r_{g_t}	-5.0728* (2)	0.0004	-5.7497* (3)	0.0000	$I(0)$
y_{g_t}	-4.7471* (2)	0.0012	-8.0044* (2)	0.0000	$I(0)$
π_{g_t}	-4.5761* (3)	0.0021	-9.2583* (2)	0.0000	$I(0)$
e_{g_t}	-3.9360** (2)	0.0145	-6.0834* (3)	0.0000	$I(0)$
tot_{g_t}	-4.5266* (3)	0.0024	-10.3173* (2)	0.0000	$I(0)$
Canada					
r_{g_t}	-5.2948* (5)	0.0002	-4.0168* (4)	0.0021	$I(0)$
y_{g_t}	-3.8305** (2)	0.0194	-5.4071* (3)	0.0000	$I(0)$
π_{g_t}	-5.4627* (3)	0.0001	-11.9218* (2)	0.0001	$I(0)$
e_{g_t}	-4.3083* (3)	0.0048	-5.3644* (3)	0.0000	$I(0)$

Variables	Level	Probability	First Difference	Probability	Decision
tot_{g_t}	-7.0383* (2)	0.0000	-11.2656* (2)	0.0001	*I*(0)
Indonesia					
r_{g_t}	-5.0968* (4)	0.0004	-4.0224* (3)	0.0021	*I*(0)
y_{g_t}	-6.3393* (4)	0.0000	-6.3222* (6)	0.0000	*I*(0)
π_{g_t}	-6.0939* (2)	0.0000	-7.2639* (2)	0.0000	*I*(0)
e_{g_t}	-4.6467* (3)	0.0016	-6.4368* (3)	0.0000	*I*(0)
tot_{g_t}	-6.2374* (2)	0.0000	-10.2644* (2)	0.0000	*I*(0)
Japan					
r_{g_t}	-5.7995* (2)	0.0000	-12.2544* (2)	0.0001	*I*(0)
y_{g_t}	-3.7863** (3)	0.0219	-5.2959* (3)	0.0000	*I*(0)
π_{g_t}	-4.5169* (4)	0.0025	-12.7626* (2)	0.0001	*I*(0)
e_{g_t}	-4.1445* (5)	0.0080	-4.3272* (4)	0.0008	*I*(0)
tot_{g_t}	-4.1429* (4)	0.0080	-9.7325* (2)	0.0000	*I*(0)
Malaysia					
r_{g_t}	-4.2232* (6)	0.0063	-5.7838* (3)	0.0000	*I*(0)
y_{g_t}	-7.1388* (4)	0.0000	-6.4729* (4)	0.0000	*I*(0)
π_{g_t}	-5.6885* (3)	0.0000	-9.7872* (2)	0.0000	*I*(0)
e_{g_t}	-4.2289* (4)	0.0062	-4.8594* (3)	0.0001	*I*(0)
tot_{g_t}	-4.6600* (3)	0.0016	-9.9382* (2)	0.0000	*I*(0)
Philippines					
r_{g_t}	-5.3752* (6)	0.0001	-5.0873* (6)	0.0000	*I*(0)
y_{g_t}	-5.8554* (4)	0.0000	-6.1279* (6)	0.0000	*I*(0)
π_{g_t}	-5.8388* (8)	0.0000	-6.1624* (9)	0.0000	*I*(0)
e_{g_t}	-4.5355* (4)	0.0024	-5.7420* (5)	0.0000	*I*(0)
tot_{g_t}	-4.9522* (3)	0.0006	-9.8556* (3)	0.0000	*I*(0)
Singapore					
r_{g_t}	-4.4350* (3)	0.0033	-6.1298* (2)	0.0000	*I*(0)
y_{g_t}	-6.1168* (4)	0.0000	-5.7837* (4)	0.0000	*I*(0)
π_{g_t}	-5.0027* (3)	0.0005	-5.7497* (3)	0.0000	*I*(0)
e_{g_t}	-3.7885** (5)	0.0218	-6.0861* (2)	0.0000	*I*(0)
tot_{g_t}	-5.4796* (2)	0.0001	-8.1161* (2)	0.0000	*I*(0)
South Korea					
r_{g_t}	-4.6676* (2)	0.0015	-7.3045* (2)	0.0000	*I*(0)
y_{g_t}	-5.4279* (2)	0.0001	-3.7770* (7)	0.0045	*I*(0)
π_{g_t}	-6.5595* (2)	0.0000	-11.2853*(2)	0.0001	*I*(0)
e_{g_t}	-4.2174* (3)	0.0064	-5.4755* (3)	0.0000	*I*(0)
tot_{g_t}	-6.5400* (2)	0.0000	-9.5225* (2)	0.0000	*I*(0)
Thailand					
r_{g_t}	-4.3511* (3)	0.0042	-4.6851* (3)	0.0002	*I*(0)
y_{g_t}	-3.6183** (4)	0.0339	-4.7411* (3)	0.0002	*I*(0)
π_{g_t}	-6.2165* (4)	0.0000	-6.4615* (9)	0.0000	*I*(0)
e_{g_t}	-4.7664* (2)	0.0011	-6.4243* (3)	0.0000	*I*(0)
tot_{g_t}	-4.6526* (3)	0.0016	-9.0652* (3)	0.0000	*I*(0)
United States					
r_{g_t}	-3.8635** (5)	0.0178	-5.0474* (3)	0.0001	*I*(0)
y_{g_t}	-3.6955** (8)	0.0281	-4.8714* (3)	0.0001	*I*(0)
π_{g_t}	-5.2572* (3)	0.0002	-7.0058* (6)	0.0000	*I*(0)

Variables	Level	Probability	First Difference	Probability	Decision
e_{g_t}	-4.3325* (3)	0.0045	-5.9942* (2)	0.0000	$I(0)$
tot_{g_t}	-10.9590* (2)	0.0000	-7.7188* (6)	0.0000	$I(0)$

Notes: *, ** and *** imply significance at the 1%, 5% and 10% level respectively. Numbers in ( ) represent lag lengths used and is examined by using Schwarz Info Criterion (SIC). $I(0)$ represents integrated of order zero and $I(1)$ represents integrated of order one. The sample period is obtained from 1995 quarter one until 2016 quarter four.

Table 2: Unit Root Test for PP Test

Variables	Level	Probability	First Difference	Probability	Decision
Australia					
r_{g_t}	-5.1903* [3]	0.0003	-12.9557* [10]	0.0001	$I(0)$
y_{g_t}	-4.1301* [2]	0.0083	-9.7947* [4]	0.0000	$I(0)$
π_{g_t}	-8.3578* [5]	0.0000	-20.8497* [5]	0.0001	$I(0)$
e_{g_t}	-3.9102** [4]	0.0156	-10.2649* [14]	0.0000	$I(0)$
tot_{g_t}	-9.5070* [6]	0.0000	-22.4364* [3]	0.0001	$I(0)$
Canada					
r_{g_t}	-4.6757* [3]	0.0015	-9.7012* [2]	0.0000	$I(0)$
y_{g_t}	-3.5566** [3]	0.0396	-6.7056* [9]	0.0000	$I(0)$
π_{g_t}	-8.9181* [3]	0.0000	-14.5115* [5]	0.0001	$I(0)$
e_{g_t}	-4.1910* [2]	0.0069	-9.5346* [11]	0.0000	$I(0)$
tot_{g_t}	-9.4437* [5]	0.0000	-18.8245* [3]	0.0001	$I(0)$
Indonesia					
r_{g_t}	-3.6358** [4]	0.0325	-9.1025* [3]	0.0000	$I(0)$
y_{g_t}	-4.3930* [5]	0.0037	-12.1279* [10]	0.0001	$I(0)$
π_{g_t}	-4.8239* [5]	0.0009	-16.7126* [12]	0.0001	$I(0)$
e_{g_t}	-4.0016** [3]	0.0120	-7.3895* [8]	0.0000	$I(0)$
tot_{g_t}	-10.5944* [5]	0.0000	-35.3392* [10]	0.0001	$I(0)$
Japan					
r_{g_t}	-10.1832* [3]	0.0000	-34.5202* [10]	0.0001	$I(0)$
y_{g_t}	-4.0762* [4]	0.0097	-11.3345* [4]	0.0001	$I(0)$
π_{g_t}	-11.3358* [5]	0.0000	-38.5842* [10]	0.0001	$I(0)$
e_{g_t}	-3.3884***[3]	0.0595	-9.5836* [4]	0.0000	$I(0)$
tot_{g_t}	-9.4687* [2]	0.0000	-23.6350* [3]	0.0001	$I(0)$
Malaysia					
r_{g_t}	-5.1970* [3]	0.0002	-14.5563* [14]	0.0001	$I(0)$
y_{g_t}	-4.1069* [8]	0.0089	-8.7508* [5]	0.0000	$I(0)$
π_{g_t}	-8.0661* [3]	0.0000	-15.4682* [3]	0.0001	$I(0)$
e_{g_t}	-3.5715** [3]	0.0382	-8.4476* [7]	0.0000	$I(0)$
tot_{g_t}	-10.6053* [5]	0.0000	-25.1424* [5]	0.0001	$I(0)$
Philippines					
r_{g_t}	-5.6118* [11]	0.0001	-12.2999* [3]	0.0001	$I(0)$
y_{g_t}	-20.9419* [3]	0.0000	-41.1717* [4]	0.0001	$I(0)$
π_{g_t}	-7.6528* [5]	0.0000	-24.7651* [15]	0.0001	$I(0)$
e_{g_t}	-4.2798* [3]	0.0053	-11.1207* [7]	0.0001	$I(0)$
tot_{g_t}	-11.4567* [6]	0.0000	-24.9323* [3]	0.0001	$I(0)$
Singapore					
r_{g_t}	-4.4619* [3]	0.0030	-10.7510* [4]	0.0001	$I(0)$
y_{g_t}	-4.2324* [4]	0.0061	-9.4077* [3]	0.0000	$I(0)$
π_{g_t}	-6.9938* [3]	0.0000	-17.8436* [6]	0.0001	$I(0)$

Variables	Level	Probability	First Difference	Probability	Decision
e_{g_t}	-3.3922***[3]	0.0590	-9.5870* [4]	0.0000	I(0)
tot_{g_t}	-10.7586* [3]	0.0000	-26.1097* [4]	0.0001	I(0)
South Korea					
r_{g_t}	-4.7304* [5]	0.0012	-9.9420* [3]	0.0000	I(0)
y_{g_t}	-8.2406* [7]	0.0000	-23.8066* [3]	0.0001	I(0)
π_{g_t}	-10.6511* [9]	0.0000	-20.7956* [3]	0.0001	I(0)
e_{g_t}	-3.8495** [3]	0.0184	-9.6173* [3]	0.0000	I(0)
tot_{g_t}	-11.6422* [6]	0.0000	-28.1742* [3]	0.0001	I(0)
Thailand					
r_{g_t}	-4.1204* [3]	0.0085	-8.7959* [6]	0.0000	I(0)
y_{g_t}	-5.5554* [5]	0.0001	-17.6934* [15]	0.0001	I(0)
π_{g_t}	-7.1937* [10]	0.0000	-19.8238* [10]	0.0001	I(0)
e_{g_t}	-4.1216* [6]	0.0085	-9.8417* [10]	0.0000	I(0)
tot_{g_t}	-13.9462* [2]	0.0000	-30.7691* [2]	0.0000	I(0)
United States					
r_{g_t}	-4.0164** [2]	0.0115	-11.1556* [12]	0.0001	I(0)
y_{g_t}	-3.6016** [7]	0.0354	-8.7902* [3]	0.0000	I(0)
π_{g_t}	-8.9904* [12]	0.0000	-16.1030* [10]	0.0001	I(0)
e_{g_t}	-4.0869* [2]	0.0094	-9.1163* [7]	0.0000	I(0)
tot_{g_t}	-13.0025* [3]	0.0000	-26.1229* [13]	0.0001	I(0)

Notes: *, ** and *** imply significance at the 1%, 5% and 10% level respectively. Numbers in [ ] represent bandwidth used and is examined by using Bartlett kernel criteria. I(0) represents integrated of order zero and I(1) represents integrated of order one. The sample period is obtained from 1995 quarter one until 2016 quarter four.

5.2 Causality Results

Prior to the Toda-Yamamoto causality test, the optimal lag length have been obtained by using the AIC criterion. The optimal AIC lag length for Australia, Canada, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Thailand and United States are 7, 11, 4, 11, 10, 10, 2, 11, 11 and 9 respectively. The results forMWald statistics and the p-value are presented in Table 3. The shaded area in Table 3 are the null hypothesis for the Toda-Yamamoto causality test according to the causal relationship of$r_g$with y_g, π_g, e_g and tot_g individually. With reference to the shaded area in Table 3, the null hypotheses are rejected at 1%, 5% and 10% significance level, which impliesthe conventional variables, i.e., output gap and inflation gap together with the external variables, i.e., exchange rate gap and terms of trade gap can influence the monetary policy variable, i.e., interest rate.

To determine the robustness resultsof the Toda-Yamamoto test, this study further to Granger causality test that is similar with the Toda-Yamamoto test. Granger causality test examines the causal relationship between the dependent variable (i.e., interest rate (r_{g_t}) and its determinants, namely, output gap (y_{g_t}), inflation rate gap (π_{g_t}), exchange rate gap (e_{g_t}) and terms of trade gap(tot_{g_t}) for each selected countries. With reference to the shaded area in Table 4, the null hypotheses are rejected at 1%, 5% and 10% significance level, which indicate that the conventional variable (i.e., output gap and inflation rate gap) and the external variable (i.e., the exchange rate gap and the terms of trade gap) can influence the interest rate. Overall, the results of the Toda-Yamamoto causality test support the hypothesis of the study but not the Granger causality test. Although the Granger causality test suits well in various types of empirical studies, the test has limitation if compared to the Toda-Yamamoto causality test(Alimi and Ofonyelu, 2013). As argued by Alimi and Ofonyelu (2013), the Granger causality test does not take into account of the effect of other variables in its specification that may create a bias matter. Furthermore, the Granger causality test on time series data is commonly in non-stationary state(Maddala, 2001).

Undoubtedly, the results of the Granger causality test as demonstrated in Table 4 are less meaningful than the results of the Toda-Yamamoto causality testas demonstrated in Table 3.

Table 3: Results of Toda and Yamamoto Causality Test

Null Hypothesis	Developed Countries				Developing Countries					
	Australia	**Canada**	**Japan**	**United States**	**Indonesia**	**Malaysia**	**Philippines**	**Singapore**	**South Korea**	**Thailand**
	MWald statistics, (*P*-value)	**MWald statistics, (*P*-value)**	**MWald statistics, (*P*-value)**	**MWald statistics, (*P*-value)**	**MWald statistics, (*P*-value)**	**MWald statistics, (*P*-value)**	**MWald statistics, (*P*-value)**	**MWald statistics, (*P*-value)**	**MWald statistics, (*P*-value)**	**MWald statistics, (*P*-value)**
r_g and y_g										
r_g does not granger cause y_g	3.7159*, (0.0005)	5.8445*, (0.0000)	6.0461*, (0.0000)	1.2677, (0.2487)	3.2055**, (0.0012)	12.4655*, (0.0000)	3.5593*, (0.0001)	2.1243, (0.1195)	4.5283*, (0.0000)	3.9534*, (0.0000)
y_g does not Granger causer_g	2.1573**, (0.0437)	3.1216*, 0.0003	5.8335*, (0.0000)	2.3487**, (0.0121)	2.1773***, (0.06880	1.8936**, (0.0411)	3.4244*, (0.0002)	4.1962**, (0.0151)	13.5556*, (0.0000)	5.8429*, (0.0000)
π_g and y_g										
$\pi_g$does not Granger cause y_g	3.8095*, (0.0004)	9.2780*, (0.0000)	6.6514*, (0.0000)	1.4407, (0.1642)	6.2552*, (0.0000)	10.3127*, (0.0000)	4.3652*, (0.0000)	5.5444*, (0.0039)	2.0628**, (0.0195)	5.5825*, (0.0000)
$y_g$does not granger causeπ_g	1.9403***, (0.0591)	2.3842*, (0.0060)	5.8194*, (0.0000)	2.2829**, (0.0148)	0.7011, (0.5911)	3.4492*, (0.0002)	5.6632*, (0.0000)	12.0017*, (0.0000)	14.0385*, (0.0000)	11.1314*, (0.0000)
e_g and y_g										
e_g does not Granger cause y_g	3.8865*, (0.0003)	4.7418*, (0.0000)	4.2849*, (0.0000)	2.1903**, (0.0198)	3.2678**, (0.0109)	2.9611*, (0.0010)	6.5685*, (0.0000)	1.0399, (0.3535)	2.2363**, (0.0104)	3.0175*, (0.0005)
y_g does not Granger cause e_g	1.3904, (0.2042)	16.2633*, (0.0000)	6.4911*, (0.0000)	3.9441*, (0.0000)	0.1550, (0.9608)	2.1884*, (0.0016)	5.2731*, (0.0000)	5.8288*, (0.0029)	8.1998*, (0.0000)	8.5467*, (0.0000)
tot_g and y_g										
tot_gdoes not Granger cause y_g	1.5602, (0.1421)	5.6633*, (0.0000)	3.2987*, (0.0002)	2.2556**, (0.0161)	1.6692, (0.1540)	7.6769*, (0.0000)	3.4301*, (0.0002)	0.9546, (0.3850)	3.0854*, (0.0004)	7.5548*, (0.0000)
$y_g$does not Granger cause tot_g	6.8500*, (0.0000)	14.0988*, (0.0000)	7.5116*, (0.0000)	7.6220*, (0.0000)	0.4821, (0.7489)	3.3550*, (0.0002)	2.2637**, (0.0122)	1.6330, (0.1953)	9.5800*, (0.0000)	2.6392*, (0.0022)
r_g andπ_g										
r_g does not Granger cause π_g	1.5470, (0.1463)	2.8039*, (0.0012)	3.5474*, (0.0001)	2.5288*, (0.0068)	11.8609*, (0.0000)	2.0400**, (0.0257)	4.0234*, (0.0000)	5.2597*, (0.0052)	6.0880*, (0.0000)	4.7440*, (0.0000)
$\pi_g$does not Granger cause r_g	16.2453*, (0.0000)	5.8516*, (0.0000)	4.9768*, (0.0000)	7.5635*, (0.0000)	2.9029**, (0.0205)	6.4410*, (0.0000)	2.8618*, (0.0014)	13.7442*, (0.0000)	38.4035*, (0.0000)	18.5156*, (0.0000)
e_g and π_g										
e_g does not granger cause π_g	2.6083**, (0.0109)	1.9514**, (0.0289)	2.3662*, (0.0064)	3.6637*, (0.0001)	7.1009*, (0.0000)	3.5493*, (0.0000)	4.0433*, (0.0000)	4.6116*, (0.0099)	6.0505*, (0.0000)	7.0948*, (0.0000)
π_g does not Granger cause e_g	0.8331, (0.5595)	7.8693*, (0.0000)	9.0043*, (0.0000)	5.0465*, (0.0000)	4.3863*, (0.0015)	2.1887**, (0.0157)	3.8715*, (0.0000)	1.5540, (0.2114)	7.2695*, (0.0000)	8.2309*, (0.0000)
$tot_g$and π_g										
tot_gdoes not Granger cause π_g	2.7276*, (0.0079)	3.9931*, (0.0000)	5.5771*, (0.0000)	2.2502**, (0.0164)	0.9054, (0.4596)	5.3113*, (0.0000)	2.8888*, (0.0013)	1.7466, (0.1744)	6.3069*, (0.0000)	12.1435*, (0.0000)
$\pi_g$does not Granger cause tot_g	5.7478*, (0.0000)	8.4136*, (0.0000)	3.4611*, (0.0000)	7.3307*, (0.0000)	1.0591, (0.3750)	2.8186*, (0.0017)	2.5380*, (0.0047)	2.2701, (0.1033)	15.4105*, (0.0000)	0.6472, (0.7893)
r_g and e_g										

Null Hypothesis	Developed Countries				Developing Countries					
	Australia	Canada	Japan	United States	Indonesia	Malaysia	Philippines	Singapore	South Korea	Thailand
	MWald statistics, (P-value)	**MWald statistics, (P-value)**	**MWald statistics, (P-value)**	**MWald statistics, (P-value)**	**MWald statistics, (P-value)**	**MWald statistics, (P-value)**	**MWald statistics, (P-value)**	**MWald statistics, (P-value)**	**MWald statistics, (P-value)**	**MWald statistics, (P-value)**
r_g does not Granger cause e_g	2.1514**, (0.0352)	10.1831*, (0.0000)	9.2848*, (0.0000)	3.2965*, (0.0005)	10.9390*, (0.0000)	2.4363*, (0.0067)	4.3600*, (0.0000)	2.8683***, (0.0568)	8.0737*, (0.0000)	10.1308*, (0.0000)
e_g does not Granger cause r_g	3.8981*, (0.0003)	1.8752*, (0.0375)	2.4384*, (0.0049)	3.2605*, (0.0006)	3.3873*, (0.0089)	5.1075*, (0.0000)	3.1340*, (0.0005)	3.0165**, (0.0490)	13.4437*, (0.0000)	7.2448*, (0.0000)
tot_g and e_g										
tot_g does not Granger cause e_g	0.7670, (0.6150)	11.7940*, (0.0000)	8.2644*, (0.0000)	3.9059*, (0.0001)	1.2830, (0.2740)	9.0754*, (0.0000)	1.3744, (0.1850)	3.6321**, (0.0265)	9.2082*, (0.0000)	9.1067*, (0.0000)
e_g does not Granger cause tot_g	6.0595*, (0.0000)	12.3151*, (0.0000)	6.5103*, (0.0000)	10.077*, (0.0000)	1.1658, (0.3236)	2.2735**, (0.0118)	4.3232*, (0.0000)	6.1551*, (0.0021)	26.1445*, (0.0000)	1.1001, (0.3561)
r_g and tot_g										
r_g does not Granger cause tot_g	6.6222*, (0.0000)	14.0200*, (0.0000)	5.0114*, (0.0000)	8.3242*, (0.0000)	0.8213, (0.5113)	2.0088**, (0.00284)	3.1762*, (0.0004)	3.5486**, (0.0288)	9.6705*, (0.0000)	1.8631**, (0.0390)
tot_g does not Granger cause r_g	3.7269*, (0.0005)	2.8538, (0.0010)	5.3002*, (0.0000)	2.3156*, (0.0013)	3.4319*, (0.0082)	5.1008*, (0.0000)	3.9393*, (0.0000)	3.0758**, (0.0462)	7.5525*, (0.0000)	9.4096*, (0.0000)

Notes: *, ** and *** denotes statistically significant at the 1%, 5% and 10% levels, respectively. The sample period is obtained from 1995 quarter one until 2016 quarter four.

Table 4: Results of Granger Causality Test

Null Hypothesis		Developed Countries					Developing Countries				
		Australia	Canada	Japan	United States	Indonesia	Malaysia	Philippines	Singapore	South Korea	Thailand
r_g does not Granger cause y_g	F-stats	0.8577	3.0290**	2.9180***	5.9287*	4.3820*	1.5278	0.2978	1.1051	1.3544	3.2399**
	Lags	2	6	2	2	5	5	3	2	1	3
	P-values	0.4279	0.0105	0.0596	0.0039	0.0015	0.1910	0.8269	0.3360	0.2478	0.0263
y_g does not Granger cause r_g	F-stats	6.5249*	2.9170**	5.1494*	8.4578*	3.6421*	2.9211**	2.5520**	0.6283	3.3276***	4.4830*
	Lags	2	6	2	2	5	5	3	2	1	3
	P-values	0.0023	0.0130	0.0078	0.0005	0.0052	0.0181	0.0613	0.5360	0.0716	0.0058
r_g does not Granger cause π_g	F-stats	1.4178	0.7170	1.7483	2.1325**	3.8037**	1.0027	1.9945	0.9132	0.7273	3.8179**
	Lags	20	18	5	12	2	13	3	3	2	3
	P-values	0.1890	0.7781	0.1339	0.0293	0.0263	0.4601	0.1213	0.4384	0.4863	0.0130
π_g does not Granger cause r_g	F-stats	4.3208*	3.7044*	5.0109*	4.1701*	17.7611*	3.6404*	5.3665*	7.1925*	5.8695*	7.6234*
	Lags	20	18	5	12	2	13	3	3	2	3
	P-values	0.0002	0.0001	0.0005	0.0001	0.0000	0.0003	0.0020	0.0002	0.0041	0.0001
r_g does not Granger cause e_g	F-stats	2.3080	7.2518*	1.1068	1.1863	5.3048*	2.0162***	1.7831***	5.7986*	1.7754***	2.5343**
	Lags	4	1	5	6	2	5	14	2	20	10
	P-values	0.0653	0.0085	0.3639	0.3232	0.0068	0.0858	0.0689	0.0044	0.0735	0.0127
e_g does not Granger cause r_g	F-stats	3.3112**	4.2119**	0.6671	2.8894**	6.2776*	4.9915*	2.0511**	4.4289**	0.8988	3.2950*
	Lags	4	1	5	6	2	5	14	2	20	10
	P-values	0.0147	0.0432	0.6495	0.0139	0.0029	0.0005	0.0327	0.0149	0.5910	0.0018
r_g does not Granger cause tot_g	F-stats	3.2884**	2.0521**	2.6173*	5.9932*	1.8273	1.9666**	0.9015	2.4362***	0.2233	2.3195**
	Lags	4	5	11	3	3	13	14	4	2	11
	P-values	0.0153	0.0809	0.0090	0.0010	0.1489	0.0437	0.5627	0.0541	0.8004	0.0197
tot_g does not Granger cause r_g	F-stats	0.7856	4.6607*	2.0673**	3.0098**	2.6916***	1.3577	1.9661**	2.3676***	3.7966**	2.9793*
	Lags	4	5	11	3	3	13	14	4	2	11
	P-values	0.5380	0.0009	0.0380	0.0349	0.0517	0.2127	0.0421	0.0598	0.0264	0.0034

Notes: *, ** and *** denotes statistically significant at the 1%, 5% and 10% levels respectively. The sample period is obtained from 1995 quarter one until 2016 quarter four.

6. Conclusion

This paper examines the causal relationship betweenmonetary policy and economic uncertainty variables, namely interest rate gap, output gap, inflation gap, exchange rate gap and terms of trade gap, for 10 selected developed and developing countries, namely Australia, Canada, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Thailand and United States.Results from the unit root test which used to examine the stationarity of the variables before proceeding to causal analysis shows that the variables (i.e., interest rate, output gap, inflation rate gap, exchange rate gap and terms of trade gap) for both developed and developing countries are in stationary, $I(0)$. The results obtained for Toda-Yamamoto causality test shows a strong causal relationship that indicates the conventional variables and the external variables can influence the monetary policy variables.Moreover, the robustness results of Toda-Yamamoto Causality test are further strengthen when the results obtained from Granger causality test are less sensible. Thus, the finding suggest that the result from the causal analysis may provide an alternative way for the policy makers to improve the decision making process in achieving better economic outcomes.

Although the results obtained from this paper are satisfactory, this paper did have few limitations. First, this paper only encompasses 10 selected developed and developing countries, namely, Australia, Canada, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Thailand and United States. Second, this paper included only four variables in the monetary policy, namely, output, inflation rate, exchange rate and terms of trade, in which, additional explanatory variables could be included to further extend the current analysis. In addition, a similar procedure could be conducted by using different countries and variables to obtain various results. Third, this paper could be valuable for future research to investigate the same issue using different methodology on the same countries to test the relationship among the variables and may increase a wider range of time series into this model to produce more significant results.

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