Tax, spend, and democracy indices in Japan

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No. 2015-E01
2015.10

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October, 2015

Abstract

The paper investigates the revenue-expenditure nexus in the case of Japan by using five variables of revenues and four variables of expenditures. The techniques to analyze the causal relationship depend on the properties of the series. This paper utilizes three kinds of approaches; a VAR model setting by adding the extra lags, which is provided by Toda and Yamamoto (1995), a differenced VAR modeling, where there is no cointegrating relationship between non-stationary series, and a threshold error correction specification, which is proposed by Enders and Siklos (2001).

It is found that when we focus on the total expenditures excluding debt services and the total revenues excluding bond issues respectively, there is no causal relationship between them and the institutional separation hypothesis is supported in Japan. However, the expenditures excluding debt services Granger cause bond revenues. Especially regarding expenditures for social security and pensions, there exists the bidirectional causality between bond revenues and them. However, there is no causality that runs from expenditures for social security and pensions to tax revenues though there exists the causality that runs expenditures for public works to tax revenues. In addition, it is not observed such causality that when tax revenues increase, bond issues decrease. Therefore it concludes that the reason for accumulating the debt outstanding of the central government in Japan would be the increase in expenditures for social security and pensions by aging of Japanese society without taking account of the level of the revenues.

[*1]Earlier versions of the paper were presented at *Singapore Economic Review Conference 2013* (Singapore, 2013), *the Japanese Economic Association* (Tokyo, 2013), and Research workshop at Kyushu University (Fukuoka, 2013). We are grateful for helpful comments made by participants on those occasions. The research is partially supported by JSPS Grant-in-Aid for Scientific Research(C) 26380271.

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Furthermore, when more controllable variables are set as expenditures like the national land conservation and development, it is found that the MTAR setting is statistically chosen, asymmetries in the adjusting process of the deviation from the long-run equilibrium is found, and in the case of worsening changes of budget deficits the adjustment process works well to avoid the deficit crisis. But it seems to unsustainable, since deficits are reduced by utilizing non-tax revenues in Japan.

Finally, to take account of political aspects, the paper examines causal relationships of revenues and democracy indices such as the approval rates of the Cabinet and ruling parties, and the democracy index. It concludes that policymakers would finance expenditures by bond revenues and implement tax reduction policy in order to remain in power. In addition, it is found that when the approval rate for the Cabinet becomes higher, policymakers implement the issuance of more government bonds.

JEL classification: C32, C54, H50, H60

Key Words: Revenues; expenditures; central government; asymmetries; Granger non-causality; error correction model; TAR/MTAR model; structural break; aging economy; social security and pensions; democracy index

1 Introduction

The paper examines the intertemporal relationship between the Japan's central government revenues and expenditures by using Granger non-causality test for these time series. According to Payne (2003), which reviews comprehensively the revenue-expenditure nexus and the related empirical literature, four behavioral hypotheses on the relationship between revenues and expenditures have been verified in a large number of literature. These hypotheses are based on the existence and the direction of the causal relationship between government revenues and expenditures. First, the tax-spend hypothesis is that the causality runs from revenues to expenditures, which is given by Friedman (1978) and Buchanan and Wagner (1977). Second, Barro (1979) and Peacock and Wiseman (1979) propose the spend-tax hypothesis which argues that the causality run in opposite direction, from expenditures to revenues. Third, the fiscal synchronization hypothesis is that revenues and expenditures have bidirectional causality, which is provided by Musgrave (1960) and Meltzer and Richard (1981). Fourth, the institutional separation hypothesis is that revenues and expenditures have no causality; see, in detail, Wildavsky (1964, 1988) and Baghestani and McNown (1994).

Our main objective is to investigate a matter of generating budget deficits in the Japan's central government by using Granger non-causality test for several kinds of the revenues and expenditures series. Furthermore, the long-run sustainability of budget deficits is examined by testing the significance of coefficients on the error correction term. The long-term debt outstanding of Japan's central government at the end of FY 2010 is 663 trillion yen and its share of GDP runs up 134%. Adding to local governments, Figure 1 shows that the long-term debt outstanding in the whole government is 862 trillion yen and its share of GDP reaches 181%, which is the worst level in OECD countries. Although Japan's fiscal deficits have been financed by abundant domestic savings, the Japan's government might meet repayment problems and seriously decide whether cutting in expenditures or rising tax rate in the future. In fact the Japan's government decided to expand public expenditures by issuing of the government bonds adding to monetary easing measures toward the economic recovery in 2013 and the consumption tax was increased from 5% to 8% on April of 2014. The impacts of these policies on the debt outstanding and business cycles depend on domestic and international macroeconomic situations as well as the Japan's government decision making process, which would be expressed as causality between the central government revenues and expenditures.

Figure 1 should be inserted around here.

In the revenue-expenditure nexus, early studies have checked the causal relationship between revenues and expenditures by Granger non-causality test based on vector autoregressive (VAR) models or error correction models. Recently, many researches have employed to threshold autoregressive (TAR) and momentum threshold autoregressive (MTAR) models provided by Enders and Siklos (2001). Ewing et al. (2006) is the first paper which applied TAR and MTAR models to the causal analysis on revenues and expenditures. This approach has an advantage that it is possible to test whether the adjusting process toward the log-run equilibrium is symmetry and to estimate the threshold which determines whether policymakers adjust revenues and expenditures toward the log-run equilibrium. The threshold is defined by levels of budget surplus or deficit in the case of TAR model, and in the case of MTAR model, it is defined by changes in budget surplus or deficit. When the TAR model is statistically significant, it indicates that the government adjusts revenues and expenditures by reacting to levels of budget surplus or deficit. When the MTAR model is chosen, it implies that the government adjusts revenues and expenditures by reacting to changes of budget surplus or deficit. In the case that both models are statistically valid, policymakers would respond to both of levels and changes of budget surplus or deficit toward the long-run equilibrium. In this way, it is possible to gain a more insight into the government behavior by utilizing TAR and MTAR models than by using a symmetric modeling.

The paper is organized as follows. Section 2 describes the set of data used in this paper and our estimation strategy. Section 3 provides the properties of the data by using the unit root tests and the cointegration tests. In Section 4 the causal relationships between the series are investigated by using three kinds of techniques. For checking the robustness of results, Section 5 reinvestigates the causal relationships among the revenues and expenditures variables by using different types of variables; nominal and real variables, which are adjusted by GDP deflator, Consumer Price Index (CPI), and Corporate Goods Price Index (CGPI). Section 6 introduces political aspects to our analysis. Section 7 provides concluding remarks.

2 Data and estimation strategy

2.1 Data

Our data set consists of annual observations for Japan over the period FY 1955 to FY 2009 except for the bond issues, which was not allowed from FY 1965 to FY 2009. All data on revenues and expenditures are taken from the settlement of the general accounts based on "Financial Statistics of Japan" by Ministry of Finance. We use four different types of data on central government revenues;

1. the total revenues minus the bond issues ($CGR1$),
2. the bond issues ($CGR2$),
3. the bond issues and the tax and stamp revenues ($CGR3$),

4. non-tax revenues ($CGR4$) such as revenues on the sale of government assets and from government enterprises.

The $CGR1$ is the sum of $CGR3$ and $CGR4$. Regarding the data on government expenditures, we consider five different types according to controllability of expenditures by policymakers;

1. the total central government expenditures minus the debt services ($CGE1$),
2. $CGE1$ minus the expenditures for the local government finance which are mainly local allocation tax grants to local governments ($CGE2$),
3. the expenditures for the national land conservation and development, namely public works ($CGE3$),
4. $CGE2$ minus the expenditures for the social security and pensions ($CGE4$),
5. the expenditures for the social security and pensions ($CGE5$).

The series of $CGE3$ and $CGE4$ would be more controllable than $CGE1$, $CGE2$ and $CGE5$ for the central government. In the following $_G$ denotes the GDP ratio data; for example, $CGR1_G$ indicates that $100 \times CGR1$ is divided by GDP. Tables 1 and 2 summarize the relationships among each variables we will use in the following investigation.

Tables 1 and 2 should be inserted around here.

The data on GDP comes from "Annual Report on National Accounts" by Cabinet Office in Japan. Although National Accounts in Japan is currently based on SNA93 (System of National Accounts, 1993), the data created by retrospective adjustment is available since FY 1980 only. Therefore, we create the series of GDP from FY 1955 to FY 2009 by calculating the ratio of GDP by SNA93 to GDP by SNA68 in FY 1980 and multiplying the series of GDP from FY 1955 to FY 1979 by this ratio.

The series for revenues and expenditures in Japan are displayed in Figure 2 and their basic statistics are given by Table 3.

Figure 2 and Table 3 should be inserted around here.

2.2 Estimation strategy

To test four behavioral hypotheses of the Japan's central government, the paper adopts the following estimation strategy:

Step 1: Check the stationarity of each series by unit root tests with/without a break.

Step 2: If the series are $I(1)$ processes, check the cointegrating relationships between them by cointegration tests with/without a break and with/without a threshold. If the integrated order of the series is not determined by unit root tests or larger than one, test Granger non-causality by Toda and Yamamoto (1995)'s approach.

Step 3: Based on the error correction representation, including no cointegration, test Granger non-causality between the series.

3 Preliminary tests

3.1 Unit root tests

First of all, the order of integration for each series is determined by ADF, PP, and KPSS tests. The former two test the null hypothesis of a unit root, and the last one tests the null hypothesis of stationarity. Table 4 reports the results of these unit root tests. This table shows that, taking into account three testing procedures, all series seem to be $I(1)$ process except for $CGR4_G$ under no structural break. In addition to the whole sample case, we deal with three cases where the last one, two, and three years in the sample are deleted for checking the robustness of the unit root test results, since Figure 2 shows some of variables are increasing steeply, especially in the last three years. But this treatment did not affect the test results.

Table 4 should be inserted around here.

3.2 Unit root tests with a break

Although the orders of integration are chosen by ADF, PP, and KPSS tests, it is necessary to check them with an endogenously determined structural break. By using the method by Zivot and Andrews (1992), consider the following three models:

$$\begin{aligned}
\text{Model A: } y_t &= \mu + \theta DU_t(\lambda) + \beta t + \alpha y_{t-1} + \sum_{j=1}^{k} c_j \triangle y_{t-j} + e_t, \\
\text{Model B: } y_t &= \mu + \beta t + \gamma DT_t^*(\lambda) + \alpha y_{t-1} + \sum_{j=1}^{k} c_j \triangle y_{t-j} + e_t, \\
\text{Model C: } y_t &= \mu + \theta DU_t(\lambda) + \beta t + \gamma DT^*(\lambda) + \alpha y_{t-1} + \sum_{j=1}^{k} c_j \triangle y_{t-j} + e_t,
\end{aligned}$$

where

$$\begin{aligned}
DU_t(\lambda) &= \begin{cases} 1 & \text{if } t > T\lambda \\ 0 & \text{if } t \leq T\lambda \end{cases}, \\
DT_t^*(\lambda) &= \begin{cases} t - T\lambda & \text{if } t > T\lambda \\ 0 & \text{if } t \leq T\lambda \end{cases},
\end{aligned}$$

$e_t \sim i.i.d.(0, \sigma_e^2)$, and T indicates the sample size. Each model is estimated by ordinary least squares with the break fraction λ, using the middle 70% of the whole sample. For each value of λ, t statistic on $\hat{\alpha}$ is evaluated, and the minimum t statistic among them is set as $t_{\hat{\alpha}}^*$;

$$t_{\hat{\alpha}}^* = \inf_{\lambda \in \Lambda} t_{\hat{\alpha}}(\lambda).$$

Zivot and Andrews (1992) provide the critical values of $t_{\hat{\alpha}}^*$, where the null hypothesis is given by $H_0: \ \alpha = 1$. In this paper, Λ is set as $[0.15, 0.85]$, that is, the middle 70% of the whole data is used to search the break point. Table 5 reports t statistics and a break year for each model and indicates that $CGR1_G$, $CGR3_G$, $CGE3_G$, and $CGE4_G$ are still $I(1)$ variables, but the order of integration of $CGR2_G$, $CGE1_G$ and $CGE5_G$ is two under an endogenously determined structural break. Also the order of integration of $CGE2_G$ is undetermined by Table 5. In the case of $CGR4_G$, the order of integration is zero, which is not related with the presence of breaks.

Table 5 should be inserted around here.

Following our estimation strategy, we divide the set of the series into 24 groups:

Group 1: $CGR1_G$ and $CGE3_G$

Group 2: $CGR1_G$ and $CGE4_G$

Group 3: $CGR3_G$ and $CGE3_G$

Group 4: $CGR3_G$ and $CGE4_G$

Group 5: $CGR1_G$ and $CGE1_G$

Group 6: $CGR1_G$ and $CGE2_G$

Group 7: $CGR1_G$ and $CGE5_G$

Group 8: $CGR2_G$ and $CGE1_G$

Group 9: $CGR2_G$ and $CGE2_G$

Group 10: $CGR2_G$ and $CGE3_G$

Group 11: $CGR2_G$ and $CGE4_G$

Group 12: $CGR2_G$ and $CGE5_G$

Group 13: $CGR3_G$ and $CGE1_G$

Group 14: $CGR3_G$ and $CGE2_G$

Group 15: $CGR3_G$ and $CGE5_G$

Group 16: $CGR4_G$ and $CGE1_G$

Group 17: $CGR4_G$ and $CGE2_G$

Group 18: $CGR4_G$ and $CGE3_G$

Group 19: $CGR4_G$ and $CGE4_G$

Group 20: $CGR4_G$ and $CGE5_G$

Group 21: $CGR2_G$ and $CGR1_G$

Group 22: $CGR2_G$ and $CGR3_G$

Group 23: $CGR4_G$ and $CGR2_G$

Group 24: $CGR4_G$ and $CGR3_G$

Regarding Groups 1 to 4, we will check the existence of cointegrating relationships between the series, since the order of integration of each series in Groups 1 to 4 is one. The causal relationships between the series in Groups 5 to 24 will be investigated based on the method by Toda and Yamamoto (1995), where the merits of Toda and Yamamoto's approach are that it is not necessary to identify the order of integration of each series and the cointegrating relationship between them, and it can deal with the case that each series has the different order of integration. Groups 21 and 24 examine causal relationships among revenues variables to examine a policy maker's decision on the amount of bound issues and non-tax revenues.

If the policymaker issued bonds without increasing tax and non-tax revenues to finance public services and social infrastructures, the debt outstanding in the Japan's central government would expand unlimitedly.

3.3 Cointegration tests

As each group is constructed of just two series in the paper, the method by Engle and Granger (1987) is utilized to test the existence of cointegration between the series in each group. For checking the robustness of the cointegration test, estimate the model twice by replacing the dependent variable with the independent one. Table 6 reports the results of the cointegration tests and implies that there is no long-run relationship between the series. In Groups 1 and 3, when $CGE3_G$ is set as the dependent variable the test statistics are statistically significant, but by replacing the role of the variable these significances disappear. We conclude that there is no cointegrating relationship between the series in each group.

Table 6 should be inserted around here.

3.4 Cointegration tests with a break

Although the previous subsection shows no cointegration, we consider the cointegration test by Gregory and Hansen (1996), where endogenous breaks are taken into account. Following Gregory and Hansen (1996), three kinds of models are examined:

$$\begin{aligned}
\text{Level shift (C): } y_{1t} &= \mu_1 + \mu_2\phi_{t\lambda} + \alpha y_{2t} + e_t, \\
\text{Level shift with trend (C/T): } y_{1t} &= \mu_1 + \mu_2\phi_{t\lambda} + \beta t + \alpha y_{2t} + e_t, \\
\text{Regime shift (C/S): } y_{1t} &= \mu_1 + \mu_2\phi_{t\lambda} + \alpha_1 y_{2t} + \alpha_2 y_{2t}\phi_{t\lambda} + e_t,
\end{aligned}$$

where $e_t \sim (0, \sigma_e^2)$ and

$$\phi_{t\lambda} = \begin{cases} 1 & \text{if } t > T\lambda \\ 0 & \text{if } t \leq T\lambda \end{cases}.$$

The above cointegrating equation is estimated by ordinary least squares, and a unit root test is applied to the regression errors. For each $\lambda \in \Lambda = [0.15, 0.85]$, evaluate $ADF(\lambda)$, $Z_\alpha(\lambda)$, and $Z_t(\lambda)$ statistics, and test the null hypothesis of no cointegration based on the minimum $ADF(\lambda)$, $Z_\alpha(\lambda)$, and $Z_t(\lambda)$ statistics. The $ADF(\lambda)$ is given by t statistic on $\hat{e}_{t-1\lambda}$, where $\triangle \hat{e}_{t\lambda}$ is regressed on $\hat{e}_{t-1\lambda}, \triangle \hat{e}_{t-1\lambda}, \cdots, \triangle \hat{e}_{t-K\lambda}$;

$$ADF(\lambda) = t_{\hat{\rho}_\lambda}.$$

The $Z_\alpha(\lambda)$ and $Z_t(\lambda)$ are given by

$$\begin{aligned} Z_\alpha(\lambda) &= T(\hat{\rho}^*_\lambda - 1), \\ Z_t(\lambda) &= (\hat{\rho}^*_\lambda - 1)/s.e.(\hat{\rho}_\lambda), \end{aligned}$$

where $\hat{\rho}^*_\lambda$ is the bias-corrected first-order serial correlation coefficient estimate. The final statistics we use are given by

$$\begin{aligned} ADF^* &= \inf_{\lambda \in \Lambda} ADF(\lambda), \\ Z^*_\alpha &= \inf_{\lambda \in \Lambda} Z_\alpha(\lambda), \\ Z^*_t &= \inf_{\lambda \in \Lambda} Z_t(\lambda). \end{aligned}$$

Asymptotic distribution of each test statistics are provided by Gregory and Hansen (1996), and Table 7 gives test statistics, break years, and selected lags order for ADF statistics. Table 7 implies that there is no cointegrating relationship between the series in each group even in the presence of endogenously determined structural breaks.

Table 7 should be inserted around here.

3.5 Threshold cointegration tests

Although the cointegrating relationship between the series is not found irrespective of the existence of structural breaks, it seems to be possible that there is a threshold cointegrating relationship between the series, which is given by Enders and Siklos (2001). The paper investigates the threshold autoregressive (TAR) and momentum TAR (MTAR) model to test the existence of the cointegration, where in the TAR model the degree of autoregressive decay depends on the state of the variable concerned, and in the MTAR model a variable to display differing amounts of autoregressive decay depends on whether it is increasing or decreasing. To deal with the case of unknown threshold, Chan (1993)'s method is utilized in this paper. Consider the following model:

$$y_{1t} = \beta_0 + \beta_1 y_{2t} + e_t, \tag{3.1}$$

$$\triangle e_t = I_t \rho_1 e_{t-1} + (1 - I_t)\rho_2 e_{t-1} + \sum_{j=1}^{k} \gamma_j \triangle e_{t-j} + \varepsilon_t, \tag{3.2}$$

where $e_t \sim i.i.d.(0, \sigma_e^2)$, $\varepsilon_t \sim i.i.d.(0, \sigma_\varepsilon^2)$, and the Heaviside indicator I_t is given by

$$I_t = \begin{cases} 1 & \text{if } e_{t-1} \geq \tau \\ 0 & \text{if } e_{t-1} < \tau \end{cases}, \tag{3.3}$$

where τ is a threshold. As another identification of adjustment process, consider

$$I_t = \begin{cases} 1 & \text{if } \triangle e_{t-1} \geq \tau \\ 0 & \text{if } \triangle e_{t-1} < \tau \end{cases}. \tag{3.4}$$

When I_t is defined by (3.3), it is called to be the TAR model, and in the case (3.4) is set as I_t it is the MTAR model. By using the residuals obtained in the cointegration equation (3.1), estimate (3.2). Enders and Siklos (2001) provide two test statistics, that is, the one is to use maximum value between t statistics on $\hat{\rho}_1$ and on $\hat{\rho}_2$, which is called to be t-Max test, and another one is Φ test based on F statistic of $\rho_1 = \rho_2 = 0$. When the null hypothesis of $\rho_1 = \rho_2 = 0$ is rejected, test the null hypothesis of $\rho_1 = \rho_2$ based on F distribution; see, for example, Ewing et al. (2006) and Payne et al. (2008). The distribution of t-Max and Φ statistics are provided by Enders and Siklos (2001). Although it is well known that the necessary and sufficient conditions for the stationarity of $\{e_t\}$ is $\rho_1 < 0, \rho_2 < 0$ and $(1+\rho_1)(1+\rho_2) < 1$ for any value of τ, this paper just confirms whether final estimates of ρ_1 and ρ_2 satisfy the conditions. In all cases the estimates of ρ_1 and ρ_2 for TAR models do not meet the conditions, while the stationary conditions are satisfied in all MTAR settings. Table 8 reports MTAR estimation results and indicates in the case of Groups 1 and 2 the null hypothesis of $\rho_1 = \rho_2 = 0$ is rejected and this result does not depend on how to choose the dependent variable. Furthermore, the null hypothesis of $\rho_1 = \rho_2$ is rejected in both cases. It concludes that there is a threshold cointegration in Groups 1 and 2 respectively, that is, by taking asymmetry adjustments into account we can find a long-run relationship between the series. But in the case of Groups 3 and 4, the result of threshold cointegration tests depends on the selected dependent variable, and it concludes that the null hypothesis of $\rho_1 = \rho_2 = 0$ is not rejected in each group. In the following, the causal relationship in Groups 1 and 2 are examined by using threshold error correction representations and differenced VAR models are used to identify Granger causality in Groups 3 and 4.

Table 8 should be inserted around here.

4 Empirical results

4.1 Causal analyses by VAR model

As Groups 5 to 24 include the variables whose orders of integration are not one, we use Toda and Yamamoto's approach, where we estimate a $(p + d_{\max})$th order VAR model, where $d_{\max}$ is the maximal order of integration that we suspect might occur in the series. The $d_{\max}$ is set by two in this paper. For Groups 5 to 24, the likelihood ratio tests select one, two, and four as the lag orders for each model, that is, by taking account of extra two lags we estimate VAR(3), VAR(4) and VAR(6) models respectively to test Granger non-causality. Consider the bivariate VAR(3) model, which is constructed of x_t and y_t. To test the null hypothesis of Granger non-causality from $\{y_t\}$ to $\{x_t\}$, it needs to test whether the coefficient on y_{t-1} is significantly different from zero or not by using its t-statistic. In the cases of VAR(4) and VAR(6) models, the number of zero restrictions on coefficients is not equal to one, the $Wald$ test is available to test Granger non-causality. Tables 9 and 10 report t-statistics, $Wald$ statistics and their p-values, and it concludes that the null hypotheses of Granger non-causality from $CGE1_G$ to $CGR2_G$, from $CGE1_G$ and $CGR3_G$, and from $CGR4_G$ to $CGR3_G$ are rejected at 10%, 5%, and 1% significance levels respectively, that is, $CGE1_G$ Granger causes $CGR2_G$ and $CGR3_G$, and $CGR4_G$ causes $CGE3_G$ in the sense of Granger. Furthermore, in the cases of Group 12 and 23, the null hypotheses of non-causality for both directions are rejected at 5% and 10% significance levels respectively, and these results indicate that the fiscal synchronization hypothesis is valid for the pair of $CGR2_G$ and $CGE5_G$, and the one of $CGR4_G$ and $CGR2_G$.

Tables 9 and 10 should be inserted around here.

4.2 Causal analyses by differenced VAR models

As there is no cointegrating relationship between the series in Groups 3 and 4, we apply the differenced VAR estimation approach to test Granger non-causality. Consider the bivariate VAR model constructed of x_t and y_t as in the previous subsection. The null hypothesis of Granger non-causality from y_t to x_t is identified by zero restrictions of all coefficients on the lagged y_t variables, and Granger non-causality tests are conducted by the $Wald$ statistics. Table 11 gives the results of causal analyses based on differenced VAR models. In the case that $CGR3_G$ is set as the dependent variable in 3 to 5th lag order VAR models, the null hypothesis of zero restrictions are rejected and it is found that $CGE3_G$ causes $CGR3_G$ in the sense of Granger.

Table 11 should be inserted around here.

4.3 Causal analyses by threshold error correction model

As asymmetries in the adjustment process under the cointegrating relationship are found between the series in Groups 1 and 2, a momentum threshold error correction model is estimated to identify the causal relationship between them. The error correction term is defined by

$$\begin{aligned} R_t &= \beta_0 + \beta_1 G_t + e_t, \\ \triangle \hat{e}_t &= I_t \rho_1 \hat{e}_{t-1} + (1 - I_t)\rho_2 \hat{e}_{t-1} + \sum_{j=1}^{k} \gamma_j \triangle \hat{e}_{t-j} + \varepsilon_t, \\ I_t &= \begin{cases} 1 & \text{if } \triangle \hat{e}_{t-1} \geq \tau \\ 0 & \text{if } \triangle \hat{e}_{t-1} < \tau \end{cases}, \end{aligned}$$

where $e_t \sim i.i.d.(0, \sigma_e^2)$, $\varepsilon_t \sim i.i.d.(0, \sigma_\varepsilon^2)$, $\{\hat{e}_t\}$ is the residual sequence, and R_t and G_t indicate the revenues and the expenditures respectively. The error term $\hat{e}_t$ implies the level of the surplus if e_t is positive, and the level of deficits otherwise. We estimate the corresponding asymmetric error correction model which is given by

$$\begin{aligned} \triangle R_t &= \mu_0 + \sum_{i=1}^{p} \alpha_i \triangle R_{t-i} + \sum_{i=1}^{p} \beta_i \triangle G_{t-i} + \rho_1 I_t \hat{e}_{t-1} + \rho_2 (1 - I_t)\hat{e}_{t-1} + u_{1t}, \\ \triangle G_t &= \tilde{\mu}_0 + \sum_{i=1}^{p} \tilde{\alpha}_i \triangle R_{t-i} + \sum_{i=1}^{p} \tilde{\beta}_i \triangle G_{t-i} + \tilde{\rho}_1 I_t \hat{e}_{t-1} + \tilde{\rho}_2 (1 - I_t)\hat{e}_{t-1} + u_{2t}. \end{aligned}$$

Table 12 gives the $Wald$ statistics to test the Granger non-causality, their p-values, estimates of ρ_i for $i = 1, 2$, their p-values, and estimated thresholds $\hat{\tau}$ for the lag order from 1 to 5.

Table 12 should be inserted around here.

In Group 1, there is no proof to imply the short-run Granger causality from $\triangle CGR1_G$ to $\triangle CGE3_G$, and from the error correction term to $\triangle CGE3_G$. However in the opposite direction, the null hypothesis of no Granger causality from $\triangle CGE3_G$ to $\triangle CGR1_G$ is rejected for all lag orders, and, furthermore, ρ_2 is significantly different from zero at 1% significance level for all the specifications. The result of Group 2 is that Granger causality from the variable $CGR1_G$ of revenues to the variable $CGE4_G$ of expenditures is not found at all, and this is the same as in Group 1. Although the short-run causality from $\triangle CGE4_G$ to $\triangle CGR1_G$ is not found and ρ_1 is not significantly different from zero, the null hypothesis of $\rho_2 = 0$ is rejected at 1% significance level for all the lag orders. In both cases of Groups 1 and 2, the estimates of ρ_2 are negative and their absolute values are less than one, and the estimated signs of thresholds τ are negative.

4.4 Implication

Our main result is that there is no causal relationship between $CGR1_G$ (the total revenues excluding the bond issues) and $CGE1_G$ (the total expenditures excluding the debt services) as well as $CGE2_G$ ($CGE1_G$ minus expenditures for grants to local governments). This result supports for the institutional separation hypothesis in the Japan's central government. Thus, $CGR1_G$ and $CGE1_G$ (or $CGE2_G$) would be decided independently. However it seems that the level of deficits in Japan is not still in the critical phase. This implies that there exist some relationships between the revenues and expenditures variables, and by dividing the revenues variable into three variables it is found that $CGE1_G$ Granger causes $CGR2_G$ (the revenues by the bond issues) and $CGE3_G$ (public works) one-sidedly. Although these mechanisms, that is, issuing bonds and raising the tax, have been working well to avoid the deficit crisis in Japan so far, the budget deficits have been increasing because of not enough increase in tax. To investigate the reason of expanding deficits, it is required to consider each item of the expenditures variable.

Regarding more controllable expenditures, $CGE3_G$ and $CGE4_G$ (government expenditures except the debt services, grants to local governments, and social security with pensions), the threshold cointegration relationships between $CGE3_G$ (or $CGE4_G$) and $CGR1_G$ are found. When these expenditures increase and then the deviation from the long-run equilibrium expands beyond a certain negative threshold, $CGR1_G$ will be adjusted to the long-run equilibrium, but $CGR3_G$ (tax and stamp revenues) will not. This asymmetric finding implies that $CGR4_G$ (non-tax revenues such as revenues on the sale of government assets and revenues from government enterprises) would be adjusted to the long-run equilibrium because $CGR1_G$ consists of $CGR3_G$ and $CGR4_G$. The absolute values of estimates of ρ_2 in the M-TAR specifications for Groups 1 and 2 are less than one, this indicates in the long-run the relationship between $CGR4_G$ and $CGE3_G$ (or $CGE4_G$) is sustainable. But as the order of integration of $CGR4_G$ is determined by zero, we could not apply TAR specifications to $CGR4_G$. Furthermore, it is found that $CGR4_G$ and $\triangle CGE3_G$ Granger cause $CGE3_G$ and $\triangle CGR3_G$ respectively. It might indicate that to increase the public work, the policy maker consider to sell government assets and when the budget is not enough to do the public work, in the short run she or he will increase the tax, but the level of tax rates are not enough to avoid the debt crisis in the long run. As a result, it concludes that Japan's central government utilizes non-tax revenues for improving the budget deficits when controllable expenditures expand. However, this policy seems to be a lack of plan, since Spend-Tax hypothesis is valid only in the short run and it would be impossible to continue it forever, since government's assets are not unlimited.

Which components of expenditures generate fiscal deficits in Japan crucially? While there is no causality between $CGE3_G$ and $CGR2_G$ as well as between $CGE4_G$ and $CGR2_G$, there exists the bidirectional causality between $CGE5_G$ (social security and pensions) and $CGR2_G$. In addition, there is no causal relationship between $CGR3_G$ (or $CGR4_G$) and $CGE5_G$, and there exists the causality that runs from $CGE3_G$ to $CGR3_G$ in the short run. Although tax revenues react to expenditures for public works, these do not react to expenditures for social security and pensions. This results show that the expenditure for social security and pensions is financed by not raising tax but issuing bonds and that issuing bonds would also generate expenditures for social security and pensions inversely.

In pairs of revenues variables, although there exists the bidirectional causal relationship between $CGR2_G$ and $CGR4_G$, $CGR2_G$ does not Granger cause $CGR1_G$ and $CGR3_G$ and vice versa, that is, when raising tax revenues, bond issues do not decrease necessarily. Accordingly, it concludes that expanding expenditures for social security and pensions by aging of Japanese society results in more increasing the debt outstanding of Japan's central government, and the way of financing more controllable expenditures is not sustainable.

5 Robustness checks

To check the robustness of our results based on the GDP ratio data, we reestimate the causal relationship between revenues and expenditures by using four types of variables; nominal and three versions of real variables defined by using GDP deflator, CPI, and CGPI, since there is no consensus about the measures of revenues and expenditures in the empirical literature. See, for example, Ram (1988) and Baghestani and McNown (1994). By using not only GDP deflator but also CPI and CGPI as in Ram (1988), we transform nominal data to real data. In the following, $_{r1}$, $_{r2}$ and $_{r3}$ indicate that the series is adjusted by GDP deflator, CPI and CGPI respectively. The data on GDP deflator comes from "Annual Report on National Accounts" by Cabinet Office in Japan, and the data on CPI and CGPI is available on Bank of Japan's website. All variables are transformed into natural logs. Table 13 shows basic statistics for them.

Table 13 should be inserted around here.

Following the same estimation procedures in the previous analysis, Tables 14 to 28 shows Granger non-causality test results. For the same reason in Section 3, we report MTAR specification results when there exists a threshold cointegration between variables. In all the cases, it is observed that $CGE1$, $CGE5$ and $CGR4$ Granger cause $CGR2$, and the causality runs from $CGE3$ to $CGR3$. These results indicate that the public work is financed healthly, but other expenditures, especially social security and pensions, depend on issuing the bonds. These findings are observed consistently in Japan. However, there are considerably various results, which depend on the setting as in Ram (1988). When real variables are used, it is necessary to consider which type of real variables are suitable to the purpose of the research. Although Tables 14 to 28 cannot provide consistent results, it is found that the spend-tax hypothesis is valid when there is any causal relationship between revenues and expenditures.

Tables 14 to 28 should be inserted around here.

6 Political aspects

This section investigates relationships between revenue variables such as $CGR1_G$ and $CGR2_G$, and election data three kinds of election data: the approval rates for the Cabinet and political parties which construct the Cabinet, and the democracy index. Although a variety of democracy indices are proposed, the democracy index in the paper is defined based on the approval rates for the Cabinet and the ruling parties, which is given by

$$\textit{democracy index}\ (DEMO) = 1 - \sqrt{\frac{(p_1 - q_1)^2 + (p_2 - q_2)^2 + (p_3 - q_3)^2}{2}},$$

where p_1, p_2 and p_3 denote the approval rate for the Cabinet, the disapproval rate for the Cabinet and the rate of non-responder respectively. Similarly, q_1, q_2 and q_3 expresses the approval rate for the ruling parties, the disapproval rate for ruling parties and the rate of non-responder respectively. Thus, the democracy index in the paper describes the degree of similarity between approval ratings for the Cabinet and ruling parties. If disapproval for the ruling party cannot determine the reject of the Cabinet, then the democracy index indicates low value. Seabright (1996) defined diminished accountability as the reduced probability that citizens can determine the reelection of government. Our democracy index is based on the Seabright (1996)'s idea on the definition of accountability.

As unit root tests fail to identify the integrated orders of them, Toda and Yamamoto test is used to analyze causal relationships between them by adding two extra lag in the model. Table 29 shows that $CGR1$ and $CGR2$ Granger cause democracy index ($DEMO$) at 5% and 1% significance levels respectively. This result implies that the policymakers finance expenditures by bond revenues and implement tax reduction policy in order to remain in power. Furthermore, the approval rate for the Cabinet (ARC) causes $CGR2$ in Granger's sense at 5% significance level. Therefore, it is concluded that when the approval rate for the Cabinet becomes higher, policymakers implement the issuance of more government bonds. On the other hand, the approval rate for the ruling party (ARR) has no causal relation to $CGR1$ and $CGR2$.

Tables 29 should be inserted around here.

7 Concluding remarks

The paper investigated the revenue-expenditure nexus in the case of Japan by using five variables of revenues and three variables of expenditures. The techniques to analyze the causal relationship depend on the properties of the series. This paper utilizes three kinds of approaches; VAR models by adding the extra lags, differenced VAR models, and threshold error correction models.

It is found that when we focus on the total expenditures excluding debt services and the total revenues excluding bond issues respectively, there is no causal relationship between them and the institutional separation hypothesis is supported in Japan. However, the expenditures excluding debt services Granger cause bond revenues. Especially regarding expenditures for social security and pensions, there exists the bidirectional causality between bond revenues and them. However, there is no causality that runs from expenditures for social security and pensions to tax revenues though there exists the causality that runs expenditures for public works to tax revenues. In addition, it is not observed such causality that when tax revenues increase, bond issues decrease. Therefore it concludes that the reason for accumulating the debt outstanding of the central government in Japan would be the increase in expenditures for social security and pensions by aging of Japanese society.

Furthermore, when more controllable variables are set as expenditures, it is found that the MTAR setting is statistically chosen, asymmetries in the adjusting process of the deviation from the long-run equilibrium is found, and in the case of worsening changes of budget deficits the adjustment process works well to avoid the deficit crisis. But financial resources for reducing the budget deficit are mainly from revenues on the sale of government assets and from government enterprises, and it seems to be unsustainable. It is necessarily to construct the link between expenditures and tax revenues to avoid the deficit crisis with absolute certainty.

Finally, introducing political aspects such as the approval rates and the democracy index to our analysis, it concludes that policymakers would finance expenditures by bond revenues and implement tax reduction policy in order to remain in power. In addition, it is found that when the approval rate for the Cabinet becomes higher, policymakers implement the issuance of more government bonds.

ACKNOWLEDGMENT

To conduct this research, the second author is partially supported by JSPS Grant-in-Aid for Scientific Research(C) 26380271.

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Figure 1: Balance of government bonds/GDP ratio (%) in Japan

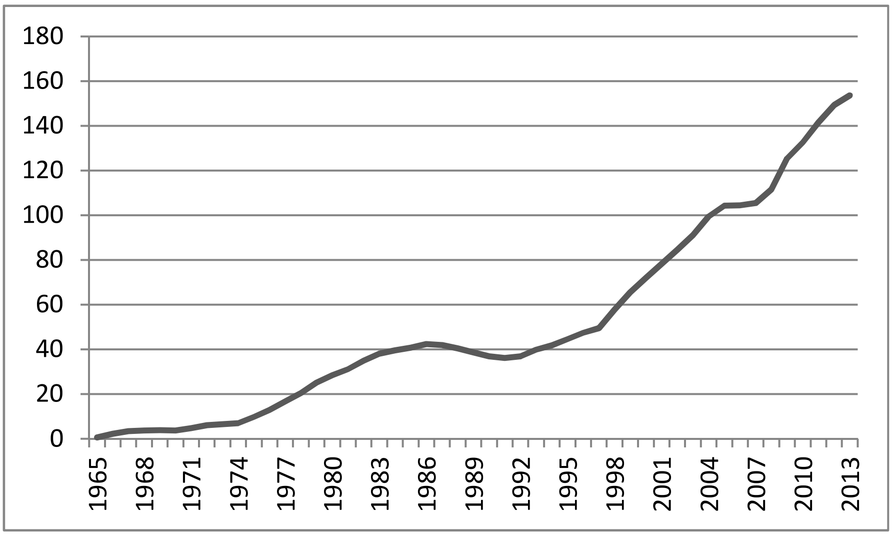

Figure 2: Revenues and expenditures in Japan

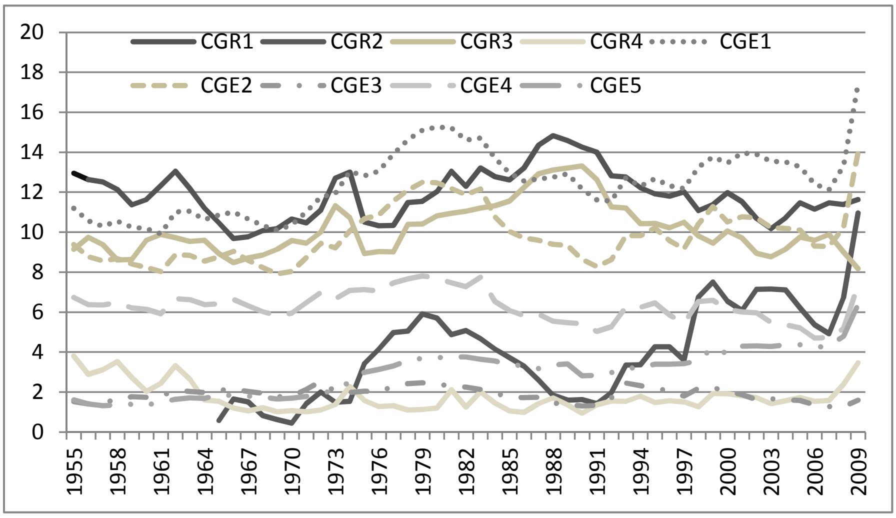

Table 1: Revenue variables

Item	$CGR1$	$CGR2$	$CGR3$	$CGR4$	%
Bond issues	-	•	-	-	48.5
Tax and stamp revenues	•	-	•	-	36.2
Other revenues	•	-	-	•	15.3
Total					100.0

1. % is evaluated in FY2009.
2. The symbols of • and - indicate that each variable in the column contains and does not contain the corresponding item in the row respectively.

Table 2: Expenditure variables

Item	$CGE1$	$CGE2$	$CGE3$	$CGE4$	$CGE5$	%
Debt services	-	-	-	-	-	18.3
Local finance	•	-	-	-	-	16.4
Social security, etc.	•	•	-	-	•	29.9
National land conservation and development	•	•	•	•	-	7.5
Agencies' administration	•	•	-	•	-	5.0
National defense	•	•	-	•	-	4.8
Industrial development	•	•	-	•	-	7.6
Education and culture	•	•	-	•	-	5.8
Pensions for former military	•	•	-	•	-	0.8
Others	•	•	-	•	-	3.9
Total						100.0

1. % is evaluated in FY2009.
2. The symbols of • and - indicate that each variable in the column contains and does not contain the corresponding item in the row respectively.

Table 3: Basic Statistics

Variables	Mean	Median	Max	Min	S.D.	Skew	Kurt	JB	p-value	Obs.
$CGR1_G$	11.885	11.798	14.820	9.679	1.242	0.364	2.640	1.511	0.470	55
$CGR2_G$	3.990	4.147	10.960	0.456	2.365	0.473	2.906	1.694	0.429	45
$CGR3_G$	10.137	9.751	13.307	8.171	1.288	0.910	3.139	7.632^b	0.022	55
$CGR4_G$	1.747	1.541	3.799	0.949	0.709	1.320	3.960	18.089^a	0.000	55
$CGE1_G$	12.456	12.556	17.410	9.918	1.624	0.473	3.048	2.053	0.358	55
$CGE2_G$	9.833	9.589	14.011	7.916	1.360	0.871	3.329	7.202^b	0.027	55
$CGE3_G$	1.886	1.943	2.540	1.275	0.341	-0.055	2.098	1.893	0.388	55
$CGE4_G$	6.294	6.311	7.814	4.700	0.773	0.076	2.490	0.648	0.723	55
$CGE5_G$	2.982	3.230	6.370	1.320	1.134	0.242	2.718	0.719	0.698	55

1. The Skew, Kurt, JB and Obs. indicate skewness, kurtsis, Jarque-Bera statistic, and the number of observations respectively.
2. ^{a},^{b} ,^{c} indicate significance at the 1%, 5%, 10% level respectively.

Table 4: Unit root Tests

Variables	ADF(C)	ADF(T)	PP(C)	PP(T)	KPSS(C)	KPSS(T)
$CGR1_G$	$-2.205(0)$	$-2.212(0)$	-2.346	-2.349	0.135	0.123^c
$\triangle CGR1_G$	$-6.142^a(0)$	$-6.085^a(0)$	-6.111^a	-6.032^a	0.101	0.099
$\triangle^2 CGR1_G$	$-7.024^a(2)$	$-6.955^a(2)$	-24.010^a	-23.595^a	0.177	0.177^b
$CGR2_G$	$-0.525(1)$	$-1.965(1)$	-0.613	-1.711	0.538^b	0.086
$\triangle CGR2_G$	$-3.644^a(0)$	$-3.644^b(0)$	-3.508^b	-3.602^b	0.139	0.090
$\triangle^2 CGR2_G$	$-6.306^a(1)$	$-6.335^a(1)$	-7.650^a	-7.728^a	0.267	0.092
$CGR3_G$	$-1.787(1)$	$-1.601(1)$	-1.619	-1.272	0.246	0.183^b
$\triangle CGR3_G$	$-5.744^a(0)$	$-5.780^a(0)$	-5.569^a	-5.608^a	0.228	0.090
$\triangle^2 CGR3_G$	$-6.950^a(2)$	$-6.915^a(2)$	-23.247^a	-28.462^a	0.220	0.219^a
$CGR4_G$	$-3.108^b(0)$	$-2.520(0)$	-2.957^b	-2.011	0.292	0.210^b
$\triangle CGR4_G$	$-7.462^a(0)$	$-7.759^a(0)$	-7.699^a	-11.301^a	0.504^b	0.208^b
$\triangle^2 CGR4_G$	$-5.181^a(5)$	$-8.113^a(2)$	-22.905^a	-24.278^a	0.194	0.191^b
$CGE1_G$	$-1.060(1)$	$-2.213(1)$	-0.810	-1.503	0.548^b	0.120^c
$\triangle CGE1_G$	$-2.897^c(0)$	$-2.885(0)$	-2.801^c	-2.837	0.150	0.122^c
$\triangle^2 CGE1_G$	$-7.371^a(0)$	$-7.417^a(0)$	-7.324^a	-7.386^a	0.212	0.118
$CGE2_G$	$-1.512(1)$	$-2.138(1)$	-0.878	-1.819	0.318	0.100
$\triangle CGE2_G$	$-3.227^b(0)$	$-3.236^c(0)$	-3.199^b	-3.225^c	0.192	0.119
$\triangle^2 CGE2_G$	$-5.870^a(1)$	$-5.897^a(1)$	-7.333^a	-7.388^a	0.209	0.117
$CGE3_G$	$-3.190^b(1)$	$-3.393^c(1)$	-2.588	-2.542	0.184	0.129^c
$\triangle CGE3_G$	$-5.499^a(1)$	$-5.528^a(1)$	-5.774^a	-5.781^a	0.123	0.059
$\triangle^2 CGE3_G$	$-6.057^a(4)$	$-5.987^a(4)$	-25.834^a	-30.450^a	0.206	0.184^b
$CGE4_G$	$-2.581(1)$	$-2.566(1)$	-2.283	-2.165	0.338	0.118
$\triangle CGE4_G$	$-4.986^a(0)$	$-4.915^a(0)$	-4.783^a	-4.736^a	0.102	0.078
$\triangle^2 CGE4_G$	$-7.064^a(1)$	$-7.085^a(1)$	-10.902^a	-11.019^a	0.205	0.122^c
$CGE5_G$	$0.399(10)$	$-2.286(10)$	0.854	-1.300	0.908^a	0.084
$\triangle CGE5_G$	$-1.114(10)$	$-1.053(10)$	-3.406^b	-3.543^b	0.252	0.117
$\triangle^2 CGE5_G$	$-2.149(9)$	$-3.188(8)$	-9.433^a	-9.503^a	0.214	0.116

1. The lag lengths for ADF(C) and ADF(T) were chosen by AIC and denoted in parentheses.
2. ^{a},^{b},^{c} indicate significance at the 1%, 5%, 10% level respectively.
3. $(C), (T)$ indicate that the constant term and the constant and trend terms are included in the model concerned respectively.

Table 5: Unit root tests with a break

Variables	ZA(A)	break date	lag	ZA(B)	break date	lag	ZA(C)	break date	lag
$CGR1_G$	-3.783	1978	1	-3.356	1989	1	-3.855	1983	1
$\triangle CGR1_G$	-6.690^a	1989	0	-6.148^a	1973	0	-6.621^a	1989	0
$\triangle^2 CGR1_G$	-5.547^a	1984	5	-5.312^a	1971	5	-6.316^a	1974	5
$CGR2_G$	-3.651	1986	1	-2.474	1995	1	-3.425	1986	1
$\triangle CGR2_G$	-4.144	1980	0	-3.828	1988	0	-4.134	1980	0
$\triangle^2 CGR2_G$	-6.585^a	1978	1	-6.765^a	2001	1	-7.393^a	2000	1
$CGR3_G$	-3.087	1994	1	-4.275^c	1990	1	-4.782	1986	1
$\triangle CGR3_G$	-6.432^a	1991	0	-5.966^a	1981	0	-6.372^a	1991	0
$\triangle^2 CGR3_G$	-7.071^a	1995	2	-6.906^a	1965	2	-7.165^a	1995	2
$CGR4_G$	-4.925^b	1964	0	-4.244^c	1968	0	-4.848^c	1964	0
$\triangle CGR4_G$	-7.878^a	1982	0	-7.844^a	2000	0	-7.950^a	2000	0
$\triangle^2 CGR4_G$	-5.573^a	1975	5	-5.316^a	2000	5	-6.232^a	1975	5
$CGE1_G$	-3.183	1988	1	-2.149	1964	1	-2.552	1984	1
$\triangle CGE1_G$	-3.600	1981	0	-3.050	1992	0	-3.392	1981	0
$\triangle^2 CGE1_G$	-7.612^a	1979	0	-8.032^a	1999	0	-8.504^a	1999	0
$CGE2_G$	-3.380	1984	1	-2.091	1964	1	-2.826	1984	1
$\triangle CGE2_G$	-3.953	1980	0	-3.395	1991	0	-3.791	1984	0
$\triangle^2 CGE2_G$	-1.832	1980	0	-1.607	1985	5	-1.823	1980	5
$CGE3_G$	-3.830	1971	1	-3.749	1978	1	-4.007	1983	1
$\triangle CGE3_G$	-6.086^a	1991	1	-5.532^a	1985	1	-6.088^a	1992	1
$\triangle^2 CGE3_G$	-6.332^a	1994	4	-5.979^a	2000	4	-6.531^a	1996	4
$CGE4_G$	-4.044	1984	1	-2.733	1975	1	-3.923	1984	1
$\triangle CGE4_G$	-5.347^a	1980	0	-5.021^a	1987	0	-5.509^b	2000	0
$\triangle^2 CGE4_G$	-5.428^a	1973	2	-5.564^a	1999	2	-5.971^a	1996	2
$CGE5_G$	-2.040	1985	0	-0.962	2000	0	-1.718	1990	0
$\triangle CGE5_G$	-4.363	1980	0	-3.948	1992	0	-4.238	1982	0
$\triangle^2 CGE5_G$	-9.824^a	1976	0	-10.070^a	1999	0	-10.232^a	1999	0

1. The lag lengths were chosen by AIC.
2. ^{a}, ^{b}, ^{c} indicate significance at the 1%, 5%, 10% level respectively.
3. Critical values are provided by Zivot and Andrews (1992) in Tables 2 to 4 respectively.

   •For Model A: 1% : -5.34, 5% : -4.80, 10% : -4.58.

   •For Model B: 1% : -4.93, 5% : -4.42, 10% : -4.11.

   •For Model C: 1% : -5.57, 5% : -5.08, 10% : -4.82.

Table 6: Cointegration tests

	Group 1		Group 2		Group 3		Group 4	
Dependent	$CGR1_G$	$CGE3_G$	$CGR1_G$	$CGE4_G$	$CGR3_G$	$CGE3_G$	$CGR3_G$	$CGE4_G$
τ statistic	-2.230	-3.251^c	-2.287	-2.637	-1.712	-3.132^c	-1.771	-2.310
p-value	0.417	0.078	0.389	0.238	0.674	0.099	0.646	0.378
z statistic	-9.203	-21.523^b	-9.254	-16.789^c	-7.637	-19.545^b	-7.512	-10.431
p-value	0.380	0.022	0.377	0.075	0.496	0.038	0.506	0.303
lag order	0	1	0	1	1	1	1	0

1. The lag lengths were chosen by AIC.
2. ^{a},^{b},^{c} indicate significance at the 1%, 5%, 10% level respectively.

Table 7: Cointegration tests with a break

Model C	Group 1		Group 2		Group 3		Group 4	
Dependent	$CGR1_G$	$CGE3_G$	$CGR1_G$	$CGE4_G$	$CGR3_G$	$CGE3_G$	$CGR3_G$	$CGE4_G$
ADF statistic	−3.269	−4.269	−3.083	−3.288	−2.188	−3.871	−2.303	−3.297
break date	1999	1998	1975	1985	1975	1998	1998	1985
lag-order	1	1	1	1	1	1	1	1
Z_α statistic	−16.420	−20.193	−14.449	−20.503	−9.316	−16.708	−9.437	−20.356
break date	1999	2000	1998	1986	1999	2000	1999	1986
Z_t statistic	−2.988	−3.463	−2.791	−3.084	−2.281	−3.242	−2.282	−3.085
break date	1999	2000	1974	1986	1999	2000	1999	1986
Model C/T	Group 1		Group 2		Group 3		Group 4	
Dependent	$CGR1_G$	$CGE3_G$	$CGR1_G$	$CGE4_G$	$CGR3_G$	$CGE3_G$	$CGR3_G$	$CGE4_G$
ADF statistic	−4.517	-4.905^c	−4.349	−4.239	−3.946	−4.298	−3.998	−4.122
break date	1975	1973	1976	1985	1998	1998	1995	1985
lag-order	1	1	2	1	1	1	1	1
Z_α statistic	−23.949	−25.179	−22.661	−31.576	−22.695	−21.122	−21.110	−29.307
break date	1999	2000	1978	1972	1996	1999	1996	1972
Z_t statistic	−3.778	−3.871	−3.666	−3.969	−3.498	−3.570	−3.406	−3.937
break date	1978	2000	1981	1984	1999	2000	1996	1972
Model C/S	Group 1		Group 2		Group 3		Group 4	
Dependent	$CGR1_G$	$CGE3_G$	$CGR1_G$	$CGE4_G$	$CGR3_G$	$CGE3_G$	$CGR3_G$	$CGE4_G$
ADF statistic	−3.314	−4.103	−2.990	−3.475	−2.540	−3.942	−2.312	−3.949
break date	1992	1998	1998	1985	1992	1998	1998	1985
lag-order	1	1	1	1	1	1	1	1
Z_α statistic	−16.346	−20.061	−14.772	−21.464	−9.477	−18.528	−9.416	−27.203
break date	1992	2000	1998	1986	1993	1982	1999	1984
Z_t statistic	−2.971	−3.449	−2.886	−3.193	−2.296	−3.305	−2.266	−3.860
break date	1992	2000	1996	1986	1993	1982	1999	1984

1. The lag lengths were chosen by AIC.
2. Critical values are provided by Gregory and Hansen (1996) Table1.

•ADF and Z_t statistics:

–For Model C: 1% : −5.13, 5% : −4.61, 10% : −4.34.

–For Model C/T: 1% : −5.45, 5% : −4.99, 10% : −4.72.

–For Model C/S: 1% : −5.47, 5% : −4.95, 10% : −4.68.

•Z_α statistic:

–For Model C: 1% : −50.07, 5% : −40.48, 10% : −36.19.

–For Model C/T: 1% : −57.28, 5% : −47.96, 10% : −43.22.

–For Model C/S: 1% : −57.17, 5% : −47.04, 10% : −41.85.

Table 8: Threshold cointegration tests

MTAR	Group 1		Group 2		Group 3		Group 4	
Dependent	$CGR1_G$	$CGE3_G$	$CGR1_G$	$CGE4_G$	$CGR3_G$	$CGE3_G$	$CGR3_G$	$CGE4_G$
$\hat{\tau}$	-0.632	-0.107	-0.752	0.426	-0.424	-0.122	-0.384	0.354
F statistic of $\rho_1 = \rho_2 = 0$	$9.09^b(2,49)$	$8.91^b(2,49)$	$12.06^a(2,49)$	$8.78^b(2,51)$	$2.50(2,49)$	$8.98^b(2,49)$	$3.83(2,49)$	$8.14^b(2,51)$
t statistic of $\max \rho_i = 0$	-1.368	-1.716^c	-1.555	-0.640	-0.751	-2.036^b	-0.581	-0.946
F statistic of $\rho_1 = \rho_2$	$9.94^a(1,49)$	$6.27^b(1,49)$	$15.24^a(1,49)$	$11.02^a(1,51)$	$2.12(1,49)$	$7.07^b(1,49)$	$4.41^b(1,49)$	$10.15^a(1,51)$
p-value	0.003	0.016	0.000	0.002	0.152	0.011	0.041	0.003

1. For tests of symmetry, the standard F distribution is used, as in Ewing et al. (2006) and Payne et al. (2008). p-values are evaluated based on the standard F distribution.
2. Enders and Siklos (2001) gives critical values for Φ test and t-max test in Tables 5 and 6 respectively.

Table 9: Granger non-causality tests by Toda and Yamamoto

	Trend model				
	Null hypothesis	selected lag	estimated model	t ($Wald$) statistic	p-value
Group 5	$CGR1_G \overset{G}{\nrightarrow} CGE1_G$	2	4	0.401	0.818
	$CGE1_G \overset{G}{\nrightarrow} CGR1_G$	2	4	2.347	0.309
Group 6	$CGR1_G \overset{G}{\nrightarrow} CGE2_G$	1	3	−0.629	0.533
	$CGE2_G \overset{G}{\nrightarrow} CGR1_G$	1	3	−0.423	0.674
Group 7	$CGR1_G \overset{G}{\nrightarrow} CGE5_G$	1	3	0.036	0.972
	$CGE5_G \overset{G}{\nrightarrow} CGR1_G$	1	3	−0.719	0.476
Group 8	$CGR2_G \overset{G}{\nrightarrow} CGE1_G$	1	3	1.181	0.246
	$CGE1_G \overset{G}{\nrightarrow} CGR2_G$	1	3	1.894^c	0.067
Group 9	$CGR2_G \overset{G}{\nrightarrow} CGE2_G$	1	3	1.161	0.254
	$CGE2_G \overset{G}{\nrightarrow} CGR2_G$	1	3	1.572	0.125
Group 10	$CGR2_G \overset{G}{\nrightarrow} CGE3_G$	1	3	1.258	0.217
	$CGE3_G \overset{G}{\nrightarrow} CGR2_G$	1	3	−0.747	0.461
Group 11	$CGR2_G \overset{G}{\nrightarrow} CGE4_G$	1	3	1.258	0.217
	$CGE4_G \overset{G}{\nrightarrow} CGR2_G$	1	3	0.381	0.705
Group 12	$CGR2_G \overset{G}{\nrightarrow} CGE5_G$	2	4	6.222^b	0.045
	$CGE5_G \overset{G}{\nrightarrow} CGR2_G$	2	4	7.033^b	0.030
Group 13	$CGR3_G \overset{G}{\nrightarrow} CGE1_G$	4	6	1.160	0.885
	$CGE1_G \overset{G}{\nrightarrow} CGR3_G$	4	6	9.951^b	0.041
Group 14	$CGR3_G \overset{G}{\nrightarrow} CGE2_G$	4	6	3.807	0.433
	$CGE2_G \overset{G}{\nrightarrow} CGR3_G$	4	6	5.398	0.249

1. ^{a},^{b} ,^{c} indicate significance at the 1%, 5%, 10% level respectively.
2. In each group, LR statistics select the lag-order of VAR model and two extra lags are added to test the causality.

Table 10: Granger non-causality tests by Toda and Yamamoto (cont.)

Trend model					
	Null hypothesis	selected lag	estimated model	t ($Wald$) statistic	p-value
Group 15	$CGR3_G \overset{G}{\nrightarrow} CGE5_G$	1	3	-1.007	0.319
	$CGE5_G \overset{G}{\nrightarrow} CGR3_G$	1	3	-0.217	0.830
Group 16	$CGR4_G \overset{G}{\nrightarrow} CGE1_G$	1	3	0.208	0.836
	$CGE1_G \overset{G}{\nrightarrow} CGR4_G$	1	3	0.569	0.572
Group 17	$CGR4_G \overset{G}{\nrightarrow} CGE2_G$	1	3	0.426	0.672
	$CGE2_G \overset{G}{\nrightarrow} CGR4_G$	1	3	0.605	0.548
Group 18	$CGR4_G \overset{G}{\nrightarrow} CGE3_G$	1	3	6.482^a	0.000
	$CGE3_G \overset{G}{\nrightarrow} CGR4_G$	1	3	0.021	0.984
Group 19	$CGR4_G \overset{G}{\nrightarrow} CGE4_G$	1	3	0.455	0.651
	$CGE4_G \overset{G}{\nrightarrow} CGR4_G$	1	3	0.522	0.605
Group 20	$CGR4_G \overset{G}{\nrightarrow} CGE5_G$	1	3	1.474	0.148
	$CGE5_G \overset{G}{\nrightarrow} CGR4_G$	1	3	0.451	0.654
Group 21	$CGR2_G \overset{G}{\nrightarrow} CGR1_G$	1	3	1.128	0.267
	$CGR1_G \overset{G}{\nrightarrow} CGR2_G$	1	3	0.103	0.919
Group 22	$CGR2_G \overset{G}{\nrightarrow} CGR3_G$	1	3	0.510	0.614
	$CGR3_G \overset{G}{\nrightarrow} CGR2_G$	1	3	-1.256	0.218
Group 23	$CGR4_G \overset{G}{\nrightarrow} CGR2_G$	2	4	8.117^b	0.017
	$CGR2_G \overset{G}{\nrightarrow} CGR4_G$	2	4	5.755^c	0.056
Group 24	$CGR4_G \overset{G}{\nrightarrow} CGR3_G$	1	3	-1.378	0.175
	$CGR3_G \overset{G}{\nrightarrow} CGR4_G$	1	3	0.970	0.337

1. ^{a}, ^{b}, ^{c} indicate significance at the 1%, 5%, 10% level respectively.
2. In each group, LR statistics select the lag-order of VAR model and two extra lags are added to test the causality.

Table 11: Granger non-causality tests by differenced VAR model

	Constant model										
	lag-order	1		2		3		4		5	
	Null hypothesis	$Wald$	p-value	$Wald$	p-value	$Wald$	p-value	$Wald$	p-value	$Wald$	p-value
Group 3	$\triangle CGR3_G \overset{G}{\not\to} \triangle CGE3_G$	3.294^c	0.070	2.750	0.253	2.495	0.476	4.369	0.358	6.329	0.275
	$\triangle CGE3_G \overset{G}{\not\to} \triangle CGR3_G$	1.944	0.163	2.950	0.229	8.338^b	0.040	7.879^c	0.096	12.128^b	0.033
Group 4	$\triangle CGR3_G \overset{G}{\not\to} \triangle CGE4_G$	1.188	0.276	1.656	0.437	2.303	0.512	2.633	0.621	4.185	0.523
	$\triangle CGE4_G \overset{G}{\not\to} \triangle CGR3_G$	0.091	0.763	1.181	0.554	3.912	0.271	3.883	0.422	3.975	0.553

1. ^{a},^{b},^{c} indicate significance at the 1%, 5%, 10% level respectively.

Table 12: Granger non-causality tests by threshold (MTAR) error correction model

		Constant model									
	lag-order	1		2		3		4		5	
		$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value
Group 1	$\triangle CGR1_G \overset{G}{\nrightarrow} \triangle CGE3_G$	1.337	0.248	1.287	0.525	2.121	0.548	2.327	0.676	2.346	0.799
	$\hat{\rho}_1$	−0.016	0.584	−0.006	0.836	0.002	0.962	−0.004	0.894	−0.006	0.864
	$\hat{\rho}_2$	0.009	0.888	0.006	0.926	0.030	0.660	0.022	0.757	−0.003	0.973
	$\triangle CGE3_G \overset{G}{\nrightarrow} \triangle CGR1_G$	5.527^b	0.019	6.046^b	0.049	9.502^b	0.023	10.560^b	0.032	12.557^b	0.028
	$\hat{\rho}_1$	−0.070	0.386	−0.069	0.428	−0.060	0.501	−0.067	0.475	−0.073	0.461
	$\hat{\rho}_2$	-0.777^a	0.000	-0.751^a	0.000	-0.753^a	0.000	-0.776^a	0.000	-0.690^a	0.002
	$\hat{\tau} = -0.632$										
Group 2	$\triangle CGR1_G \overset{G}{\nrightarrow} \triangle CGE4_G$	0.078	0.780	1.318	0.517	2.700	0.440	5.699	0.223	6.409	0.268
	$\hat{\rho}_1$	−0.045	0.483	−0.070	0.306	−0.046	0.536	−0.073	0.334	−0.088	0.293
	$\hat{\rho}_2$	−0.011	0.952	−0.059	0.754	−0.038	0.844	−0.113	0.573	−0.170	0.434
	$\triangle CGE4_G \overset{G}{\nrightarrow} \triangle CGR1_G$	0.000	0.988	0.198	0.906	2.585	0.460	3.372	0.498	4.377	0.497
	$\hat{\rho}_1$	−0.107	0.151	−0.100	0.215	−0.093	0.277	−0.108	0.229	−0.154	0.118
	$\hat{\rho}_2$	-0.980^a	0.000	-0.968^a	0.000	-0.929^a	0.000	-0.957^a	0.000	-0.937^a	0.001
	$\hat{\tau} = -0.752$										

1. ^{a},^{b},^{c} indicate significance at the 1%, 5%, 10% level respectively.
2. $Wald$ statistics is for Granger non-causality test and coef indicates an estimate of ρ_i for $i = 1$ and 2.

Table 13: Basic Statistics 2

Variables	Mean	Median	Max	Min	S.D.	Skew	Kurt	JB	p-value	Obs.
$CGR1$	9.825	10.450	11.101	7.027	1.344	−0.793	2.139	7.465^b	0.024	55
$CGR2$	9.018	9.456	10.858	5.284	1.456	−1.068	3.118	8.576^b	0.014	45
$CGR3$	9.664	10.326	11.004	6.680	1.381	−0.845	2.263	7.793^b	0.020	55
$CGR4$	7.845	8.145	9.707	5.643	1.214	−0.449	1.711	5.657^c	0.059	55
$CGE1$	9.869	10.605	11.321	6.881	1.421	−0.858	2.248	8.048^b	0.018	55
$CGE2$	9.632	10.398	11.104	6.704	1.399	−0.861	2.243	8.110^b	0.017	55
$CGE3$	7.973	8.667	9.380	4.884	1.336	−0.991	2.671	9.253^a	0.010	55
$CGE4$	9.187	9.901	10.462	6.372	1.297	−0.927	2.385	8.738^b	0.013	55
$CGE5$	8.369	9.247	10.316	4.918	1.713	−0.788	2.146	7.366^b	0.025	55
$CGR1_{r1}$	9.288	10.243	11.106	5.242	1.956	−0.793	2.106	7.593^b	0.022	55
$CGR2_{r1}$	8.709	9.258	10.688	4.006	1.835	−1.163	3.160	10.200^a	0.006	45
$CGR3_{r1}$	9.126	10.135	11.004	4.895	1.992	−0.827	2.189	7.779^b	0.020	55
$CGR4_{r1}$	7.308	8.021	9.536	3.907	1.811	−0.585	1.773	6.580^b	0.037	55
$CGE1_{r1}$	9.332	10.414	11.151	5.096	2.032	−0.841	2.179	8.020^b	0.018	55
$CGE2_{r1}$	9.095	10.208	10.951	4.919	2.010	−0.843	2.175	8.080^b	0.018	55
$CGE3_{r1}$	7.436	8.541	9.402	3.099	1.944	−0.926	2.450	8.549^b	0.014	55
$CGE4_{r1}$	8.650	9.717	10.426	4.587	1.908	−0.883	2.265	8.384^b	0.015	55
$CGE5_{r1}$	7.832	9.057	10.145	3.156	2.323	−0.798	2.112	7.648^b	0.022	55
$CGR1_{r2}$	9.251	10.245	11.067	5.268	1.994	−0.764	2.028	7.511^b	0.023	55
$CGR2_{r2}$	8.681	9.253	10.832	3.906	1.887	−1.138	3.104	9.741^a	0.008	45
$CGR3_{r2}$	9.089	10.138	10.964	4.920	2.030	−0.798	2.107	7.673^b	0.022	55
$CGR4_{r2}$	7.271	7.987	9.680	3.889	1.855	−0.555	1.728	6.534^b	0.038	55
$CGE1_{r2}$	9.295	10.417	11.294	5.122	2.071	−0.807	2.101	7.823^b	0.020	55
$CGE2_{r2}$	9.057	10.210	11.077	4.945	2.050	−0.809	2.096	7.877^b	0.019	55
$CGE3_{r2}$	7.398	8.515	9.372	3.125	1.980	−0.891	2.345	8.255^b	0.016	55
$CGE4_{r2}$	8.613	9.719	10.435	4.613	1.946	−0.848	2.175	8.152^b	0.017	55
$CGE5_{r2}$	7.794	9.060	10.289	3.165	2.364	−0.767	2.047	7.471^b	0.024	55
$CGR1_{r3}$	9.668	10.688	11.206	6.367	1.644	−0.779	1.998	7.858^b	0.020	55
$CGR2_{r3}$	8.967	9.613	10.860	4.674	1.668	−1.211	3.241	11.116^a	0.004	45
$CGR3_{r3}$	9.507	10.567	11.120	6.020	1.680	−0.815	2.093	7.981^b	0.018	55
$CGR4_{r3}$	7.688	8.352	9.709	5.043	1.507	−0.553	1.664	6.899^b	0.032	55
$CGE1_{r3}$	9.713	10.811	11.323	6.221	1.720	−0.831	2.079	8.278^b	0.016	55
$CGE2_{r3}$	9.475	10.566	11.106	6.044	1.699	−0.833	2.072	8.328^b	0.016	55
$CGE3_{r3}$	7.816	8.781	9.437	4.224	1.631	−0.927	2.371	8.776^b	0.012	55
$CGE4_{r3}$	9.031	10.046	10.464	5.712	1.597	−0.876	2.163	8.633^b	0.013	55
$CGE5_{r3}$	8.212	9.436	10.318	4.281	2.012	−0.785	2.021	7.840^b	0.020	55

1. The Skew, Kurt, JB and Obs. indicate skewness, kurtsis, Jarque-Bera statistic, and the number of observations respectively.
2. ^{a},^{b} ,^{c} indicate significance at the 1%, 5%, 10% level respectively.

Table 14: Granger non-causality tests by Toda and Yamamoto (nominal)

Trend model					
	Null hypothesis	selected lag	estimated model	t $(Wald)$ statistic	p-value
Group 5	$CGR1 \overset{G}{\nrightarrow} CGE1$	2	4	0.188	0.910
	$CGE1 \overset{G}{\nrightarrow} CGR1$	2	4	3.920	0.141
Group 6	$CGR1 \overset{G}{\nrightarrow} CGE2$	4	6	13.232^a	0.010
	$CGE2 \overset{G}{\nrightarrow} CGR1$	4	6	12.231^b	0.016
Group 8	$CGR2 \overset{G}{\nrightarrow} CGE1$	1	3	1.048	0.302
	$CGE1 \overset{G}{\nrightarrow} CGR2$	1	3	1.982^c	0.055
Group 9	$CGR2 \overset{G}{\nrightarrow} CGE2$	4	6	8.040^c	0.090
	$CGE2 \overset{G}{\nrightarrow} CGR2$	4	6	6.098	0.192
Group 10	$CGR2 \overset{G}{\nrightarrow} CGE3$	1	3	0.969	0.339
	$CGE3 \overset{G}{\nrightarrow} CGR2$	1	3	0.407	0.687
Group 11	$CGR2 \overset{G}{\nrightarrow} CGE4$	1	3	0.744	0.462
	$CGE4 \overset{G}{\nrightarrow} CGR2$	1	3	1.191	0.242
Group 12	$CGR2 \overset{G}{\nrightarrow} CGE5$	2	4	2.735	0.255
	$CGE5 \overset{G}{\nrightarrow} CGR2$	2	4	7.934^b	0.019
Group 13	$CGR3 \overset{G}{\nrightarrow} CGE1$	2	4	0.301	0.860
	$CGE1 \overset{G}{\nrightarrow} CGR3$	2	4	4.184	0.123
Group 14	$CGR3 \overset{G}{\nrightarrow} CGE2$	2	4	3.821	0.148
	$CGE2 \overset{G}{\nrightarrow} CGR3$	2	4	4.017	0.134

1. ^{a},^{b},^{c} indicate significance at the 1%, 5%, 10% level respectively.
2. In each group, LR statistics select the lag-order of VAR model and two extra lags are added to test the causality.

Table 15: Granger non-causality tests by Toda and Yamamoto (nominal) (cont.)

	Trend model				
	Null hypothesis	selected lag	estimated model	t $(Wald)$ statistic	p-value
Group 16	$CGR4 \overset{G}{\nrightarrow} CGE1$	2	4	1.055	0.590
	$CGE1 \overset{G}{\nrightarrow} CGR4$	2	4	2.075	0.354
Group 17	$CGR4 \overset{G}{\nrightarrow} CGE2$	2	4	0.132	0.936
	$CGE2 \overset{G}{\nrightarrow} CGR4$	2	4	4.045	0.132
Group 18	$CGR4 \overset{G}{\nrightarrow} CGE3$	1	3	0.460	0.648
	$CGE3 \overset{G}{\nrightarrow} CGR4$	1	3	1.295	0.202
Group 19	$CGR4 \overset{G}{\nrightarrow} CGE4$	1	3	−0.394	0.696
	$CGE4 \overset{G}{\nrightarrow} CGR4$	1	3	1.878^c	0.067
Group 20	$CGR4 \overset{G}{\nrightarrow} CGE5$	1	3	0.765	0.448
	$CGE5 \overset{G}{\nrightarrow} CGR4$	1	3	0.746	0.460
Group 21	$CGR2 \overset{G}{\nrightarrow} CGR1$	5	7	6.131	0.294
	$CGR1 \overset{G}{\nrightarrow} CGR2$	5	7	10.309^c	0.067
Group 22	$CGR2 \overset{G}{\nrightarrow} CGR3$	5	7	7.183	0.207
	$CGR3 \overset{G}{\nrightarrow} CGR2$	5	7	15.425^a	0.009
Group 23	$CGR4 \overset{G}{\nrightarrow} CGR2$	1	3	2.331^b	0.026
	$CGR2 \overset{G}{\nrightarrow} CGR4$	1	3	1.209	0.235
Group 24	$CGR4 \overset{G}{\nrightarrow} CGR3$	1	3	−1.405	0.167
	$CGR3 \overset{G}{\nrightarrow} CGR4$	1	3	1.300	0.200

1. ^{a},^{b} ,^{c} indicate significance at the 1%, 5%, 10% level respectively.
2. In each group, LR statistics select the lag-order of VAR model and two extra lags are added to test the causality.

Table 16: Granger non-causality tests by Toda and Yamamoto (real (GDP deflator))

	Trend model				
	Null hypothesis	selected lag	estimated model	t $(Wald)$ statistic	p-value
Group 6	$CGR1_{r1} \overset{G}{\nrightarrow} CGE2_{r1}$	2	4	2.467	0.291
	$CGE2_{r1} \overset{G}{\nrightarrow} CGR1_{r1}$	2	4	4.863^{c}	0.088
Group 8	$CGR2_{r1} \overset{G}{\nrightarrow} CGE1_{r1}$	2	4	2.114	0.348
	$CGE1_{r1} \overset{G}{\nrightarrow} CGR2_{r1}$	2	4	6.741^{b}	0.034
Group 9	$CGR2_{r1} \overset{G}{\nrightarrow} CGE2_{r1}$	4	6	9.560^{b}	0.049
	$CGE2_{r1} \overset{G}{\nrightarrow} CGR2_{r1}$	4	6	8.512^{c}	0.075
Group 10	$CGR2_{r1} \overset{G}{\nrightarrow} CGE3_{r1}$	1	3	0.967	0.340
	$CGE3_{r1} \overset{G}{\nrightarrow} CGR2_{r1}$	1	3	0.999	0.325
Group 11	$CGR2_{r1} \overset{G}{\nrightarrow} CGE4_{r1}$	1	3	0.413	0.682
	$CGE4_{r1} \overset{G}{\nrightarrow} CGR2_{r1}$	1	3	2.109^{b}	0.042
Group 12	$CGR2_{r1} \overset{G}{\nrightarrow} CGE5_{r1}$	2	4	2.629	0.269
	$CGE5_{r1} \overset{G}{\nrightarrow} CGR2_{r1}$	2	4	10.968^{a}	0.004
Group 14	$CGR3_{r1} \overset{G}{\nrightarrow} CGE2_{r1}$	2	4	2.656	0.265
	$CGE2_{r1} \overset{G}{\nrightarrow} CGR3_{r1}$	2	4	4.694^{c}	0.096
Group 17	$CGR4_{r1} \overset{G}{\nrightarrow} CGE2_{r1}$	2	4	0.396	0.820
	$CGE2_{r1} \overset{G}{\nrightarrow} CGR4_{r1}$	2	4	6.895^{b}	0.032
Group 21	$CGR2_{r1} \overset{G}{\nrightarrow} CGR1_{r1}$	5	7	2.958	0.707
	$CGR1_{r1} \overset{G}{\nrightarrow} CGR2_{r1}$	5	7	9.533^{c}	0.090
Group 22	$CGR2_{r1} \overset{G}{\nrightarrow} CGR3_{r1}$	5	7	3.805	0.578
	$CGR3_{r1} \overset{G}{\nrightarrow} CGR2_{r1}$	5	7	13.013^{b}	0.023
Group 23	$CGR4_{r1} \overset{G}{\nrightarrow} CGR2_{r1}$	1	3	2.618^{b}	0.013
	$CGR2_{r1} \overset{G}{\nrightarrow} CGR4_{r1}$	1	3	1.210	0.235

1. ^{a},^{b} ,^{c} indicate significance at the 1%, 5%, 10% level respectively.
2. In each group, LR statistics select the lag-order of VAR model and two extra lags are added to test the causality.

Table 17: Granger non-causality tests by Toda and Yamamoto (real (CPI))

	Trend model				
	Null hypothesis	selected lag	estimated model	t ($Wald$) statistic	p-value
Group 5	$CGR1_{r2} \overset{G}{\nrightarrow} CGE1_{r2}$	2	4	1.280	0.527
	$CGE1_{r2} \overset{G}{\nrightarrow} CGR1_{r2}$	2	4	45.062^{a}	0.000
Group 6	$CGR1_{r2} \overset{G}{\nrightarrow} CGE2_{r2}$	2	4	4.554	0.103
	$CGE2_{r2} \overset{G}{\nrightarrow} CGR1_{r2}$	2	4	4.149	0.126
Group 8	$CGR2_{r2} \overset{G}{\nrightarrow} CGE1_{r2}$	2	4	1.459	0.482
	$CGE1_{r2} \overset{G}{\nrightarrow} CGR2_{r2}$	2	4	8.543^{b}	0.014
Group 9	$CGR2_{r2} \overset{G}{\nrightarrow} CGE2_{r2}$	2	4	0.228	0.892
	$CGE2_{r2} \overset{G}{\nrightarrow} CGR2_{r2}$	2	4	8.548^{b}	0.014
Group 10	$CGR2_{r2} \overset{G}{\nrightarrow} CGE3_{r2}$	1	3	0.817	0.420
	$CGE3_{r2} \overset{G}{\nrightarrow} CGR2_{r2}$	1	3	1.224	0.229
Group 11	$CGR2_{r2} \overset{G}{\nrightarrow} CGE4_{r2}$	1	3	0.413	0.682
	$CGE4_{r2} \overset{G}{\nrightarrow} CGR2_{r2}$	1	3	2.109^{b}	0.042
Group 12	$CGR2_{r2} \overset{G}{\nrightarrow} CGE5_{r2}$	2	4	2.044	0.360
	$CGE5_{r2} \overset{G}{\nrightarrow} CGR2_{r2}$	2	4	12.630^{a}	0.002
Group 13	$CGR3_{r2} \overset{G}{\nrightarrow} CGE1_{r2}$	2	4	1.795	0.408
	$CGE1_{r2} \overset{G}{\nrightarrow} CGR3_{r2}$	2	4	4.136	0.127
Group 14	$CGR3_{r2} \overset{G}{\nrightarrow} CGE2_{r2}$	2	4	5.364^{c}	0.068
	$CGE2_{r2} \overset{G}{\nrightarrow} CGR3_{r2}$	2	4	4.531	0.104
Group 16	$CGR4_{r2} \overset{G}{\nrightarrow} CGE1_{r2}$	2	4	1.237	0.539
	$CGE1_{r2} \overset{G}{\nrightarrow} CGR4_{r2}$	2	4	4.537	0.104
Group 17	$CGR4_{r2} \overset{G}{\nrightarrow} CGE2_{r2}$	2	4	0.281	0.869
	$CGE2_{r2} \overset{G}{\nrightarrow} CGR4_{r2}$	2	4	7.329^{b}	0.026
Group 21	$CGR2_{r2} \overset{G}{\nrightarrow} CGR1_{r2}$	1	3	1.323	0.195
	$CGR1_{r2} \overset{G}{\nrightarrow} CGR2_{r2}$	1	3	1.449	0.157
Group 22	$CGR2_{r2} \overset{G}{\nrightarrow} CGR3_{r2}$	3	5	6.386^{c}	0.094
	$CGR3_{r2} \overset{G}{\nrightarrow} CGR2_{r2}$	3	5	5.354	0.148
Group 23	$CGR4_{r2} \overset{G}{\nrightarrow} CGR2_{r2}$	1	3	2.735^{a}	0.010
	$CGR2_{r2} \overset{G}{\nrightarrow} CGR4_{r2}$	1	3	1.297	0.204

1. ^{a},^{b},^{c} indicate significance at the 1%, 5%, 10% level respectively.
2. In each group, LR statistics select the lag-order of VAR model and two extra lags are added to test the causality.

Table 18: Granger non-causality tests by Toda and Yamamoto (real (CGPI))

Trend model					
	Null hypothesis	selected lag	estimated model	t $(Wald)$ statistic	p-value
Group 8	$CGR2_{r3} \overset{G}{\nrightarrow} CGE1_{r3}$	2	4	5.111^{c}	0.078
	$CGE1_{r3} \overset{G}{\nrightarrow} CGR2_{r3}$	2	4	7.569^{b}	0.023
Group 9	$CGR2_{r3} \overset{G}{\nrightarrow} CGE2_{r3}$	2	4	0.776	0.412
	$CGE2_{r3} \overset{G}{\nrightarrow} CGR2_{r3}$	2	4	7.829^{b}	0.020
Group 10	$CGR2_{r3} \overset{G}{\nrightarrow} CGE3_{r3}$	1	3	0.820	0.418
	$CGE3_r3 \overset{G}{\nrightarrow} CGR2_r3$	1	3	1.340	0.189
Group 11	$CGR2_r3 \overset{G}{\nrightarrow} CGE4_r3$	1	3	0.820	0.418
	$CGE4_r3 \overset{G}{\nrightarrow} CGR2_r3$	1	3	2.046^{b}	0.049
Group 12	$CGR2_{r3} \overset{G}{\nrightarrow} CGE5_{r3}$	2	4	6.299^{b}	0.043
	$CGE5_{r3} \overset{G}{\nrightarrow} CGR2_{r3}$	2	4	11.067^{a}	0.004
Group 16	$CGR4_{r3} \overset{G}{\nrightarrow} CGE1_{r3}$	2	4	2.265	0.322
	$CGE1_{r3} \overset{G}{\nrightarrow} CGR4_{r3}$	2	4	5.734^{c}	0.057
Group 17	$CGR4_{r3} \overset{G}{\nrightarrow} CGE2_{r3}$	2	4	1.337	0.513
	$CGE2_{r3} \overset{G}{\nrightarrow} CGR4_{r3}$	2	4	8.349^{b}	0.015
Group 18	$CGR4_{r3} \overset{G}{\nrightarrow} CGE3_{r3}$	1	3	0.134	0.894
	$CGE3_{r3} \overset{G}{\nrightarrow} CGR4_{r3}$	1	3	1.932^{c}	0.060
Group 19	$CGR4_{r3} \overset{G}{\nrightarrow} CGE4_{r3}$	2	4	0.756	0.685
	$CGE4_{r3} \overset{G}{\nrightarrow} CGR4_{r3}$	2	4	10.906^{a}	0.004
Group 20	$CGR4_{r3} \overset{G}{\nrightarrow} CGE5_{r3}$	2	4	2.073	0.355
	$CGE5_{r3} \overset{G}{\nrightarrow} CGR4_{r3}$	2	4	4.318	0.116
Group 21	$CGR2_{r3} \overset{G}{\nrightarrow} CGR1_{r3}$	1	3	1.955^{c}	0.059
	$CGR1_{r3} \overset{G}{\nrightarrow} CGR2_{r3}$	1	3	1.237	0.225
Group 22	$CGR2_{r3} \overset{G}{\nrightarrow} CGR3_{r3}$	3	5	9.813^{b}	0.020
	$CGR3_{r3} \overset{G}{\nrightarrow} CGR2_{r3}$	3	5	6.338^{c}	0.096
Group 23	$CGR4_{r3} \overset{G}{\nrightarrow} CGR2_{r3}$	1	3	2.702^{b}	0.011
	$CGR2_{r3} \overset{G}{\nrightarrow} CGR4_{r3}$	1	3	1.580	0.123
Group 24	$CGR4_{r3} \overset{G}{\nrightarrow} CGR3_{r3}$	1	3	-0.927	0.359
	$CGR3_{r3} \overset{G}{\nrightarrow} CGR4_{r3}$	1	3	2.592^{b}	0.013

1. ^{a},^{b},^{c} indicate significance at the 1%, 5%, 10% level respectively.
2. In each group, LR statistics select the lag-order of VAR model and two extra lags are added to test the causality.

Table 19: Granger non-causality tests by differenced VAR model (nominal)

		Trend model									
	lag-order	1		2		3		4		5	
	Null hypothesis	$Wald$	p-value	$Wald$	p-value	$Wald$	p-value	$Wald$	p-value	$Wald$	p-value
Group 7	$\triangle CGR1 \overset{G}{\nrightarrow} \triangle CGE5$	2.537	0.111	3.076	0.215	3.872	0.276	6.130	0.190	6.059	0.301
	$\triangle CGE5 \overset{G}{\nrightarrow} \triangle CGR1$	0.001	0.972	0.607	0.738	0.192	0.979	0.651	0.957	0.623	0.987
Group 15	$\triangle CGR3 \overset{G}{\nrightarrow} \triangle CGE5$	2.693	0.101	3.572	0.168	4.695	0.196	8.575^c	0.073	7.591	0.180
	$\triangle CGE5 \overset{G}{\nrightarrow} \triangle CGR3$	0.266	0.606	0.875	0.646	0.788	0.852	1.462	0.833	1.637	0.897

1. ^{a},^{b},^{c} indicate significance at the 1%, 5%, 10% level respectively.

Table 20: Granger non-causality tests by differenced VAR model (real (GDP deflator))

	Trend model										
	lag-order	1		2		3		4		5	
	Null hypothesis	$Wald$	p-value	$Wald$	p-value	$Wald$	p-value	$Wald$	p-value	$Wald$	p-value
Group 5	$\triangle CGR1_{r1} \overset{G}{\not\rightarrow} \triangle CGE1_{r1}$	0.198	0.656	1.390	0.499	1.228	0.746	2.465	0.651	3.265	0.659
	$\triangle CGE1_{r1} \overset{G}{\not\rightarrow} \triangle CGR1_{r1}$	0.155	0.694	3.076	0.215	1.918	0.590	2.700	0.609	6.788	0.237
Group 7	$\triangle CGR1_{r1} \overset{G}{\not\rightarrow} \triangle CGE5_{r1}$	3.139^{c}	0.076	4.243	0.120	4.248	0.236	7.820^{c}	0.098	7.427	0.191
	$\triangle CGE5_{r1} \overset{G}{\not\rightarrow} \triangle CGR1_{r1}$	0.046	0.831	1.733	0.420	0.337	0.953	0.412	0.981	0.342	0.997
Group 13	$\triangle CGR3_{r1} \overset{G}{\not\rightarrow} \triangle CGE1_{r1}$	1.137	0.286	3.377	0.185	2.288	0.515	2.955	0.565	4.702	0.453
	$\triangle CGE1_{r1} \overset{G}{\not\rightarrow} \triangle CGR3_{r1}$	0.164	0.686	5.276^{c}	0.071	3.099	0.377	4.799	0.309	7.928	0.160
Group 15	$\triangle CGR3_{r1} \overset{G}{\not\rightarrow} \triangle CGE5_{r1}$	3.970^{b}	0.046	4.826^{c}	0.090	4.913	0.178	10.650^{b}	0.031	11.077^{b}	0.050
	$\triangle CGE5_{r1} \overset{G}{\not\rightarrow} \triangle CGR3_{r1}$	0.340	0.560	2.862	0.239	0.573	0.903	1.164	0.884	1.336	0.931
Group 24	$\triangle CGR4_{r1} \overset{G}{\not\rightarrow} \triangle CGR3_{r1}$	0.622	0.430	0.700	0.705	0.462	0.927	1.914	0.752	1.913	0.861
	$\triangle CGR3_{r1} \overset{G}{\not\rightarrow} \triangle CGR4_{r1}$	10.607^{a}	0.001	11.029^{a}	0.004	15.802^{a}	0.001	15.062^{a}	0.005	13.831^{b}	0.017

1. ^{a},^{b},^{c} indicate significance at the 1%, 5%, 10% level respectively.

Table 21: Granger non-causality tests by differenced VAR model (real (CPI))

	Trend model										
	lag-order	1		2		3		4		5	
	Null hypothesis	$Wald$	p-value	$Wald$	p-value	$Wald$	p-value	$Wald$	p-value	$Wald$	p-value
Group 7	$\triangle CGR1_{r2} \overset{G}{\nrightarrow} \triangle CGE5_{r2}$	5.536^b	0.019	6.274^b	0.043	6.406^c	0.093	8.579^c	0.073	8.432	0.134
	$\triangle CGE5_{r2} \overset{G}{\nrightarrow} \triangle CGR1_{r2}$	0.235	0.628	2.072	0.355	0.234	0.972	0.190	0.996	0.292	0.998
Group 15	$\triangle CGR3_{r2} \overset{G}{\nrightarrow} \triangle CGE5_{r2}$	7.076^a	0.008	7.226^b	0.027	7.910^b	0.048	11.937^b	0.018	13.855^b	0.017
	$\triangle CGE5_{r2} \overset{G}{\nrightarrow} \triangle CGR3_{r2}$	1.040	0.308	3.693	0.158	0.463	0.927	1.210	0.876	1.669	0.893
Group 24	$\triangle CGR4_{r2} \overset{G}{\nrightarrow} \triangle CGR3_{r2}$	0.334	0.563	0.672	0.714	0.376	0.945	1.551	0.818	1.780	0.879
	$\triangle CGR3_{r2} \overset{G}{\nrightarrow} \triangle CGR4_{r2}$	11.562^a	0.001	12.291^a	0.002	17.383^a	0.001	15.964^a	0.003	14.735^b	0.012

1. ^{a},^{b},^{c} indicate significance at the 1%, 5%, 10% level respectively.

Table 22: Granger non-causality tests by differenced VAR model (real (CGPI))

	Trend model										
	lag-order	1		2		3		4		5	
	Null hypothesis	$Wald$	p-value	$Wald$	p-value	$Wald$	p-value	$Wald$	p-value	$Wald$	p-value
Group 5	$\triangle CGR1_{r3} \overset{G}{\not\to} \triangle CGE1_{r3}$	0.453	0.501	2.500	0.287	2.093	0.553	2.186	0.702	2.383	0.794
	$\triangle CGE1_{r3} \overset{G}{\not\to} \triangle CGR1_{r3}$	0.174	0.676	2.244	0.326	1.450	0.694	2.625	0.622	3.678	0.597
Group 6	$\triangle CGR1_{r3} \overset{G}{\not\to} \triangle CGE2_{r3}$	0.903	0.342	1.181	0.554	1.328	0.723	1.477	0.831	1.353	0.929
	$\triangle CGE2_{r3} \overset{G}{\not\to} \triangle CGR1_{r3}$	0.543	0.461	2.670	0.263	2.684	0.443	3.929	0.416	4.318	0.505
Group 7	$\triangle CGR1_{r3} \overset{G}{\not\to} \triangle CGE5_{r3}$	3.024^{c}	0.082	4.138	0.126	3.814	0.282	4.790	0.310	4.521	0.477
	$\triangle CGE5_{r3} \overset{G}{\not\to} \triangle CGR1_{r3}$	0.197	0.657	1.268	0.530	0.248	0.969	0.526	0.971	1.185	0.946
Group 13	$\triangle CGR3_{r3} \overset{G}{\not\to} \triangle CGE1_{r3}$	0.801	0.371	3.470	0.176	2.559	0.465	3.352	0.501	3.919	0.561
	$\triangle CGE1_{r3} \overset{G}{\not\to} \triangle CGR3_{r3}$	0.284	0.594	3.474	0.176	2.301	0.512	3.724	0.445	4.245	0.515
Group 14	$\triangle CGR3_{r3} \overset{G}{\not\to} \triangle CGE2_{r3}$	1.498	0.221	2.243	0.326	1.849	0.604	2.191	0.701	2.182	0.823
	$\triangle CGE2_{r3} \overset{G}{\not\to} \triangle CGR3_{r3}$	0.507	0.477	3.455	0.178	3.205	0.361	4.667	0.323	4.815	0.439
Group 15	$\triangle CGR3_{r3} \overset{G}{\not\to} \triangle CGE5_{r3}$	3.054^{c}	0.081	4.104	0.128	3.366	0.339	5.512	0.239	6.432	0.266
	$\triangle CGE5_{r3} \overset{G}{\not\to} \triangle CGR3_{r3}$	0.683	0.409	2.170	0.338	0.609	0.894	1.449	0.836	2.381	0.794

1. ^{a},^{b},^{c} indicate significance at the 1%, 5%, 10% level respectively.

Table 23: Granger non-causality tests by threshold (MTAR) error correction model (nominal)

	lag-order	1		2		3		4		5	
		$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value
Group 1	$\triangle CGR1 \overset{G}{\nrightarrow} \triangle CGE3$	0.200	0.654	0.171	0.918	0.154	0.985	1.851	0.763	1.583	0.903
	$\hat{\rho}_1$	0.044	0.459	0.038	0.582	0.049	0.523	0.038	0.644	0.093	0.315
	$\hat{\rho}_2$	0.649^a	0.000	0.646^a	0.000	0.644^a	0.000	0.610^a	0.000	0.591^a	0.001
	$\triangle CGE3 \overset{G}{\nrightarrow} \triangle CGR1$	0.764	0.382	1.425	0.491	9.616^b	0.022	9.619^b	0.047	20.808^a	0.001
	$\hat{\rho}_1$	−0.073	0.155	−0.053	0.354	−0.071	0.220	−0.072	0.253	-0.161^b	0.016
	$\hat{\rho}_2$	−0.171	0.144	−0.163	0.172	-0.204^c	0.070	-0.203^c	0.095	−0.155	0.179
	$\hat{\tau} = -0.126$										
Group 2	$\triangle CGR1 \overset{G}{\nrightarrow} \triangle CGE4$	0.004	0.952	1.881	0.390	2.159	0.540	4.162	0.385	5.852	0.321
	$\hat{\rho}_1$	0.001	0.989	0.000	0.999	0.021	0.810	0.017	0.864	0.061	0.591
	$\hat{\rho}_2$	0.415^a	0.001	0.406^a	0.007	0.413^a	0.008	0.397^b	0.013	0.398^b	0.014
	$\triangle CGE4 \overset{G}{\nrightarrow} \triangle CGR1$	0.000	0.991	0.199	0.905	4.750	0.191	6.431	0.169	14.346^b	0.014
	$\hat{\rho}_1$	-0.123^c	0.097	−0.100	0.216	-0.140^c	0.094	-0.169^c	0.068	-0.306^a	0.003
	$\hat{\rho}_2$	−0.206	0.145	−0.189	0.192	−0.187	0.176	−0.220	0.127	-0.250^c	0.069
	$\hat{\tau} = -0.060$										
Group 3	$\triangle CGR3 \overset{G}{\nrightarrow} \triangle CGE3$	0.595	0.441	0.706	0.703	0.673	0.880	0.983	0.912	2.341	0.800
	$\hat{\rho}_1$	0.065	0.311	0.067	0.358	0.061	0.419	0.038	0.644	0.096	0.292
	$\hat{\rho}_2$	0.563^a	0.000	0.557^a	0.001	0.659^a	0.000	0.618^a	0.001	0.552^a	0.003
	$\triangle CGE3 \overset{G}{\nrightarrow} \triangle CGR3$	0.770	0.380	1.485	0.476	8.950^b	0.030	8.935^c	0.063	19.327^a	0.002
	$\hat{\rho}_1$	−0.056	0.286	−0.012	0.827	−0.055	0.327	−0.059	0.338	-0.136^b	0.032
	$\hat{\rho}_2$	-0.327^a	0.008	-0.299^b	0.015	-0.243^b	0.036	-0.278^b	0.030	-0.210^c	0.079
	$\hat{\tau} = -0.137$										
Group 4	$\triangle CGR3 \overset{G}{\nrightarrow} \triangle CGE4$	0.057	0.812	1.236	0.539	1.483	0.686	2.280	0.684	5.111	0.402
	$\hat{\rho}_1$	0.0289	0.706	0.029	0.729	0.042	0.645	0.025	0.800	0.049	0.669
	$\hat{\rho}_2$	0.359^b	0.017	0.351^b	0.022	0.365^b	0.022	0.357^b	0.031	0.329^b	0.046
	$\triangle CGE4 \overset{G}{\nrightarrow} \triangle CGR3$	0.284	0.594	1.030	0.597	3.978	0.264	5.196	0.268	6.947	0.225
	$\hat{\rho}_1$	−0.085	0.254	−0.028	0.719	−0.071	0.360	−0.103	0.233	-0.176^c	0.078
	$\hat{\rho}_2$	-0.379^a	0.010	-0.349^b	0.016	-0.315^b	0.021	-0.338^b	0.017	-0.336^b	0.019
	$\hat{\tau} = -0.096$										

1. Trend model
2. ^{a},^{b},^{c} indicate significance at the 1%, 5%, 10% level respectively.
3. $Wald$ statistics is for Granger non-causality test and coef indicates an estimate of ρ_i for $i = 1$ and 2.

Table 24: Granger non-causality tests by threshold (MTAR) error correction model (real (GDP deflater))

	lag-order	1		2		3		4		5	
		$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value
Group 1	$\triangle CGR1_{r1} \overset{G}{\nrightarrow} \triangle CGE3_{r1}$	0.602	0.438	0.790	0.674	1.192	0.755	4.250	0.373	3.108	0.683
	$\hat{\rho}_1$	0.026	0.675	0.036	0.619	0.046	0.557	0.040	0.627	0.087	0.355
	$\hat{\rho}_2$	0.640^a	0.000	0.630^a	0.000	0.631^a	0.000	0.595^a	0.001	0.593^a	0.001
	$\triangle CGE3_{r1} \overset{G}{\nrightarrow} \triangle CGR1_{r1}$	0.102	0.749	1.848	0.397	7.291^c	0.063	7.132	0.129	16.355^a	0.006
	$\hat{\rho}_1$	-0.102^c	0.098	−0.066	0.343	−0.090	0.205	−0.092	0.232	-0.195^b	0.018
	$\hat{\rho}_2$	−0.186	0.189	−0.180	0.209	−0.210	0.121	−0.219	0.140	−0.197	0.159
	$\hat{\tau} = -0.128$										
Group 2	$\triangle CGR1_{r1} \overset{G}{\nrightarrow} \triangle CGE4_{r1}$	0.301	0.583	0.793	0.673	0.570	0.903	2.270	0.686	2.635	0.756
	$\hat{\rho}_1$	−0.007	0.928	0.010	0.912	0.052	0.601	0.045	0.689	0.050	0.708
	$\hat{\rho}_2$	0.395^b	0.018	0.394^b	0.019	0.402^b	0.018	0.387^b	0.029	0.384^b	0.037
	$\triangle CGE4_{r1} \overset{G}{\nrightarrow} \triangle CGR1_{r1}$	0.031	0.861	0.593	0.744	2.252	0.522	2.754	0.600	9.375^c	0.095
	$\hat{\rho}_1$	-0.152^c	0.088	−0.116	0.235	−0.150	0.150	−0.165	0.163	-0.336^b	0.012
	$\hat{\rho}_2$	−0.250	0.153	−0.231	0.196	−0.227	0.191	−0.245	0.179	-0.305^c	0.084
	$\hat{\tau} = -0.068$										
Group 3	$\triangle CGR3_{r1} \overset{G}{\nrightarrow} \triangle CGE3_{r1}$	0.134	0.715	0.366	0.833	0.749	0.862	2.732	0.604	2.145	0.829
	$\hat{\rho}_1$	0.059	0.388	0.082	0.286	0.063	0.425	0.040	0.632	0.093	0.328
	$\hat{\rho}_2$	0.515^a	0.002	0.519^a	0.002	0.655^a	0.000	0.643^a	0.000	0.609^a	0.626
	$\triangle CGE3_{r1} \overset{G}{\nrightarrow} \triangle CGR3_{r1}$	0.240	0.624	3.152	0.207	7.305^c	0.063	6.968	0.138	15.485^a	0.008
	$\hat{\rho}_1$	−0.068	0.276	−0.005	0.936	−0.065	0.335	−0.068	0.354	-0.160^b	0.039
	$\hat{\rho}_2$	-0.392^a	0.008	-0.354^b	0.015	-0.262^c	0.060	-0.281^c	0.062	−0.230	0.105
	$\hat{\tau} = -0.138$										
Group 4	$\triangle CGR3_{r1} \overset{G}{\nrightarrow} \triangle CGE4_{r1}$	0.252	0.615	0.238	0.888	0.157	0.984	1.086	0.896	1.947	0.856
	$\hat{\rho}_1$	0.021	0.800	0.051	0.577	0.070	0.480	0.062	0.577	0.056	0.672
	$\hat{\rho}_2$	0.343^b	0.037	0.350^b	0.037	0.364^b	0.032	0.366^b	0.039	0.355^c	0.051
	$\triangle CGE4_{r1} \overset{G}{\nrightarrow} \triangle CGR3_{r1}$	0.278	0.598	2.708	0.258	2.235	0.525	2.827	0.587	4.914	0.426
	$\hat{\rho}_1$	−0.099	0.270	−0.022	0.819	−0.063	0.511	−0.072	0.507	−0.153	0.222
	$\hat{\rho}_2$	-0.413^b	0.019	-0.374^b	0.031	-0.339^b	0.040	-0.337^b	0.048	-0.346^b	0.044
	$\hat{\tau} = -0.096$										

1. Trend model
2. ^{a},^{b},^{c} indicate significance at the 1%, 5%, 10% level respectively.
3. $Wald$ statistics is for Granger non-causality test and coef indicates an estimate of ρ_i for $i = 1$ and 2.

Table 25: Granger non-causality tests by threshold (MTAR) error correction model (real (GDP deflater)) (cont.)

	lag-order	1		2		3		4		5	
		$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value
Group 16	$\triangle CGR4_{r1} \overset{G}{\nrightarrow} \triangle CGE1_{r1}$	0.004	0.949	0.222	0.895	1.406	0.704	1.813	0.770	2.853	0.723
	$\hat{\rho}_1$	−0.081	0.303	−0.084	0.301	−0.061	0.456	−0.058	0.496	−0.060	0.490
	$\hat{\rho}_2$	−0.026	0.500	−0.033	0.464	−0.001	0.987	−0.020	0.729	−0.066	0.304
	$\triangle CGE1_{r1} \overset{G}{\nrightarrow} \triangle CGR4_{r1}$	0.538	0.463	2.538	0.281	3.705	0.295	4.590	0.332	7.527	0.184
	$\hat{\rho}_1$	-1.239^a	0.000	-1.240^a	0.000	-1.210^a	0.000	-1.244^a	0.000	-1.199^a	0.000
	$\hat{\rho}_2$	−0.176	0.191	−0.161	0.282	−0.144	0.386	−0.144	0.449	−0.229	0.281
	$\hat{\tau} = 0.239$										
Group 18	$\triangle CGR4_{r1} \overset{G}{\nrightarrow} \triangle CGE3_{r1}$	0.111	0.739	0.128	0.938	0.437	0.932	5.921	0.205	4.455	0.486
	$\hat{\rho}_1$	−0.002	0.974	−0.005	0.931	0.024	0.707	−0.002	0.971	0.021	0.758
	$\hat{\rho}_2$	0.175	0.254	0.214	0.212	0.154	0.387	0.278	0.339	0.369	0.270
	$\triangle CGE3_{r1} \overset{G}{\nrightarrow} \triangle CGR4_{r1}$	1.290	0.256	1.669	0.434	2.199	0.532	3.804	0.433	4.955	0.421
	$\hat{\rho}_1$	−0.109	0.349	−0.132	0.311	−0.161	0.284	−0.157	0.294	−0.214	0.188
	$\hat{\rho}_2$	-1.012^a	0.007	-0.874^b	0.032	-0.847^b	0.049	-2.084^a	0.004	-2.342^a	0.004
	$\hat{\tau} = -0.256$										
Group 19	$\triangle CGR4_{r1} \overset{G}{\nrightarrow} \triangle CGE4_{r1}$	0.041	0.840	1.197	0.550	2.135	0.545	2.346	0.672	2.823	0.727
	$\hat{\rho}_1$	−0.048	0.595	−0.046	0.614	−0.028	0.761	−0.025	0.792	−0.023	0.822
	$\hat{\rho}_2$	−0.003	0.946	−0.014	0.780	0.030	0.609	0.022	0.738	0.015	0.840
	$\triangle CGE4_{r1} \overset{G}{\nrightarrow} \triangle CGR4_{r1}$	2.031	0.154	3.648	0.161	6.560^c	0.087	8.135^c	0.087	11.368^b	0.045
	$\hat{\rho}_1$	-0.958^a	0.000	-0.966^a	0.000	-0.915^a	0.000	-0.972^a	0.000	-0.973^a	0.000
	$\hat{\rho}_2$	−0.101	0.402	−0.075	0.566	−0.074	0.611	−0.093	0.567	−0.181	0.320
	$\hat{\tau} = 0.242$										
Group 20	$\triangle CGR4_{r1} \overset{G}{\nrightarrow} \triangle CGE5_{r1}$	0.637	0.425	1.323	0.516	1.530	0.675	1.373	0.849	5.076	0.407
	$\hat{\rho}_1$	−0.130	0.274	−0.134	0.261	−0.146	0.236	−0.148	0.256	-0.229^c	0.083
	$\hat{\rho}_2$	−0.021	0.669	−0.008	0.892	0.004	0.951	−0.011	0.882	−0.103	0.230
	$\triangle CGE5_{r1} \overset{G}{\nrightarrow} \triangle CGR4_{r1}$	0.105	0.745	1.649	0.439	3.627	0.305	6.832	0.145	11.086^b	0.050
	$\hat{\rho}_1$	-1.376^a	0.000	-1.413^a	0.000	-1.483^a	0.000	-1.507^a	0.000	-1.621^a	0.000
	$\hat{\rho}_2$	-0.267^c	0.059	−0.236	0.138	−0.248	0.159	−0.320	0.125	-0.472^b	0.046
	$\hat{\tau} = 0.235$										

1. Trend model
2. $^a, ^b, ^c$ indicate significance at the 1%, 5%, 10% level respectively.
3. $Wald$ statistics is for Granger non-causality test and coef indicates an estimate of ρ_i for $i = 1$ and 2.

Table 26: Granger non-causality tests by threshold (MTAR) error correction model (real (CPI))

	lag-order	1		2		3		4		5	
		$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value
Group 1	$\triangle CGR1_{r2} \overset{G}{\nrightarrow} \triangle CGE3_{r2}$	2.311	0.128	2.572	0.276	2.515	0.473	4.220	0.377	2.545	0.770
	$\hat{\rho}_1$	0.033	0.598	0.041	0.576	0.054	0.507	0.052	0.552	0.102	0.310
	$\hat{\rho}_2$	0.637^a	0.000	0.623^a	0.000	0.634^a	0.000	0.608^a	0.001	0.614^a	0.001
	$\triangle CGE3_{r2} \overset{G}{\nrightarrow} \triangle CGR1_{r2}$	0.134	0.714	1.581	0.454	5.181	0.159	5.421	0.247	13.209^b	0.022
	$\hat{\rho}_1$	-0.102^c	0.092	−0.069	0.315	−0.095	0.189	−0.094	0.235	-0.201^b	0.021
	$\hat{\rho}_2$	−0.191	0.167	−0.186	0.185	−0.213	0.117	−0.211	0.156	−0.187	0.189
	$\hat{\tau} = -0.128$										
Group 2	$\triangle CGR1_{r2} \overset{G}{\nrightarrow} \triangle CGE4_{r2}$	1.393	0.238	1.840	0.399	1.241	0.743	2.193	0.700	2.464	0.782
	$\hat{\rho}_1$	−0.004	0.963	0.019	0.834	0.060	0.555	0.056	0.628	0.077	0.586
	$\hat{\rho}_2$	0.435^a	0.009	0.434^b	0.010	0.443^a	0.010	0.435^b	0.016	0.441^b	0.020
	$\triangle CGE4_{r2} \overset{G}{\nrightarrow} \triangle CGR1_{r2}$	0.029	0.866	0.630	0.730	1.807	0.613	2.466	0.651	7.110	0.213
	$\hat{\rho}_1$	-0.159^c	0.069	−0.125	0.200	−0.161	0.126	−0.175	0.148	-0.336^b	0.018
	$\hat{\rho}_2$	−0.215	0.208	−0.198	0.259	−0.200	0.242	−0.215	0.234	−0.264	0.140
	$\hat{\tau} = -0.068$										
Group 3	$\triangle CGR3_{r2} \overset{G}{\nrightarrow} \triangle CGE3_{r2}$	1.294	0.255	1.968	0.374	2.031	0.566	3.280	0.512	1.813	0.874
	$\hat{\rho}_1$	0.061	0.379	0.083	0.281	0.065	0.420	0.047	0.588	0.105	0.294
	$\hat{\rho}_2$	0.536^a	0.001	0.532^a	0.002	0.661^a	0.000	0.659^a	0.000	0.632^a	0.001
	$\triangle CGE3_{r2} \overset{G}{\nrightarrow} \triangle CGR3_{r2}$	0.395	0.530	3.284	0.194	5.660	0.129	5.609	0.230	12.997^b	0.023
	$\hat{\rho}_1$	−0.071	0.233	−0.014	0.833	−0.073	0.276	−0.072	0.322	-0.164^b	0.037
	$\hat{\rho}_2$	-0.376^a	0.007	-0.346^b	0.013	-0.257^c	0.059	-0.274^c	0.064	−0.219	0.120
	$\hat{\tau} = -0.138$										
Group 4	$\triangle CGR3_{r2} \overset{G}{\nrightarrow} \triangle CGE4_{r2}$	1.337	0.248	1.311	0.519	0.769	0.857	1.085	0.897	1.729	0.885
	$\hat{\rho}_1$	0.021	0.806	0.052	0.565	0.069	0.492	0.062	0.592	0.067	0.625
	$\hat{\rho}_2$	0.385^b	0.019	0.391^c	0.019	0.401^b	0.019	0.402^b	0.025	0.400^b	0.032
	$\triangle CGE4_{r2} \overset{G}{\nrightarrow} \triangle CGR3_{r2}$	0.105	0.746	3.129	0.209	1.969	0.579	2.539	0.638	3.888	0.566
	$\hat{\rho}_1$	−0.105	0.224	−0.031	0.737	−0.073	0.440	−0.080	0.455	−0.140	0.264
	$\hat{\rho}_2$	-0.370^b	0.028	-0.336^b	0.043	-0.313^b	0.048	-0.310^c	0.059	-0.311^c	0.063
	$\hat{\tau} = -0.095$										

1. Trend model
2. ^{a},^{b},^{c} indicate significance at the 1%, 5%, 10% level respectively.
3. $Wald$ statistics is for Granger non-causality test and coef indicates an estimate of ρ_i for $i = 1$ and 2.

Table 27: Granger non-causality tests by threshold (MTAR) error correction model (real (CPI)) (cont.)

	lag-order	1		2		3		4		5	
		$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value
Group 18	$\triangle CGR4_{r2} \overset{G}{\nrightarrow} \triangle CGE3_{r2}$	0.396	0.529	0.341	0.843	0.573	0.903	5.932	0.204	4.122	0.532
	$\hat{\rho}_1$	0.002	0.961	−0.002	0.978	0.030	0.636	0.003	0.958	0.034	0.626
	$\hat{\rho}_2$	0.127	0.404	0.154	0.362	0.096	0.588	0.190	0.518	0.303	0.376
	$\triangle CGE3_{r2} \overset{G}{\nrightarrow} \triangle CGR4_{r2}$	1.190	0.275	1.593	0.451	2.086	0.555	3.860	0.425	5.141	0.399
	$\hat{\rho}_1$	−0.108	0.354	−0.135	0.304	−0.161	0.288	−0.155	0.308	−0.219	0.187
	$\hat{\rho}_2$	-1.009^a	0.006	-0.885^b	0.028	-0.873^b	0.041	-2.119^a	0.004	-2.420^a	0.004
	$\hat{\tau} = -0.258$										
Group 19	$\triangle CGR4_{r2} \overset{G}{\nrightarrow} \triangle CGE4_{r2}$	0.111	0.739	0.978	0.613	2.388	0.496	2.545	0.637	3.304	0.653
	$\hat{\rho}_1$	−0.041	0.654	−0.039	0.669	−0.022	0.809	−0.021	0.828	−0.015	0.885
	$\hat{\rho}_2$	−0.002	0.974	−0.012	0.820	0.036	0.540	0.030	0.660	0.032	0.686
	$\triangle CGE4_{r2} \overset{G}{\nrightarrow} \triangle CGR4_{r2}$	2.054	0.152	4.505	0.105	7.380^c	0.061	8.800^c	0.066	11.173^b	0.048
	$\hat{\rho}_1$	-0.958^a	0.000	-0.971^a	0.000	-0.919^a	0.000	-0.983^a	0.000	-0.978^a	0.000
	$\hat{\rho}_2$	−0.101	0.407	−0.084	0.525	−0.081	0.586	−0.107	0.520	−0.192	0.318
	$\hat{\tau} = 0.242$										
Group 20	$\triangle CGR4_{r2} \overset{G}{\nrightarrow} \triangle CGE5_{r2}$	0.835	0.361	1.585	0.453	1.956	0.582	1.808	0.771	4.819	0.438
	$\hat{\rho}_1$	−0.125	0.287	−0.124	0.296	−0.139	0.259	−0.137	0.289	−0.215	0.104
	$\hat{\rho}_2$	−0.025	0.606	−0.012	0.838	−0.004	0.943	−0.021	0.795	−0.114	0.204
	$\triangle CGE5_{r2} \overset{G}{\nrightarrow} \triangle CGR4_{r2}$	0.144	0.705	2.860	0.239	4.596	0.204	7.143	0.129	11.170^b	0.048
	$\hat{\rho}_1$	-1.357^a	0.000	-1.407^a	0.000	-1.473^a	0.000	-1.489^a	0.000	-1.602^a	0.000
	$\hat{\rho}_2$	-0.267^c	0.060	−0.246	0.120	−0.268	0.128	−0.349	0.101	-0.505^b	0.039
	$\hat{\tau} = 0.235$										

1. Trend model
2. ^{a},^{b},^{c} indicate significance at the 1%, 5%, 10% level respectively.
3. $Wald$ statistics is for Granger non-causality test and coef indicates an estimate of ρ_i for $i = 1$ and 2.

Table 28: Granger non-causality tests by threshold (MTAR) error correction model (real (CGPI))

	lag-order	1		2		3		4		5	
		$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value	$Wald$/coef	p-value
Group 1	$\triangle CGR1_{r3} \overset{G}{\nrightarrow} \triangle CGE3_{r3}$	2.173	0.140	1.322	0.516	2.103	0.551	2.939	0.568	1.587	0.903
	$\hat{\rho}_1$	−0.014	0.822	0.010	0.891	0.021	0.797	−0.004	0.961	0.052	0.621
	$\hat{\rho}_2$	0.590^a	0.000	0.582^a	0.000	0.580^a	0.000	0.518^a	0.003	0.526^a	0.004
	$\triangle CGE3_{r3} \overset{G}{\nrightarrow} \triangle CGR1_{r3}$	0.093	0.761	1.471	0.479	7.832^b	0.050	7.317	0.120	14.226^b	0.014
	$\hat{\rho}_1$	-0.143^b	0.042	−0.099	0.206	-0.141^c	0.087	−0.150	0.103	-0.267^a	0.010
	$\hat{\rho}_2$	−0.236	0.140	−0.216	0.176	−0.229	0.127	−0.262	0.120	−0.243	0.137
	$\hat{\tau} = -0.128$										
Group 2	$\triangle CGR1_{r3} \overset{G}{\nrightarrow} \triangle CGE4_{r3}$	1.471	0.225	1.265	0.531	1.000	0.801	1.191	0.880	0.970	0.965
	$\hat{\rho}_1$	−0.050	0.569	−0.020	0.841	0.028	0.803	0.024	0.862	0.029	0.866
	$\hat{\rho}_2$	0.325^c	0.058	0.334^c	0.059	0.329^c	0.067	0.324^c	0.089	0.325	0.106
	$\triangle CGE4_{r3} \overset{G}{\nrightarrow} \triangle CGR1_{r3}$	0.142	0.706	0.235	0.889	3.118	0.374	3.017	0.555	8.373	0.137
	$\hat{\rho}_1$	-0.198^c	0.055	−0.162	0.149	-0.225^c	0.069	−0.246	0.100	-0.468^a	0.009
	$\hat{\rho}_2$	−0.313	0.108	−0.278	0.155	−0.266	0.161	−0.281	0.166	-0.351^c	0.080
	$\hat{\tau} = -0.060$										
Group 3	$\triangle CGR3_{r3} \overset{G}{\nrightarrow} \triangle CGE3_{r3}$	1.083	0.298	0.548	0.760	1.973	0.578	3.029	0.553	1.189	0.946
	$\hat{\rho}_1$	0.021	0.770	0.062	0.432	0.041	0.614	0.008	0.933	0.066	0.522
	$\hat{\rho}_2$	0.473^a	0.005	0.479^a	0.005	0.602^a	0.001	0.591^a	0.001	0.575^a	0.003
	$\triangle CGE3_{r3} \overset{G}{\nrightarrow} \triangle CGR3_{r3}$	0.108	0.742	2.454	0.293	7.805^c	0.050	7.221	0.125	12.344^b	0.030
	$\hat{\rho}_1$	−0.110	0.127	−0.038	0.628	−0.118	0.144	−0.130	0.146	-0.232^b	0.022
	$\hat{\rho}_2$	-0.439^a	0.009	-0.387^b	0.019	-0.296^c	0.063	-0.303^c	0.084	−0.268	0.121
	$\hat{\tau} = -0.137$										
Group 4	$\triangle CGR3_{r3} \overset{G}{\nrightarrow} \triangle CGE4_{r3}$	1.147	0.284	1.445	0.485	1.094	0.778	1.269	0.867	1.101	0.954
	$\hat{\rho}_1$	−0.020	0.817	0.025	0.769	0.037	0.734	0.051	0.695	0.048	0.768
	$\hat{\rho}_2$	0.331^c	0.054	0.352^b	0.047	0.345^c	0.055	0.355^c	0.060	0.346^c	0.080
	$\triangle CGE4_{r3} \overset{G}{\nrightarrow} \triangle CGR3_{r3}$	0.485	0.486	1.261	0.532	2.879	0.411	2.672	0.614	3.727	0.589
	$\hat{\rho}_1$	−0.149	0.153	−0.073	0.502	−0.146	0.209	−0.148	0.285	−0.245	0.156
	$\hat{\rho}_2$	-0.432^b	0.033	-0.383^c	0.052	-0.359^c	0.059	-0.357^c	0.073	-0.369^c	0.074
	$\hat{\tau} = -0.096$										

1. Trend model
2. ^{a},^{b},^{c} indicate significance at the 1%, 5%, 10% level respectively.
3. $Wald$ statistics is for Granger non-causality test and coef indicates an estimate of ρ_i for $i = 1$ and 2.

Table 29: Granger non-causality tests by Toda and Yamamoto

	Trend model				
	Null hypothesis	selected lag	estimated model	t $(Wald)$ statistic	p-value
Group A	$CGR1_G \overset{G}{\nrightarrow} DEMO$	1	3	2.075^b	0.044
	$DEMO \overset{G}{\nrightarrow} CGR1_G$	1	3	-0.367	0.716
Group B	$CGR2_G \overset{G}{\nrightarrow} DEMO$	2	4	17.167^a	0.009
	$DEMO \overset{G}{\nrightarrow} CGR2_G$	2	4	6.763	0.149
Group C	$CGR1_G \overset{G}{\nrightarrow} ARC$	1	3	-1.466	0.151
	$ARC \overset{G}{\nrightarrow} CGR1_G$	1	3	-0.719	0.602
Group D	$CGR2_G \overset{G}{\nrightarrow} ARC$	1	3	0.197	0.845
	$ARC \overset{G}{\nrightarrow} CGR2_G$	1	3	-0.526^b	0.036
Group E	$CGR1_G \overset{G}{\nrightarrow} ARR$	1	3	0.337	0.738
	$ARR \overset{G}{\nrightarrow} CGR1_G$	1	3	0.215	0.831
Group F	$CGR2_G \overset{G}{\nrightarrow} ARR$	1	3	0.276	0.784
	$ARR \overset{G}{\nrightarrow} CGR2_G$	1	3	-1.345	0.188

1. ^{a},^{b},^{c} indicate significance at the 1%, 5%, 10% level respectively.
2. In each group, LR statistics select the lag-order of VAR model and two extra lags are added to test the causality.