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Dynamic linkages of stock prices among G7 countries: effects of the American financial crisis

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Abstract

In this paper, we use the cross-correlation function developed by Cheung and Ng (1996) to investigate the dynamic linkages among G7 countries in the mean and volatility of stock prices from June 2, 2003, through July 31, 2010. In particular, we examined the impact of the American financial crisis, which erupted in the US in September 2008 as a result of the sub-prime loan losses of 2007. The sample period is divided into two—the pre- and post-crisis periods—in order to study the causal relationship in mean and volatility. Our research has shown that the international transmission of stock market indices among G7 countries weakened in the mean but became stronger in volatility through the 2007–2008 American financial crisis.

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1. Introduction

The international linkages among national stock markets have been examined in a number of studies. Kasa (1992) presented evidence of common stochastic trends in stock price indices in the US, Japan, the UK, Germany, and Canada, using a vector error correction model (VECM)[1]. Chowdhury (1994) used a vector autoregression (VAR) methodology to analyze the relationship among the stock markets of four newly industrialized economies (NIEs) in Asia, including Hong Kong, Korea, Singapore, and Taiwan. In addition, some papers have investigated the interdependence of price volatility across national stock markets—French et al. (1987), Chou (1988), Baillie and DeGennaro (1990), and Poon and Taylor (1992), for example.

Furthermore, a number of empirical analyses have been devoted to examine the international linkages among G7 countries. Chowdhury (1993) examined the impact of exchange rate volatility on the trade flows of G7 countries in the context of a multivariate error correction model. Bill and Lori (1995) investigated the long-term co-movement of the stock markets of the G5 and the G7 countries. Hamori and Imamura (2000) empirically analyzed the causal relationship among stock prices in the G7 countries, employing the LA-VAR method[2]. Nieh and Lee (2001) explored the dynamic relationship between the stock prices and exchange rate of each G7 country. Yang et al. (2006) investigated the international transmission of inflation among G7 countries using data-determined VAR analysis.

Moreover, a large number of empirical studies have focused on the impact of the financial crisis on the international transmission of stock prices. Malliaris and Urrutia (1992), Masih and Masih (1997), and Wang et al. (2003) examined dynamic causal linkages and relationships among national stock markets during the market crisis.

Cheung and Ng (1996) developed a two-step procedure to test for causality in mean and variance, called the cross-correlation function (CCF). Hamori (2003) applied the method to analyze the causal relationship between stock markets. He also compared the results of the Granger causality test with those of the CCF approach. More complex and dynamic causation patterns are evident in the CCF approach for both causality in mean and causality in volatility. Some recent studies used the CCF approach to find causal relationships. Bhar and Hamori (2008) used it to empirically analyze the relationships between commodity futures prices and economic activities.

This paper extends the literature by using the CCF approach to investigate the international transmission of G7 stock market indices in both mean and volatility. To the best of our knowledge, this is the first work to analyze the dynamic linkages among G7 stock markets during the 2007–2008 American financial crisis. Since the American stock market index fell by over 6.9% in September 29, 2008, we divide the entire sample period into two sub-periods, and use the CCF approach to examine the causal relationship of stock prices.

1 See Sims (1980).
2 See Toda and Yamamoto (1995).

Further, we compare the results of the two sub-periods and indicate the impact of the 2007–2008 American financial crisis in both mean and volatility.

The remainder of the paper is organized as follows. Section 2, describes the details of the data used in this study. Section 3 explains the CCF methodology. Section 4 presents the empirical results. In Section 5, we compare and discuss the empirical results. Finally, we offer some concluding remarks in Section 6.

2. Description of the date

The data used in this study consist of a time series of daily stock market indices at closing time, in terms of local currency units of the G7 countries. TSX, CAC, DAX, FTSE MIB, Nikkei 225, FTSE, and Dow are taken as representative stock market indices of Canada, France, Germany, Italy, Japan, the UK, and the US, respectively. It covers the period from June 2, 2003, through July 31, 2010, with a total of 1617 observations for each country. These stock price indices have been obtained from the Yahoo! Finance website (http://finance.yahoo.com), and their first differences are used as follows: $x_t = \ln S_t - \ln S_{t-1}$, where S_t is the stock price index at time t. In order to compensate for any missing value in the data for a particular country, the corresponding observation is excluded for all countries.

Since the US stock market index fell by over 6.9% in September 29, 2008, the entire sample period is divided into two sub-periods: the pre-crisis period from June 2, 2003 to September 28, 2008, and the post-crisis period from September 29, 2008 to July 31, 2010. Using this database, we compare the causal relationships in mean and volatility in the international stock markets before and after the crisis. We also compare the causal relationships before and after the crisis.

3. Methodology

In this paper, we use the two-step procedure proposed by Cheung and Ng (1996) to test for causality in mean and variance[3]. The procedure is based on the CCF between the residuals of each variable. In the first of the two steps, we estimate a set of univariate time-series models that allow for time variation in both the conditional mean and conditional variance. Further, the AR(*k*)-EGARCH(*p*, *q*) specification is used in this step. The conditional mean and conditional variance are specified in the following manner respectively:

$$x_t = a_0 + \sum_{i=1}^{k} a_i x_{t-i} + \varepsilon_t \quad , \tag{1}$$

$$\log\left(\sigma_t^2\right) = \omega + \sum_{i=1}^{p}\left(\alpha_i \left|\frac{\varepsilon_{t-i}}{\sigma_{t-i}}\right| + \gamma_i \frac{\varepsilon_{t-i}}{\sigma_{t-i}}\right) + \sum_{i=1}^{q}\beta_i \log\left(\sigma_{t-i}^2\right) \tag{2}$$

[3] See, also, Hamori (2003).

We assume that the error term has a generalized error distribution (GED). Each model is estimated by the maximum likelihood method. The Schwarz Bayesian information criterion[4] (SBIC) is used to specify the AR model, and the smallest values of SBIC are preferred. The Ljung–Box test[5] is used to check the residual of the AR model. The choice of k, p, and q is made from $k = 1, 2, \ldots, 10$, $p = 1, 2$, and $q = 1, 2$ using SBIC and residual diagnostics.

The second step uses the Cheung–Ng test to analyze the causality in mean and variance based on the empirical results obtained in the first step. In the second step, we construct the residuals standardized by the conditional mean and the squared residuals standardized by the conditional variance. The CCF of the standardized residuals is used to test the null hypothesis of no causality in mean, while the CCF of squared standardized residuals is used to test the null hypothesis of no causality in variance.

We begin by summarizing the two-step procedure to test causality, developed by Cheung and Ng (1996). Suppose that there are two stationary time series, X_t and Y_t, and three information sets, $I_{1t} = (X_{t-j}; j \geq 0)$, $I_{2t} = (Y_{t-j}; j \geq 0)$, and $I_t = (X_{t-j}, Y_{t-j}; j \geq 0)$. Y_t is said to cause X_t in mean if

$$E[X_t \mid I_{1t-1}] \neq E[X_t \mid I_t]. \tag{3}$$

Similarly, X_t is said to cause Y_t in mean if

$$E[Y_t \mid I_{2t-1}] \neq E[Y_t \mid I_t]. \tag{4}$$

We encounter feedback in mean if Y_t causes X_t in mean or vice versa. On the other hand, Y_t causes X_t in variance if

$$E[(X_t - \mu_{x,t})^2 \mid I_{1t-1}] \neq E[(X_t - \mu_{x,t})^2 \mid I_{t-1}], \tag{5}$$

where $\mu_{x,t}$ is the mean of X_t conditioned on I_{1t-1}. Similarly, X_t causes Y_t in variance if

$$E[(Y_t - \mu_{y,t})^2 \mid I_{2t-1}] \neq E[(Y_t - \mu_{y,t})^2 \mid I_{t-1}], \tag{6}$$

where $\mu_{y,t}$ is the mean of Y_t conditioned on I_{2t-1}. We encounter feedback in variance if X_t causes Y_t in variance or vice versa. The causality in variance is interesting, given that it has a directional relation to volatility spillover across different assets or markets.

Since the concept defined in equations (1)–(4) is too general for empirical testing, an additional structure is required in order to make the general causality concept practically applicable.

Suppose X_t and Y_t are rewritten as

$$X_t = \mu_{x,t} + \sqrt{h_{x,t}}\,\varepsilon_t, \tag{7}$$

and

[4] See Schwarz (1978).

5 See Ljung and Box (1978).

$$Y_t = \mu_{y,t} + \sqrt{h_{y,t}}\varsigma_t, \tag{8}$$

respectively,

where ε_t and ς_t are two independent white noise processes with zero mean and unit variance.

For the causality-in-mean test, the following standardized innovations may be used:

$$\varepsilon_t = \frac{X_t - \mu_{x,t}}{\sqrt{h_{x,t}}}, \tag{9}$$

$$\varsigma_t = \frac{Y_t - \mu_{y,t}}{\sqrt{h_{y,t}}}. \tag{10}$$

Since both ε_t and ς_t are unobservable, their estimates—$\hat{\varepsilon}_t$ and $\hat{\varsigma}_t$—are used in order to test the hypothesis of no causality in mean.

Next, we compute the sample cross-correlation coefficient at lag k, $\hat{r}_{\varepsilon\varsigma}(k)$, from the consistent estimates of the conditional mean and variance of X_t and Y_t. This computation yields

$$\hat{r}_{\varepsilon\varsigma}(k) = \frac{c_{\varepsilon\varsigma}(k)}{\sqrt{c_{\varepsilon\varepsilon}(0)c_{\varsigma\varsigma}(0)}}, \tag{11}$$

where $c_{\varepsilon\varsigma}(k)$ is the k-th lag sample cross-covariance given by

$$c_{\varepsilon\varsigma}(k) = \begin{cases} \frac{1}{T}\sum_{t=1}^{T-k}\sum\left(\hat{\varepsilon}_t - \overline{\varepsilon}\right)\left(\hat{\varsigma}_{t+k} - \overline{\varsigma}\right) & \text{for } \quad k = 0,1,2,\cdots \\ \frac{1}{T}\sum_{t=1}^{T+k}\sum\left(\hat{\varepsilon}_{t-k} - \overline{\varepsilon}\right)\left(\hat{\varsigma}_t - \overline{\varsigma}\right) & \text{for } \quad k = 0,-1,-2,\cdots \end{cases} \tag{12}$$

where $c_{\varepsilon\varepsilon}(0)$ and $c_{\varsigma\varsigma}(0)$ are defined as the sample variances of ε_t and ς_t, respectively.

Causality in the means of X_t and Y_t can be tested by examining $\hat{r}_{\varepsilon\varsigma}(k)$, the univariate standardized residual CCF. Under the condition of regularity, the following condition holds:

$$\sqrt{T}\hat{r}_{\varepsilon\varsigma}(k_i) \xrightarrow{L} N(0,1), \quad i = 1,2,\cdots,m, \tag{13}$$

where $\xrightarrow{L}$ indicates the convergence in distribution.

This test statistic can be used to test the null hypothesis of no causality in mean. In order to test for a causal relationship at a specified lag k, we compare $\hat{r}_{\varepsilon\varsigma}(k)$ with the standard normal distribution. If the test statistic is larger than the critical value of the normal distribution, the null hypothesis is rejected.

For the causality-in-variance test, let u_t and v_t be the squares of the standardized innovations, given by

$$u_t = \frac{(X_t - \mu_{X,t})^2}{h_{X,t}} = \varepsilon_t^2 \tag{14}$$

and

$$v_t = \frac{(Y_t - \mu_{y,t})^2}{h_{y,t}} = \varsigma_t^2 . \tag{15}$$

Since both u_t and v_t are unobservable, their estimates—$\hat{u}_t$ and $\hat{v}_t$—are used to test the hypothesis of no causality in variance.

Next, we compute the sample cross-correlation coefficient at lag k, $\hat{r}_{uv}(k)$, from the consistent estimates of the conditional mean and variance of X_t and Y_t. This yields

$$\hat{r}_{uv}(k) = \frac{c_{uv}(k)}{\sqrt{c_{uu}(0)c_{vv}(0)}} , \tag{16}$$

where $c_{uv}(k)$ is the k-th lag sample cross-covariance given by

$$c_{uv}(k) = \begin{cases} \frac{1}{T}\sum_{t=1}^{T-k}\left(\hat{u}_t - \bar{u}\right)\left(\hat{v}_{t+k} - \bar{v}\right) & for \quad k = 0,1,2,\cdots \\ \frac{1}{T}\sum_{t=1}^{T+k}\left(\hat{u}_{t-k} - \bar{u}\right)\left(\hat{v}_t - \bar{v}\right) & for \quad k = 0,-1,-2,\cdots \end{cases} , \tag{17}$$

where $c_{uu}(0)$ and $c_{vv}(0)$ are defined as the sample variances of u_t and v_t, respectively.

Causality in the variance of X_t and Y_t can be tested by examining the squared standardized residual CCF—$\hat{r}_{uv}(k)$. Under the condition of regularity, the following condition holds:

$$\sqrt{T}\hat{r}_{uv}(k_i) \xrightarrow{L} N(0,1) \qquad i = 1,2,\cdots,m . \tag{18}$$

This test statistic can be used to test the null hypothesis of no causality in variance. In order to test for a causal relationship at a specified lag k, we compare $\hat{r}_{uv}(k)$ with the standard normal distribution. If the test statistic is larger than the critical value of the normal distribution, the null hypothesis is rejected.

4. Empirical Results

4.1 The pre-crisis period

The empirical results are discussed for both the pre- and post-crisis periods. In the pre-crisis period, the AR(1)-EGARCH(2,2) model is selected for Canada, France, Germany, Italy, Japan, and the US, whereas the AR(3)-EGARCH(1,1) model is selected for the UK.

Table 1 presents the empirical results of the AR-EGARCH model. As shown in this table, the coefficients of the GARCH term (β_1, β_2) are estimated to be 1.797 and −0.780 for Canada, 1.726 and −0.737 for France, 1.843 and −0.848 for Germany, 0.661 and 0.289 for Italy, 1.645 and −0.654 for Japan, 0.997 for the UK, and 1.490 and −0.500 for the US, and they are statistically significant at the 1% level. The coefficients of the asymmetric effect (γ_1, γ_2) are estimated to be −0.216 and 0.223 for Canada, −0.254 and 0.220 for France, −0.217 and 0.207 for Germany, −0.150 and −0.024 for Italy, −0.224 and 0.208 for Japan, −0.140 for the UK, and −0.257 and 0.220 for the US. It is noteworthy that this asymmetric parameter (γ_2) is not statistically significant for Italy. The GED parameter is estimated to be 1.554 for Canada, 1.747 for France, 1.549 for Germany, 1.117 for Italy, 1.492 for Japan, 1.676 for the UK, and 1.441 for the US. All parameters are statistically significant at the 1% level. Since each of these parameters is below 2, the tails of the error terms are heavier than those of a normal distribution. Further, Table 1 also shows the diagnostics of the empirical results of the AR-EGARCH model, the $Q(s)$ statistic, and the $Q^2(s)$ statistic. The Q statistic at lag s, $Q(s)$, is a test statistic for the null hypothesis that there is no autocorrelation up to order s for standardized residuals; it is asymptotically distributed as χ^2 with degrees of freedom equal to the number of autocorrelation coefficients less the number of parameters. The Q^2 statistic at lag s, $Q^2(s)$, is a test statistic for the null hypothesis that no autocorrelation exists up to order s for standardized residuals squared. As it is clear shown in table 1, all of p values of the $Q(20)$ and the $Q^2(20)$ are larger than 0.01, it means that the null hypothesis of no autocorrelation up to order 20 for standardized residuals and standardized residuals squared is accepted for all countries.

4.2 The post-crisis period

In this sub-section, we examine the causality of stock prices using the CCF approach for the post-crisis period. The AR(1)-EGARCH(2,2) model is used for Canada, France, Italy, Japan, and the US, whereas the AR(1)-EGARCH(2,1) model is used for Germany and the AR(1)-EGARCH(1,1) model for the UK.

Table 2 reports the empirical results of the AR-EGARCH model. The coefficients of the GARCH term (β_1, β_2) are estimated to be 0.062 and 0.927 for Canada, 1.787 and −0.792 for France, 0.977 for Germany, 1.709 and −0.713 for Italy, 0.402 and 0.557 for Japan, 0.978 for the UK, and 0.035 and 0.948 for the US. It must be noted that this asymmetric parameter (β_1) is not statistically significant for Canada, Japan, and the US. The coefficients of the asymmetric effect (γ_1, γ_2) are estimated to be −0.106 and 0.051 for Canada, −0.305 and 0.285 for France, −0.212 and 0.074 for Germany, −0.285 and −0.266 for Italy, −0.191 and 0.017 for Japan, −0.132 for the UK, and −0.170 and 0.006 for the US. It is noteworthy that this asymmetric parameter (γ_2) is not statistically significant for Canada, Germany, Japan, and the US. The GED parameter is estimated to be 1.851 for Canada, 1.651 for France, 1.696 for Germany, 1.658 for Italy, 1.823 for Japan, 1.583 for the UK, and 1.583 for the US. All parameters are statistically significant at the 1% level. Further, the table also shows the diagnostics of the empirical results of the AR-EGARCH model. The resluts of the $Q(20)$ and the $Q^2(20)$ indicate that the null hypothesis of no autocorrelation up to order 20 for standardized residuals and standardized residuals squared is accepted for all countries.

5. Discussion

In this section, we compare the causal relationships in the mean and volatility of stock prices in the pre- and post-crisis periods. Tables 3 reports the Causality in mean and volatility of stock markets among G7 countries in the pre- and post-crisis periods. From the results, we find that the stock market volatility in G7 countries other than the UK, and the US exerts less influence on the mean in the post-crisis period than in the pre-crisis period. This means that the influential power of Canada, France, Germany, Italy, and Japan weakened in the mean during the crisis. However, the Canada, French, Italian, and German stock markets caused more volatility in other markets after the 2008 American crisis. Germany, especially, influenced all countries whereas France and Italy affected five countries, in the post-crisis period. These results indicate a strengthening of the influential power of France, Italy, and Germany with regard to volatility.

We also find out that Japan is the most integrated market in the G7 countries; all other markets affect Japan in the mean and volatility, in both sub-periods. Canada is the second most integrated market among the G7 countries. Similar to Japan, Canada is affected in volatility by all G7 countries except France in the post-crisis period. Another interesting finding is the feedback in mean between the US and all other countries except Canada in the post-crisis period.

6. Conclusion

In this paper, we investigate the dynamic linkages among the G7 countries in both the mean and volatility of stock prices, using the CCF approach developed by Cheung and Ng (1996). In particular, we examined the impact of the American financial crisis that erupted in September 2008. Our research has shown that the international transmission of stock market indices among G7 countries weakened in the mean but became stronger in volatility during the 2007–2008 American financial crisis.

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Table 1: Empirical results of the AR-EGARCH model for the pre-crisis period

Model	Canada AR(1)-EGARCH(2,2)	France AR(1)-EGARCH(2,2)	Germany AR(1)-EGARCH(2,2)	Italy AR(1)-EGARCH(2,2)	Japan AR(1)-EGARCH(2,2)	UK AR(1)-EGARCH(1,1)	USA AR(1)-EGARCH(2,2)
Mean equation							
a_0	0.068(0.023)**	0.024(0.027)	0.072(0.028)*	0.082(0.020) **	0.058(0.032)	0.025(0.022)	0.041(0.021)*
a_1	-0.010(0.029)	-0.063(0.026)*	-0.006(0.029)	-0.007(0.000)**	-0.030(0.029)	-0.040(0.030)	-0.052(0.026)*
Variance equation							
ω	-0.004(0.001)**	-0.024(0.006)**	-0.014(0.004)**	-0.145(0.040)**	-0.049(0.014)**	-0.084(0.022)**	-0.047(0.015)**
α_1	0.050(0.042)	-0.124(0.056)*	-0.058(0.039)	-0.044(0.089)	-0.0062(0.055)	0.097(0.027)**	-0.129(0.061)*
γ_1	-0.216(0.035)**	-0.254(0.032)**	-0.217(0.029)**	-0.150(0.058)**	-0.224(0.035)**	-0.140(0.020)**	-0.257(0.044)**
α_2	-0.043(0.042)	0.154(0.060)*	0.076(0.041)	0.224(0.056)**	0.076(0.063)		0.187(0.069)**
γ_2	0.223(0.037)**	0.220(0.031)**	0.207(0.028)**	-0.024(0.050)	0.208(0.034)**		0.220(0.042)**
β_1	1.797(0.023)**	1.726(0.072)**	1.843(0.041)**	0.661(0.070)**	1.645(0.087)**	0.977(0.006)**	1.490(0.148)**
β_2	-0.780(0.023)**	-0.737(0.068)**	-0.848(0.040)**	0.289(0.066)**	-0.654(0.085)**		-0.500(0.146)**
GED parameter	1.554 (0.096)**	1.747(0.097)**	1.549(0.086)**	1.117(0.015)**	1.492(0.080)**	1.676(0.085)**	1.441(0.072)**
Diagnostic							
$Q(20)$	10.696 [0.954]	13.150[0.871]	15.458[0.750]	3.285[1.000]	19.234[0.507]	18.568[0.550]	18.725[0.540]
$Q^2(20)$	9.802 [0.972]	14.361[0.812]	22.783[0.300]	0.0187[1.000]	18.690[0.542]	24.845[0.207]	11.884[0.920]

Note: The numbers given in parentheses are standard errors. The numbers given in brackets are the *p*-values. **(*) indicates statistical significance at the 1% (5%) level. $Q(20)$ is the Ljung-Box statistic for the null hypothesis that there is no autocorrelation up to order 20 for standardized residuals. $Q^2(20)$ is the Ljung-Box statistic for the null hypothesis that there is no autocorrelation up to order 20 for standardized residuals squared.

Table 2: Empirical results of the AR-EGARCH model for the post-crisis period

Model	Canada AR(1)-EGARCH(2,2)	France AR(1)-EGARCH(2,2)	Germany AR(1)-EGARCH(2,1)	Italy AR(1)-EGARCH(2,2)	Japan AR(1)-EGARCH(2,2)	UK AR(1)-EGARCH(1,1)	USA AR(1)-EGARCH(2,2)
Mean equation							
a_0	0.062(0.063)	0.017(0.077)	0.060(0.076)	0.024(0.083)	-0.005(0.078)	0.069(0.065)	0.117(0.030)**
a_1	-0.004(0.049)	-0.001(0.049)	-0.005(0.047)	0.034(0.049)	-0.057(0.049)	0.011(0.054)	-0.069(0.050)
Variance equation							
ω	0.029(0.028)	-0.028(0.014)*	-0.126(0.048)**	-0.050(0.018)**	0.181(0.071)**	-0.080(0.046)	0.042(0.010)**
α_1	0.035(0.041)	-0.060(0.095)	-0.175(0.131)	-0.075(0.101)	-0.057(0.109)	0.115(0.058)*	-0.072(0.014)**
γ_1	-0.106(0.042)*	-0.305(0.058)**	-0.212(0.075)**	-0.285(0.072)**	-0.191(0.065)**	-0.132(0.034)**	-0.170(0.032)**
α_2	-0.081(0.043)	0.101(0.102)	0.358(0.138)**	0.142(0.111)	0.343(0.112)**		0.002(0.019)
γ_2	0.051(0.046)	0.285(0.052)**	0.074(0.080)	0.266(0.067)**	0.017(0.074)		-0.006(0.027)
β_1	0.062(0.044)	1.787(0.075)**	0.977(0.009)**	1.709(0.099)**	0.402(0.286)	0.978(0.007)**	0.035(0.022)
β_2	0.927(0.044)**	-0.792(0.073)**		-0.713(0.092)**	0.557(0.280)*		0.948(0.021)**
GED parameter	1.851(0.220)**	1.651(0.195)**	1.696(0.204)**	1.658(0.163)**	1.823(0.225)**	1.583(0.180)**	1.583(0.135)**
Diagnostic							
$Q(20)$	21.699[0.357]	13.435[0.858]	16.209[0.704]	17.165[0.642]	10.291[0.963]	16.992[0.653]	10.148[0.965]
$Q^2(20)$	13.799[0.841]	24.520[0.220]	18.512[0.554]	26.906[0.138]	14.084[0.826]	15.865[0.725]	30.254[0.066]

Note: The numbers given in parentheses are standard errors. The numbers given in brackets are the *p*-values. **(*) indicates statistical significance at the 1% (5%) level. $Q(20)$ is the Ljung-Box statistic for the null hypothesis that there is no autocorrelation up to order 20 for standardized residuals. $Q^2(20)$ is the Ljung-Box statistic for the null hypothesis that there is no autocorrelation up to order 20 for standardized residuals squared.

Table 3: Causality among G7 countries in the pre- and post-crisis period

Causality-in-mean (pre-crisis period)	Causality-in-mean (post-crisis period)	Causality-in-variance (pre-crisis period)	Causality-in-variance (post-crisis period)
Canada → France Canada → Germany Canada → Japan Canada → UK	Canada → France Canada → Italy Canada → Japan	Canada → France Canada → Germany Canada → Japan	Canada → France Canada → Italy Canada → Japan Canada → UK
France → Germany France → Japan France → UK France → USA	France → Germany France → Japan France → USA	France → Canada France → Germany France → Japan	France → Germany France → Italy France → Japan France → UK
Italy → France Italy → Germany Italy → Japan Italy → UK	Italy → Japan Italy → USA	Italy → France Italy → Germany Italy → Japan Italy → Canada	Italy → Canada Italy → France Italy → Germany Italy → Japan Italy → USA
Germany → France Germany → Japan Germany → UK Germany → USA	Germany → Canada Germany → USA Germany → Japan	Germany → Canada Germany → Japan	Germany → Canada Germany → France Germany → Italy Germany → Japan Germany → UK Germany → USA
USA → France USA → Japan USA → UK USA → Germany	USA → Germany USA → France USA → Italy USA → Japan USA → UK	USA → Canada USA → France USA → Germany USA → Japan USA → UK	USA → Canada USA → France USA → Italy USA → Japan
Japan → Canada Japan → Italy Japan → UK Japan → USA	Japan → Canada Japan → Germany Japan → USA	Japan → Canada Japan → Germany Japan → Italy Japan → UK	Japan → Canada Japan → France Japan → Germany Japan → USA
UK → Italy UK → Japan UK → USA	UK → Canada UK → Germany UK → Japan UK → USA	UK → Canada UK → France UK → Italy UK → Japan UK → USA	UK → Canada UK → France UK → Italy UK → Japan UK → USA

Note: A → B denotes A causes B.