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An Application of Asymmetric Toda–Yamamoto Causality on Exchange Rate-inflation Differentials in Emerging Economies

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ABSTRACT

The paper employs asymmetric causality test based on Toda and Yamamoto (1995) causality approach to further investigate the causal relationship between exchange rate and inflation differentials in Brunei, Malaysia and Singapore. We simulate critical values based on leverage bootstrapping and asymmetric causality test from the underlying empirical data. The results are compared among the Granger asymptotic Chi-square, the modified WALD leverage bootstrapped distributions and asymmetric causality test. The reported conflicting findings proved the existence of size distortion and nuisance parameter estimates when the traditional Granger approach is applied. The results from Toda–Yamamoto with asymmetric causality test establish the existence of Granger causality running from positive cumulative exchange rate shocks to positive cumulative shocks in inflation differentials for Brunei and Malaysia. However, the asymmetric causality for Singapore runs from both positive and negative cumulative domestic inflation shocks to positive and negative exchange rate shocks respectively. The policy implication of the findings is that a strong price stabilization policy during both good and bad times can stabilize exchange rate fluctuations in Singapore whereas; formulation of effective exchange rate policy can only achieve price stability in Brunei and Malaysia during good period.

Keywords: Asymmetric Causality, Leverage Bootstrap, Toda–Yamamoto, Exchange Rate, Structural Break
JEL Classifications: C100, E310, F310

1. INTRODUCTION

The trend of causality between exchange rate and inflation is a significant policy debatable issue in international macroeconomics that has not yet been properly dealt with in the literature. Previous findings reveal conflicting results which suffer from methodological issues and hamper appropriate policy formulation (Toda and Yamamoto, 1995). Most previous studies test the unit root properties of the series using the traditional augmented Dickey-Fuller proposed by Dickey and Fuller (1979). This is found to be deficient and leads to bias and less power to reject the null hypothesis especially if structural breaks exist in the data generating process (Perron, 1989; Zivot and Andrews, 1992). Alternatively, this study employs Lee and Strazicich (2013) minimum Lagrange multiplier (LM) with structural break to test the unit root properties in order to determine the maximum order of integration of the series. The test is break point nuisance invariant under both null and alternative hypotheses suffering neither size nor location distortion. This makes the test free from spurious rejection and unaffected by size and incorrect estimation irrespective of whether structural break exist or not (Lee and Strazicich, 2013).

Moreover, the application of Granger non-causality test on vector error correction and ordinary vector autoregressive (VAR) model lead to nuisance parameter estimates (Guru-Gharana, 2012). Furthermore, previous tests for causality hardly distinguish between the effect of positive and negative shocks which are expected to provide different causal relationships based on the principle of asymmetric information (Hatemi, 2012). Furthermore, the traditional Granger non-causality test was developed based on asymptotic distribution theory which leads to a spurious conclusion when integrated variables are employed (Granger and Newbold, 1974). Additionally, the null hypothesis at level estimation suffers from non-standard asymptotic distribution, whereas, the integrated Granger causality suffers from independence of nuisance parameter estimates (Sims et al., 1990; Toda and Philips, 1993). Besides, the Wald and likelihood ratio test statistics for Granger test are associated with rank deficiency which leads to size distortion under null hypothesis (Toda and Philips, 1993).

The present study investigates whether causality exist among inflation differentials and exchange rate. This is further investigated using Toda-Yamamoto causality with application of modified leverage bootstrap distribution as well as asymmetric causality test in order to provide a wider comparison and draw sound conclusions. The study employs the methodology of Toda and Yamamoto (1995) modified WALD (MWALD) test statistics based on augmented VAR framework. However, it is argued that asymptotic distribution theory in the VAR framework leads to size distortion under small sample size like in this study (Sims et al., 1990). Nonetheless, we adopt bootstrap distribution and asymmetric causality test which are considered more reliable compared to asymptotic distribution especially in a finite sample study in order to avoid size distortion and spurious inferences (Hacker and Hatemi, 2006). These methods work better under small sample size, presence of autoregressive conditional heteroscedasticity (ARCH) effect and violation of the normality assumption. Moreover, the asymmetric test distinguishes causality during good and bad periods (Hatemi and Irandoust, 2006; Hatemi, 2012). Furthermore, this study seeks to address the shortfalls of the previous studies that employed the alternative causality techniques. Moreover, to the best of our knowledge, the combination of these rigorous approaches; asymmetric causality test, leverage bootstrapping and Toda–Yamamoto dynamic causality have not been widely used in the context of causation among inflation differentials and exchange rates especially in emerging economies like Brunei, Malaysia and Singapore.

The remaining part of the paper is presented under 5 sections. Section 2 reviews previous literature. Section 3 presents theoretical framework. Section 4 describes the data and methodology. Section 5 presents empirical result and Section 6 provides conclusions and policy implication.

2. REVIEW OF LITERATURE

The nature of causality between exchange rate and inflation is widely researched. However, the empirical findings on the causal relationship between the variables have been conflicting and inconsistent in the literature. Despite the fact that the nature of the causal relationship between exchange rate and inflation has not been consistent in the literature yet, Arabi (2012) and Madesha et al. (2013) found a simultaneous feedback possibility between exchange rate fluctuations and its determinants such as inflation. Nonetheless, the presence of ARCH effect in the estimation process renders Granger non-causality test to be inefficient (Hacker and Hatemi, 2006). Moreover, Arize and Malindretes (1997) study exchange rate volatility as a factor that causes variability in inflation in 41 countries. The result indicates the existence of bidirectional connection between exchange rate variability and inflation under flexible exchange rate regime. In another study conducted by Deme and Fayissa (1995) the results show that there exist two-ways causation among exchange rate and inflation in Morocco and Tunisia and a unidirectional causality from exchange rate to inflation in Egypt without any feedback. The later part of the result is supported by Imimola and Enoma (2011) and Omotor (2008) who also found a unidirectional causality running from exchange rate to inflation in Nigeria.

On the contrary, some other studies reveal that there exist no causal relationship between inflation and exchange rate (Cairns et al., 2007; Chen and Wu 2001; Emmanuel, 2013; Kamas, 1995; Nnamdi and Ifionu, 2013; Parvar et al., 2011). According to Emmanuel (2013) causality exist between foreign exchange reserves and exchange rate without any causation running from either inflation to exchange rate or exchange rate to inflation at least for the sample period. Nnamdi and Ifionu (2013) examine exchange rate uncertainty and exchange rate volatility in Nigeria. The finding of their study indicates that exchange rate volatility is independent of inflation and other variables. Besides, Chen and Wu (2001) analyze the sources of real exchange rate fluctuations in four pacific basin countries. Their study shows that exchange rate is significantly influenced by a real shock such as technology, resource endowment and preferences rather than inflation.

In the case of Asian economies, a number of studies were conducted using the traditional Granger causality approach. These include the studies by Achsani et al. (2010); Cheng and Tan (2002); Kamin and Klau (2003); Masih and Masih (1996a; 1996b); Rittenberg (1993) and Urrutia et al. (2015) among others. Achsani et al. (2010) examine the relationship between inflation and exchange rates in Asean+3, the EU and the North America. They discover one-way causality in Asia running from inflation to exchange rate in most of the Asian countries except for Malaysia. This result is in support of Rittenberg (1993) who earlier examines the relationship between price level and exchange rate changes in Turkey. The results show evidence of one-way causation running from inflation to exchange rate but not vice versa even after controlling for money supply influence. However, Cheng and Tan (2002); Kamin and Klau (2003) and Masih and Masih (1996b) found contrary results for Malaysia, Thailand and Malaysia and a Panel of Asian countries including Singapore respectively. Their findings indicate that the exchange rate Granger cause inflation without similar influence from inflation. Nonetheless, Masih and Masih (1996a; 1996b) found no causal relationship among exchange rate and inflation in Indonesia and Thailand respectively. Moreover, in a more recent study by Urrutia et al. (2015) on modelling and forecasting the exchange rate of Philippines, the result reveals that there exist no causality among the variables at least for Philippines.

However, the fact that these studies were conducted basically on vector error correction, ordinary least squares regressions and VAR models with inappropriate lag order, the results might suffer from invalid inferences as highlighted by Toda and Yamamoto (1995). This leads to non-standard asymptotic distribution, nuisance parameter estimates and rank deficiency which cause size distortion under null hypothesis (Guru-Gharana, 2012; Toda and Philips, 1993). We therefore, consider alternative approaches in order to overcome the weaknesses of the previous methodology.

3. THEORETICAL FRAMEWORK

The theoretical framework underpinning this study is the monetary theory of exchange rate determination. This theory is divided into two folds; flexible-price version suggested by Frankel (1979) and Mussa (1976) and sticky-price model developed by Dornbusch (1976). The theory of exchange rate started with the "inflation theory of exchange rate" which form the basis through which exchange rate equilibrium can be determined (Cassel, 1918). It is denoted as partial equilibrium theory because of its inability to explain the phenomenon of money market and balances of foreign payment in the determination of exchange rate (Kanamori and Zhao, 2006). The theory describes the significance of money and other assets in defining the factors responsible for determining exchange rate under flexible regime (Frankel, 1976 in Frenkel and Johnson, 2013). The equilibrium exchange rate is obtained when demand for and supply of money are willingly held. According to Cassel (1921) a unidirectional causality exist between exchange rate and prices. Cassel (1921) as emphasized by Whitney (1922) and Frankel (1979) argues that causation flows from price (inflation) to exchange rate, whereas, Einzig (1935) claims that inflation is caused by exchange rate. However some scholars recognized that exchange rate and inflation are simultaneously determined.

4. DATA AND METHODOLOGY

4.1. Data

The study employs quarterly time series data spanning from 1980Q1 to 2015Q1 for Brunei, Malaysia and Singapore. The data on exchange rate, consumer price index, interest rate, money supply and income (real gross domestic products) were collected from the international financial statistics and world development indicators. The corresponding U.S. series are considered as foreign variables in order to arrive at the differential variables in the model. The other series in the model apart from exchange rate and consumer price index are seen as control variables.

4.2. Unit Root

The methodology proposed by Toda and Yamamoto (1995) is applicable irrespective of the integration order of the variables (Hacker and Hatemi, 2006; Toda and Yamamoto, 1995). However, it is necessary to determine the appropriate order of integration as pre-requisite for estimating Toda–Yamamoto causality. The study employs the Lee and Strazicich (2013) minimum LM test with one structural break to determine the maximum order of the integration. According to Lee and Strazicich (2013) the present unit root test differs from the traditional test because of its break point nuisance invariance under both null and alternative hypotheses, unaffected by neither size nor location distortions. Moreover, the test is free from spurious rejection and unaffected by the size and incorrect estimation regardless of the existence or otherwise of the break.

4.3. Toda–Yamamoto Causality

This study employs Toda and Yamamoto (1995) methodology based on the augmented VAR ($p+d_{max}$) model to investigate the causal relationship between exchange rate and inflation differentials in Brunei, Malaysia and Singapore. The model is argued to perform better if there is no omitted important variable bias, when appropriate lag lengths are employed and a reasonable sample size is used (Zapata and Rambaldi, 1997). Therefore, following Toda and Yamamoto (1995); Shan and Sun (1998) and Zapata and Rambaldi (1997) methodology, the VAR system specified in Equation 1 would be estimated for each country.

$$\begin{bmatrix} EXC_t \\ \pi-\pi_t^* \\ r-r_t^* \\ m-m_t^* \\ y-y_t^* \end{bmatrix} = \begin{bmatrix} a_0^{EXC} \\ a_0^{\pi-\pi^*} \\ a_0^{r-r^*} \\ a_0^{m-m^*} \\ a_0^{y-y^*} \end{bmatrix} + \begin{bmatrix} a_{11}a_{12}a_{13}a_{14} \\ a_{21}a_{22}a_{23}a_{24} \\ a_{31}a_{32}a_{33}a_{34} \\ a_{41}a_{42}a_{43}a_{44} \\ a_{51}a_{52}a_{53}a_{54} \end{bmatrix} \begin{bmatrix} EXC_{t-1} \\ \pi-\pi_{t-1}^* \\ r-r_{t-1}^* \\ m-m_{t-1}^* \\ y-y_{t-1}^* \end{bmatrix} + \begin{bmatrix} a_{11}a_{12}a_{13}a_{14} \\ a_{21}a_{22}a_{23}a_{24} \\ a_{31}a_{32}a_{33}a_{34} \\ a_{41}a_{42}a_{43}a_{44} \\ a_{51}a_{52}a_{53}a_{54} \end{bmatrix} \begin{bmatrix} EXC_{t-2} \\ \pi-\pi_{t-2}^* \\ r-r_{t-2}^* \\ m-m_{t-2}^* \\ y-y_{t-2}^* \end{bmatrix} + \begin{bmatrix} \varepsilon_{EXC_t} \\ \varepsilon_{\pi-\pi_t^*} \\ \varepsilon_{r-r_t^*} \\ \varepsilon_{m-m_t^*} \\ \varepsilon_{y-y_t^*} \end{bmatrix} \quad (1)$$

Where *EXC* denotes nominal exchange rate, π represents inflation rate, r denotes domestic interest rate, and y stands for income. The variables with asterisk represent the foreign counterpart. To test the null hypothesis that inflation differentials does not Granger cause exchange rate, the following restriction is specified H_0: $a_{12} = 0$, where a_{12} is the coefficient of the restricted lag value of inflation differentials in the model. Similarly, the second hypothesis that exchange rate does not Granger cause inflation differentials is tested by imposing the following restriction: H_0: $a_{11} = 0$ where a_{11} is the coefficient of the restricted lag value of exchange rate in Equation 1. The significance of the MWALD statistics in the two hypotheses respectively indicate the rejection of the null hypothesis of non-Granger causality from inflation differentials to exchange rate and vice versa. This indicates the existence of Granger causality among the variables.

The appropriate lag length is chosen through testing the significance of the lags in Equation 1 for $p>k$ condition (Toda and Yamamoto, 1995) and minimizing the Hatemi (2003) information criterion described below.

$$HJC = ln\left(\left|\cap_z\right|\right) + z \times v^2\left(\frac{\ln N + 2\ln\left(lnN\right)}{2N}\right) z = 0,\ldots,p. \quad (2)$$

where *HJC* is the Hatemi information criterion, *ln* represents natural logarithm, $\left|\cap_z\right|$ denotes the lag order of z determinant of the estimated white noise variance-covariance matrix in the VAR framework, v and N indicate the number of variables and observations used in the VAR model respectively. Furthermore, Equation 2 has been tested to work better especially if integration exist among the variables (Hatemi, 2003).

Nevertheless, the presence of ARCH effect and non-normality of residuals make the usual asymptotic distribution theory to work less efficiently (Hatemi and Irandoust, 2006; Hatemi, 2012). Therefore, we employ more reliable test and distribution; the asymmetric causality test and leverage bootstrap distribution theory especially in this type of finite sample study to avoid spurious deductions and size distortion.

4.4. Test for Asymmetric Causality

We perform the asymmetric causality following Hatemi (2012). The above process is replicated assuming $y^+ = (y_{1t}^+, y_{2t}^+)$ and $y^- = (y_{1t}^-, y_{2t}^-)$. The following VAR ($p$) order is applied as presented in Equations 3 and 4 below.

$$y_t^+ = \gamma + A_1 y_{t-1}^+ + \ldots + A_p y_{t-1}^+ + e_t^+ \quad (3)$$

$$y_t^- = \gamma + A_1 y_{t-1}^- + \ldots + A_p y_{t-1}^- + e_t^- \quad (4)$$

Where y_t^+ and y_t^- represent vector of positive and negative variables in Equations 3 and 4 respectively. γ is a vector of constant parameters. The symbol A is a vector of parameters to be estimated and e_t^+ and e_t^- denote vectors of both positive and negative error components for the cumulative sum of positive and negative shocks respectively in the case of integrated variables analysis and positive and negative changes in the stationary variables. The information criteria in Equation 2 is also adjusted to include the squares of the number of variables N^2 in the VAR model (Hatemi, 2012). The remaining process is as presented in the following section while taking into account asymmetric condition of positive and negative shocks in the model.

4.5. Bootstrap Procedure

We simulate the asymmetric causality and leverage bootstrap critical values with GAUSS using the program procedure developed by Hatemi (2012) and Hacker and Hatemi (2010) respectively. The critical values are generated based on the underlying empirical data through bootstrap simulation. The iteration is conducted 10,000 times and MWALD t-statistics are estimated after every iteration to determine the upper $(\alpha)^{th}$ quantile of the bootstrapped distribution of the MWALD t-statistics in order to generate 1%, 5% and 10% bootstrapped critical values. Finally, the raw data rather than the bootstrapped one is utilized to calculate the MWALD statistics. The null hypothesis of non-Granger causality is usually rejected if the MWALD statistics calculated using the original data is greater than the bootstrapped critical values.

5. EMPIRICAL RESULTS

The study employs Lee and Strazicich (LS) (2013) minimum LM test with one structural break to check the unit root properties of the data. This is one of the requirements of estimating the potent Toda and Yamamoto (1995) models. The test shows the maximum order of integration used in the VAR lag length augmentation. The result is presented in Table 1.

The LS test presented in Table 1 indicates that some variables are found to be integrated of order one $I(0)$ with structural break while majority of the variables are found non-stationary at level especially for Malaysia and Singapore. However, the test rejects the null hypothesis that series are $I(2)$ at all levels of significance. Therefore, the maximum order of integration of all the variables for all countries is found to be $I(1)$ order. This denotes that the lag augmentation (d_{max}) in estimating Toda and Yamamoto (1995) VAR model for all the countries is determined to be one[1]. In this study the break point λ is computed as T_B/T and found not beyond λ=0.1 in all cases. Therefore, the critical values displayed in Table 1 can be appropriately employed for testing the null hypotheses of unit root with structural break.

Table 2 depicts the test for ARCH effect, normality and optimal lag length in the VAR model. The null hypothesis of normality of residuals in the VAR model is rejected for all countries under study. Moreover, the null hypothesis of non-existence of multivariate ARCH effect is also rejected. The optimal lag length is determined to be 2, 1 and 1 for Brunei, Malaysia and Singapore respectively. The existence of multivariate ARCH effect and failure to fulfill the normality assumption render the traditional Granger causality based on asymptotic distribution theory to be associated with size distortion, nuisance parameter estimates and less applicable, (Hatemi and Irandoust, 2006). Thus, we employ the more reliable leverage bootstrap distribution theory and asymmetric causality test which perform better in the presence of non-normality and ARCH effect (Hatemi, 2012).

The results of the Granger non-causality MWALD test statistics, critical values of the leverage bootstrap and asymmetric causality based on the underlying empirical data employed in this study are presented in Table 3. The Granger non-causality test presented in Table 3 indicates non rejection of the null hypothesis of Granger non-causality in all direction for all countries except for Brunei where inflation differentials is found to Granger cause exchange rate without any feedback causality. Nevertheless, the null hypothesis of traditional Granger causality test at level estimation suffers from non-standard asymptotic distribution, whereas, the integrated Granger causality suffers the independence of nuisance parameter estimates (Sims et al., 1990; Toda and Philips, 1993).

Nonetheless, the result of the MWALD test based on leverage bootstrap distribution indicates different findings except for Brunei where inflation differentials also causes exchange rate. The results of Toda and Yamamoto (1995) MWALD bootstrapped critical values without asymmetric effect establish a one-way causation running from inflation differentials to exchange rate in Brunei and Singapore without any feedback from exchange rate. However, bidirectional causality is found between inflation differentials and exchange rate for Malaysia. Nevertheless, the concept of asymmetric information as argued by Hatemi (2012) might leads to different response to positive and negative shocks. This leads to varying causal relationship which has not been adequately considered in the previous literature. The asymmetric Granger non-causality test establishes the existence of Granger causality running from positive cumulative exchange rate shocks

1 The LS test result for the first difference are available from the authors upon request.

Table 1: Lee and Strazicich one-break minimum LM unit root test

Variables	Model A					Model C				
	$\hat{k}$	$\hat{T}_B$	$\hat{t}_{\gamma j}$	Test statistic	λ	$\hat{k}$	$\hat{T}_B$	$\hat{t}_{\gamma j}$	Test statistic	λ
Brunei										
LEXC	4	1985:03	−1.621	−1.844	−0.01	4	1991:01	−0.459	−2.024	−0.01
$\pi_t - \pi_t^*$	4	2008:03	1.406	−3.269[c]	0.01	4	2011:04	5.128***	−4.820[b]	0.04
$i_t - i_t^*$	4	2008:03	7.268***	−3.970[b]	0.05	4	2008:02	3.935***	−5.056[a]	0.03
$m_t - m_t^*$	4	1992:04	−5.435***	−3.070	−0.04	4	1992:04	−3.890***	−4.877[b]	−0.03
$y_t - y_t^*$	4	2011:04	0.327	−1.701	0.01	4	2011:04	8.081***	−7.015[a]	0.06
Malaysia										
LEXC	4	2010:01	2.024**	−2.967	−0.01	4	1998:03	−1.260	−3.833	−0.01
$\pi_t - \pi_t^*$	4	1985:03	−1.623	−1.813	−0.01	4	1988:02	0.384	−3.363	0.01
$i_t - i_t^*$	4	1994:01	−1.743*	−3.576[b]	−0.01	4	2005:01	−0.813	−4.452[b]	−0.01
$m_t - m_t^*$	4	1998:04	1.109	−1.845	0.01	4	1995:01	1.407	−3.037	0.01
$y_t - y_t^*$	4	2011:04	−0.348	−`1.714	−0.01	4	2011:04	8.091***	−7.086[a]	0.06
Singapore										
LEXC	4	2001:03	−2.226**	−3.038	−0.02	4	2001:03	−1.580	−3.280	−0.01
$\pi_t - \pi_t^*$	4	2008:03	4.428***	−0.776	0.03	4	1984:02	−0.451	−1.799	−0.01
$i_t - i_t^*$	4	2002:04	−5.918***	−4.112[b]	−0.04	4	2003:01	−1.975**	−4.031	−0.01
$m_t - m_t^*$	4	1990:04	5.900***	−1.926	0.04	4	1991:03	3.779***	−4.441[c]	0.03
$y_t - y_t^*$	4	2011:04	−0.348	−1.714	0.01	4	2011:04	8.091***	−7.086[a]	0.06
Critical values		1%	5%	10%						
Model A		−4.239	−3.566	−3.211						
Model C		−5.110	−4.500	−4.210						

$\hat{k}$ is the optimal number of lagged first-difference terms included in the unit root test to correct for serial correlation. $\hat{T}_B$ denotes the estimated break points. $\hat{t}_{\gamma j}$ is the t value of DT_{jt}, for j=1. λ is the critical value break point. See Lee and Strazicich (2013. p. 2488), for the critical values. a, b and c indicates significance of the LM test statistics at 99%, 95% and 90% critical level, respectively. While ***,**,*Indicates the two-tailed significance level of the break date at 99%, 95% and 90% respectively. LM: Lagrange multiplier

Table 2: Test for ARCH effect, normality and optimal lag length in the VAR model

Test	Brunei	Malaysia	Singapore
ARCH effect	0.000***	0.018**	0.041**
Normality	0.000***	0.000***	0.000***
Optimal lag length	2	1	1

***,**Represent rejection of the null hypothesis at 1% and 5% significant level respectively. Source: Authors computation. ARCH: Autoregressive conditional heteroscedasticity, VAR: Vector autoregressive

to positive cumulative shocks in inflation differentials for Brunei and Malaysia. However, the asymmetric causality for Singapore runs from both positive and negative cumulative inflation shocks to positive and negative exchange rate shocks respectively. The result does not show any evidence of feedback causality in the asymmetric causality test.

The results of this study reveal the significance of employing asymmetric causality test which differentiates the existence of causality during good and bad times. Except for Singapore, the findings indicate that exchange rate appreciation in Brunei and Malaysia tend to decrease the rate of inflation in the economies. The results for Brunei and Malaysia are in support of Einzig (1935) preposition that exchange rate causes inflation. The implication of the findings is that any policy intervention formulated on exchange rate can stabilize the domestic inflation rate especially during exchange rate appreciation. Nonetheless, the findings for Singapore indicate that decrease in domestic inflation causes exchange rate appreciation in the economy. Moreover, the result further shows that any increase in inflationary rate in the economy the exchange rate will depreciate. In other words, data on Singapore shows that depreciation of exchange rate is been caused by an increase in the inflationary pressure. This finding is in line with Cassel (1921) hypothesis who argues that causality runs from inflation to exchange rate. The result reveals that policy intervention on domestic inflation can stabilize the Singapore exchange rate irrespective of good or bad period.

6. CONCLUSIONS AND POLICY IMPLICATION

The study applies asymmetric causality in addition to MWALD test based on leverage bootstrapping conducted based on Toda–Yamamoto causality approach. The presence of non-normality of residuals and ARCH effect lead to spurious inferences when asymptotic critical values are employed. This is evidents when

Table 3: The result of Granger, Toda–Yamamoto, asymmetric causality and bootstrap simulation

The null hypothesis	Non-granger causality	MWALD test statistics	Leverage bootstrap 1% CV	5% CV	10% CV
Brunei					
$\pi-\pi^* \nRightarrow EXC$	10.700 (0.005)	5.751**	7.091	4.019	2.724
$(\pi-\pi^*)^+ \nRightarrow EXC^+$		5.291	16.134	9.737	6.989
$(\pi-\pi^*)^- \nRightarrow EXC^-$		2.087	10.719	6.515	5.016
$EXC \nRightarrow \pi-\pi^*$	0.864 (0.649)	0.790	7.585	4.013	2.788
$EXC^+ \nRightarrow (\pi-\pi^*)^+$		16.129***	14.435	8.800	6.679
$EXC^- \nRightarrow (\pi-\pi^*)^-$		2.596	10.263	6.356	4.781
Malaysia					
$\pi-\pi^* \nRightarrow EXC$	1.150 (0.284)	3.584**	7.447	4.047	2.880
$(\pi-\pi^*)^+ \nRightarrow EXC^+$		1.439	7.313	3.999	2.805
$(\pi-\pi^*)^- \nRightarrow EXC^-$		1.896	7.529	4.000	2.750
$EXC \nRightarrow \pi-\pi^*$	1.853 (0.173)	4.185**	7.343	4.100	2.813
$EXC^+ \nRightarrow (\pi-\pi^*)^+$		7.150**	8.910	4.753	3.188
$EXC^- \nRightarrow (\pi-\pi^*)^-$		0.937	7.599	4.085	2.775
Singapore					
$\pi-\pi^* \nRightarrow EXC$	3.957 (0.138)	3.751*	6.694	3.855	2.703
$(\pi-\pi^*)^+ \nRightarrow EXC^+$		3.188*	7.574	3.914	2.703
$(\pi-\pi^*)^- \nRightarrow EXC^-$		3.751*	7.765	4.050	2.750
$EXC \nRightarrow \pi-\pi^*$	1.621 (0.445)	0.904	7.166	4.059	2.778
$EXC^+ \nRightarrow (\pi-\pi^*)^+$		0.000	7.451	3.871	2.757
$EXC^- \nRightarrow (\pi-\pi^*)^-$		1.028	7.992	3.979	2.764

***,**,* Represent rejection of null hypothesis at 1%, 5% and 10% significance level respectively, with reference to bootstrap simulated critical values. The symbol $\nRightarrow$ represents Granger non-causality. The estimated order of the VAR ($p+d_{max}$) model is determined to be two for all countries. This is made up of the VAR order p and a constant one lag augmentation, because the maximum order of integration does not exceed one for all series. The figures enclose in parenthesis under column two represent the P values of Granger non-causality. Source: Authors computations using RATS and GAUSS versions 8 and 11 respectively. VAR: Vector autoregressive, MWALD: Modified WALD

the traditional Granger causality is estimated where there exist no causal relationship between inflation differentials and exchange rate in all countries under study except for Brunei where inflation differentials is found to Granger cause exchange rate. The major contribution of this study is that we distinguish the existence of causality in the positive (good) and negative (bad) shocks scenarios using data from emerging economies. The contradictory findings reported in Table 3 proved the existence of size distortion and nuisance parameter estimates when the traditional Granger causality method is used. This usually occurred when normality assumption of empirical data is overlooked, ARCH effect exists and integrated series are employed in the investigation (Hacker and Hatemi, 2006; Toda and Yamamoto, 1995).

The policy implication of this study is that the monetary authorities of Brunei and Malaysia can manipulate exchange rate to stabilized inflation differentials during good period (exchange rate appreciation) in the economies. However, the monetary authority of Singapore can only manipulate domestic inflation to stabilized exchange rate fluctuation irrespective of whether during good or bad periods. This means that monitoring the rate of inflation in Singapore can regulate the level of instability in exchange rates. However, such a conclusion does not hold for Brunei and Malaysia at least for the sample period.

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