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REVISITING QUANTILE GRANGER CAUSALITY BETWEEN THE STOCK PRICE INDICES AND EXCHANGE RATES FOR G7 COUNTRIES

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ABSTRACT

The daily data of the stock price index and the foreign exchange rate in G7 were utilized for the period between January 4, 1999 and June 30 2015. From the empirical study of Granger causality test in quantiles, there are three main findings. Firstly, there is no long-run significant relationship between the stock price index and exchange rate in G7. Secondly, different types of short-run relationships exist between the two variables among G7 countries. In Canada, Italy, and U.S.A., the relationship is bidirectional, and the asymmetric effect is at different quantiles. In France and Japan, the relationship is unidirectional, from the stock price index to the exchange rate, and the relationship is at different quantiles for the two countries. In Germany and U.K., the relationship is unidirectional in the opposite direction and is also at different quantiles. Lastly, it shows that international trading effects at different quantiles exist in Canada (at high quantile), Italy (at median quantile), and U.K. (at low quantile). On the other hand, portfolio balance effects at different quantiles exist in Germany (at low and median quantiles) and U.S.A. (at high quantile). The study shows neither effect in France and Japan. The empirical findings in this paper have important implications for academicians, international institutional investors, and policy-makers on the G7 markets.

Contribution/ Originality: The paper's primary contribution is finding that there is no long-run significant relationship between the stock price index and exchange rate in G7. Different types of short-run relationships exist between the two variables in G7. International trading, portfolio balance, or neither effects are found among G7.

1. INTRODUCTION

Both the exchange rate and the stock price play crucial roles in determining the development of a country. Over the past decades, an increasing number of literature have explored the relationship between the two variables Aggarwal (1981); Najang and Seifert (1992); Ajayi and Mougoue (1996); Abdalla and Murinde (1997); Ajayi *et al.* (1998); Granger *et al.* (2000); Smyth and Nandha (2003); Phylaktis and Ravazzolo (2005); Moore (2007a;2007b); Lin (2012) and Kodongo and Ojah (2012). However, the literature had reached conflicting conclusions. While some literature stated that there exists a long-run relationship between the two variables (Ibrahim and Aziz, 2003; Kim, 2003) some concluded absence of a long-run relationship between the two markets. Some even found a bidirectional causality between them (Aggarwal, 1981; Bahmani-Oskooee and Sohrabian, 1992). The non-significance of long-run relationship between the two markets was confirmed by other literature (Granger *et al.*, 2000; Nieh and Lee, 2001;

Smyth and Nandha, 2003; Kollias *et al*., 2012). Several literature stated that the relationship is short-term (Bahmani-Oskooee and Sohrabian, 1992; Najang and Seifert, 1992; Ajayi and Mougoue, 1996; Nieh and Lee, 2001; Smyth and Nandha, 2003) while some literature found no evidence showing such a relationship (Solnik, 1984; Ozair, 2006).

Moreover, there were conflicts between the literature regarding how the stock and foreign exchange markets are interconnected. Some proposed that the stock price index and the exchange rate are positively related (Sevuktekin and Nargelecekenler, 2007) while others proposed a negative correlation (Soenen and Hennigar, 1988; Ajayi and Mougoue, 1996; Kim, 2003). In general, there are three possible effects which determine the relationship between the two variables: the international trading effect (Dornbusch and Fischer, 1980; Aggarwal, 1981; Ma and Kao, 1990; Joseph, 2002; Kim, 2003) the portfolio balance effect (Branson, 1983; Frankel, 1983; Bahmani-Oskooee and Sohrabian, 1992) and the asset market effect (Frenkel, 1976; Ajayi and Mougoue, 1996).

Dornbusch and Fischer (1980) believed that the fluctuations in exchange rates have direct impact in business profitability and international competitiveness of the firms. In other words, the appreciation of the exchange rate decreases the sales of exporters, their earnings, and thus the stock prices. On the other hand, the importers face lower prices for their products, increase the earnings, and attain higher stock prices. Opposite effects occur when the exchange rate depreciates. When the exchange rate depreciates, the competitiveness of exports increases, so does the input cost of imports (Joseph, 2002). Thus, generally speaking, depreciation causes positive (negative) effects for export (import) firms and increases (decreases) their stock prices; however, appreciation causes negative (positive) effect for export (import) firms and decreases (increases) their stock prices. Currency depreciation usually has a positive effect on the domestic stock market in these countries (Ma and Kao, 1990). Hence, the stock prices and the exchange rates should be positively correlated in an export-oriented country based on the international trading effect.

Branson (1983) and Frankel (1983) predicted that the innovations in the stock price affect the exchange rates via the capital account. The performance of the stock market may affect the demand for money, with the subsequent changes in interest rates causing the exchange rates to appreciate or depreciate. If the impact of an external parameter influences the stock market to go up, the domestic investors' wealth increases, raising the demand for the currency according to the investment portfolio equilibrium theory. The demand for money then increases and drives the interest rate to rise, consequently absorbing the inflow of foreign capital and causing the domestic currency to appreciate. Thus, if investors are more optimistic toward the stock market of a country, foreign capital investors may then increase their investments in the country's stock market due to the speculative demand, which indirectly causes the appreciation of this country's currency. In short, the portfolio balance effect states that the stock prices and the exchange rates should be negatively correlated.

In contrast to the previous two effects, the asset market effect by Frenkel (1976) supported the absence of any relationship between the two markets. The changes are due to different factors that lead the market of the exchange rates and the market of the stock prices to be fully segmented. However, Ajayi and Mougoue (1996) showed that there are certain factors such as the interest rates which may join the two markets.

The remainder of the paper is organized as follows. Section 2 briefly describes the methodology. Section 3 describes the data and presents the results of the empirical analysis. Section 4 concludes the paper.

2. METHODOLOGY

Ordinary least squares (OLS) regression focuses on the estimation of the conditional mean of the dependent variable and has much limitation. On the other hand, quantile autoregression methodology can estimate the relationship between a dependent variable and explanatory variables at different specific quantiles. It also provides a broader method in investigating the relationship between current returns and various parts of the lagged conditional returns, even when extreme values are present (Chiang and Li, 2012). In particular, it is robust to heteroskedasticity, skewness and leptokurtosis, which are the features of financial data (Koenker and Xiao, 2006). Therefore, the quantile autoregression methodology was applied for this research.

To avoid the problem of spurious regression, I used unit root tests for the stock price index and the exchange rate: Augmented Dickey–Fuller (Said and Dickey, 1984) test and Phillips and Perron (1988) test. The equations of these two tests are shown in the following.

Suppose STP denotes the variable (the stock price index or the exchange rate) for the test of stationarity. Then there are three models for obtaining the statistics of Augmented Dickey–Fuller test:

Model

$$\Delta STP_t = \rho_0 + \rho_1 t + \rho_2 STP_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta STP_{t-i} + \varepsilon_t \qquad (1)$$

$$\Delta STP_t = \rho_0 + \rho_2 STP_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta STP_{t-i} + \varepsilon_t \qquad (2)$$

$$\Delta STP_t = \rho_2 STP_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta STP_{t-i} + \varepsilon_t \qquad (3)$$

, where $\Delta STP_t = STP_t - STP_{t-1}$, and t is time trend.

The null hypothesis is $H_0: \rho_2 = 0$. That is the series has a unit root. Phillips and Perron (1988) proposed an alternative method of controlling for serial correlation when testing for a unit root. The method estimates the non-augmented Dickey–Fuller test equation:

$$\Delta STP_t = \alpha STP_{t-1} + EX'_t \delta + \mu_t$$

, where EX_t are optional exogenous regressors which may consist of a constant, or a constant and trend. The null hypothesis is $H_0: \alpha = 0$.That is, the series has a unit root. Phillips and Perron modified the t-ratio of the coefficient α so that serial correlation does not affect the asymptotic distribution of the test statistic.

If the variables are all non-stationary, the cointegration test proposed by Engle and Granger (1987) would be performed to test the linear long-run relationship between the stock price index and exchange rate. According to Engle and Granger (1987) two series (STP_t and EX_t) integrated in the order d, $I(d)$, are cointegrated if their linear combination results in a residual μ_t ($STP_t = \beta EX_t + \mu_t$) that is stationary in less than order d.

Nevertheless, Enders and Siklos (2001) stated that the Engle–Granger testing procedure could be biased towards the acceptance of no cointegration if the adjustment processes of the two markets are asymmetric. If this long-run relationship does not exist, then we further investigate the short-run relationship changes using quantile regression. The quantile regression model is used to estimate the relationship between the two markets under different market conditions.

The advantage of this approach is its capacity to permit estimation of various quantile functions in a conditional distribution. Empirical studies have been analyzing the behavior of a dependent variable given the information contained in a set of explanatory variables. The traditional approach uses the ordinary least squares to estimate a linear regression model. However, this method only provides the estimation of a median (0.5th quantile) function.

By using quantile regression, each quantile regression characterizes a particular point of the conditional distribution. Combining different quantile regressions together will be more useful, especially when the conditional distribution is heterogeneous. Since the goal of this research is to emphasize on observing various relationships between the stock and foreign exchange markets in G7, a quantile regression model is used to provide more details of the relationship. The model is briefly illustrated as follows.

Assume $\{V_t\}$ is an iid standard uniform random variable sequence, we consider the following p-th order autoregression process:

$$y_t = \theta_0(V_t) + \theta_1(V_t)y_{t-1} + \dots + \theta_p(V_t)y_{t-p} \qquad (4)$$

, where the $\theta_j s$ are the unknown functions [0, 1]→R to be estimated. Provided that the right hand side of Eq. (4) is monotone increasing in V_t, it follows that the τth conditional quantile function of y_t can be written as follows:

$$Q_{yt}(\tau \mid y_{t-1};\dots;y_{t-p}) = \theta_0(\tau) + \theta_1(\tau)y_{t-1} + \dots + \theta_p(\tau_t)y_{t-p} \qquad (5)$$

This can be reduced to

$$Q_{yt}(\tau \mid F_{t-1}) = X'_t\,\theta(\tau) \qquad (6)$$

,where $x_t = (1, y_{t-1}, \dots, y_{t-p})'$ and F_t is the σ −field generated by $\{y_s, s \le t\}$. The transition from Eq. (4) to Eq. (5) is an immediate consequence of the fact that for any monotone increasing function g and standard uniform random variable V,

$$Q_g(V)(\tau) = g(Q)_v(\tau) = g(\tau) \qquad (7)$$

,where $Q_v(\tau) = \tau$ is the quantile function of V. In the above model, the autoregressive coefficients may be τ-dependent and thus can vary over the quantiles.

Consider the following Granger non-causality test in quantiles:

$$Q_{yt}(\tau \mid Y,X)_{t-1} = Q_{yt}(\tau \mid Y_{t-1}), \forall\tau \in [a,b]\ a.s., \qquad (8)$$

,where $Q_{yt}(\tau \mid F)$ denotes the τth quantile of the distribution. If

(8) holds, then xt does not Granger-cause yt over the quantile interval [a, b]. One can perform the Granger non-causality test in quantiles using the quantile regression method in Koenker and Bassett (1978). To test for the nonlinear causal relationship from the stock price index to the exchange rate, or the opposite direction, we consider the following conditional quantile function model:

$$\mathrm{Qex}(\tau \mid X_{t-1}) = a(\tau) + \sum_{i=1}^{k} \gamma_i(\tau)EX_{t-i} + \sum_{i=1}^{k} \delta_i(\tau)STP_{t-i}$$

$$\text{Qstp}\ (\tau\ |X_{t-1}) = b(\tau) + \sum_{i=1}^{k} \alpha_i\ (\tau) STP_{t-i} + \sum_{i=1}^{k} \beta_i\ (\tau) EX_{t-i}$$

The null hypothesis of non-causality in quantiles is

$$H_0: \delta(\tau) = 0, \forall \tau \in [a, b]$$

,where $\delta(\tau) = [\ \delta_1(\tau),\ \ \delta_2(\tau), \dots, \delta_q(\tau)]'$

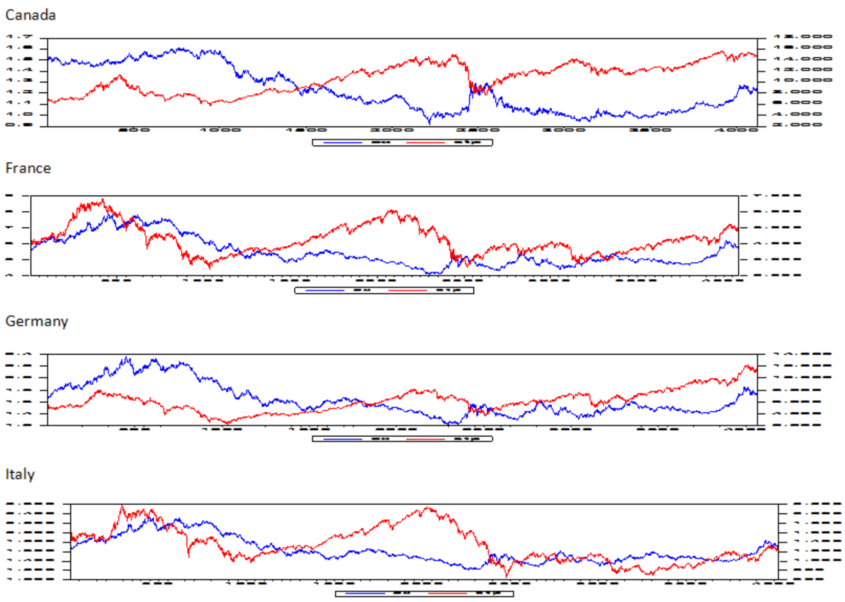
$$H_0: \beta(\tau) = 0, \forall \tau \in [a, b],$$

,where $\beta(\tau) = [\ \beta_1(\tau),\ \ \beta_2(\tau), \dots, \beta_q(\tau)]'$

3. DATA AND EMPIRICAL RESULTS

I used the daily data of the stock price index and the spot foreign exchange rate in G7, and obtain from CEIC Data for the period from January 4, 1999 to June 30, 2015. G7 stock indices of the daily closing stock market are the S&P/TSX Composite index(Canada), CAC 40(France), DAX(Germany), BCI Comit 30(Italy), Nikkei: 225(Japan), FTSE 100(U.K.), Dow Jones Composite Average(U.S.A.) and the spot exchange rates of currencies of a country to U.S. dollar are likewise used for measuring the value of a currency: CAD/USD(Canada), FRF/USD(France), DEM/USD(Germany), ITL/USD(Italy), JPY/USD(Japan), GBP/USD (U.K.),the U.S. dollar index is the Nominal Broad U.S. Trade Weighted Index(U.S.A.). Thus, an increase in the exchange rate means the value of this currency depreciates. The historical time series of the stock price index and the exchange rate of the G7 are shown in Fig. 1. Although these two series seem to be negatively related, there are some periods wherein the stock price indices and the exchange rate show positive co-movement. Table 1 shows the symbols of the stock price indices and the spot exchange rates. Table 2 shows the descriptive statistics of data. To solve spurious regression problems, the prerequisite was that the series were stationary prior to estimating the empirical model. In this research, unit root tests were conducted for level and first-order difference of the stock price indices and the exchange rates using the Augmented Dickey–Fuller and the Phillips–Perron tests. Both results in Table 3 confirm that all the variables are I(1). After I obtain the difference, all variables are confirmed to be I(0).

Figure-1:



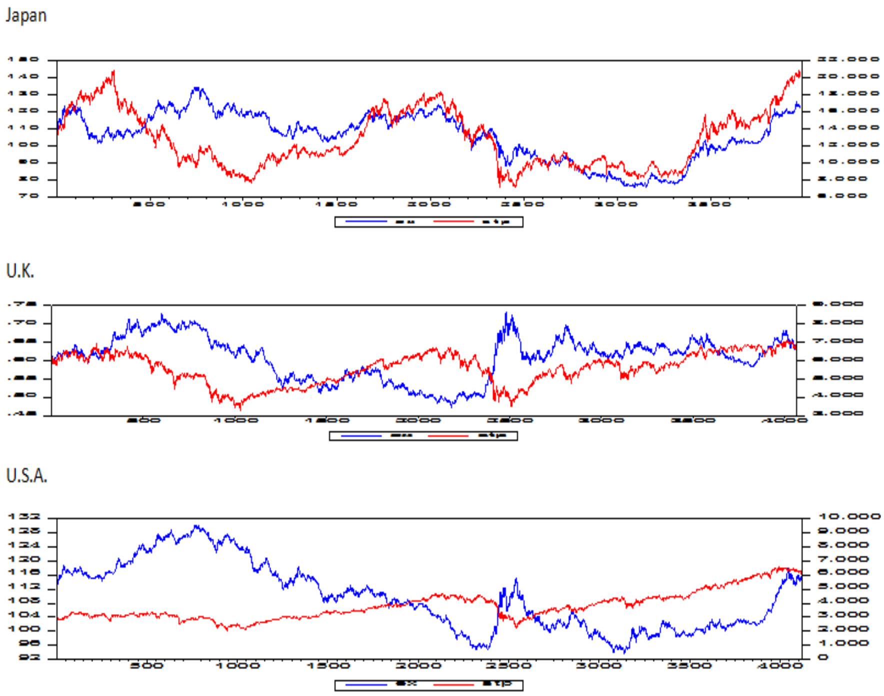


Figure-1 The symbols of the stock price indices and the spot exchange rates.

Table-1. Symbols used for G7

Country Observations*		Stock price index (STP)	Spot Exchange Rates(EX)
Canada	4121	S&P/TSX Composite index	CAD/USD
France	4086	CAC 40	FRF/USD
Germany	4067	DAX	DEM/USD
Italy	4022	BCI Comit 30	ITL/USD
Japan	3978	Nikkei: 225	JPY/USD
U.K	4063	FTSE 100	GBP/USD
U.S	4118	Dow Jones Composite	U.S. Nominal broad
		Average Index	Trade Weighted Index

*The data are daily closing indices for the sample period without covering the observations on weekend and some important holidays.

Table-2. Descriptive statistics

Variable	Country	Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
	Canada	10760.61	2641.576	-0.107948	1.752129	275.3847
	France	4280.335	931.1629	0.585484	2.634076	256.2375
	Germany	6166.816	1891.893	0.581502	3.340419	248.8430
Stock price inde (STP)	Italy	1338.739	375.5489	0.421724	2.104429	253.6294
	Japan	12779.59	3329.387	0.401248	1.983363	278.0540
	U.K.	5592.085	863.1512	-0.478608	2.225442	256.6173
	U.S.	3799.645	1011.829	0.902470	3.239724	568.8460
	Canada	1.223712	0.204833	0.471760	1.754902	419.0538
	France	5.497764	0.909397	0.960906	2.859990	632.1321
	Germany	1.639760	0.271472	0.958605	2.854129	626.4826
Exchange rate (EX)	Italy	1623.595	269.0248	0.952323	2.843014	612.0682
	Japan	105.7141	14.28828	-0.486334	2.276944	243.4689
	U.K.	0.609241	0.058483	-0.374929	2.290040	180.4764
	U.S.	109.7733	9.530574	0.362130	2.025128	253.0729

Source: This research

Then, the linear cointegration test of Engle and Granger (1987) was used to investigate if the deviations from the long-run exhibit a mean-reverting behavior, that is, whether long-run relationships between the stock price index and exchange rate exist or not. Evidence in Table 4 indicates that the ADF test and PP test fail to reject the null hypothesis of no cointegration at the 5% significance level. These results suggest that the stock price index and the exchange rate are not cointegrated, thus implying that there is no long run relationship between the two markets.

Table-3. Unit root test

Country	Exchange rate (EX)		Stock price index (STP)	
	Levels	Differences	Levels	Differences
ADF test				
Canada	-0.909683(0)	-63.75673(0)***	-2.512757(0)	-64.92865(0)***
France	-1.386282(0)	-62.98360(0)***	-1.987710(1)	-67.04442(0)***
Germany	-1.387272(0)	-62.70352(0)***	-1.552853(0)	-65.27329(0)***
Italy	-1.379960(0)	-62.20934(0)***	-1.732646(1)	-57.65017(0)***
Japan	-1.069448(0)	-65.13421(0)***	-0.95219290)	-65.11077(0)***
U.K.	-1.959640(0)	-62.92955(0)***	-2.534031(0)	-48.22460(1)***
U.S.	-0.738687(0)	62.35410(0)***	-1.828322(1)	-69.45322(0))))
PP test: Newey-West based on Bandwidth using Bartlett kernel				
Canada	-0.718305(22)	-63.94657(23)***	-2.344454(15)	-65.14559 (17)***
France	-1.460113(9)	-63.00072(7)***	-1.818806(15)	-67.69550(16)***
Germany	-1.439801(6)	-62.70387(4)***	-1.493492(3)	-65.27363(1)***
Italy	-1.446433(7)	-62.21389(5)***	-1.763017(13)	-57.68506(10)***
Japan	-0.981234(9)	65.14002(10)***	-0.826736(11)	-65.17192(11)***
U.K.	-1.948433(9)	-62.93307(10)***	-2.383521(3)	-66.73773(6)***
U.S.	-0.941666(16)	-62.49224(15)***	-1.685953(21)	-70.09572(20)***

Entry in parenthesis stands for the optimal lag length chosen by the SIC with the maximum lag set to be 30. *** Significant at 1%, ** Significant at 5%, * Significant at10%.

Table-4. cointegration test

Country	ADF test		Phillips-Perron Test	
	t-Statistic	p-value	t-Statistic	p-value
Canada	-1.567115(1)	0.1172	-1.921388(27)	0.0548
France	-1.512266(0)	0.1305	-1.512266 (6)	0.1305
Germany	-1.143942(0)	0.2527	-1.143942(0)	0.2527
Italy	-1.675251(1)	0.0940	-1.534774(11)	0.1249
Japan	-1.676104(1)	0.0938	-1.865194(2)	0.0622
U.K.	-1.954436(0)	0.0507	-1.954436(7)	0.0507
U.S.	-0.322233(1)	0.7473	-0.572409(10)	0.5671

Entry in parenthesis stands for the optimal lag length chosen by the SIC with the maximum lag set to be 30. *** Significant at 1%, ** Significant at 5%, * Significant at10%.

The results of Granger causality test in quantiles are listed in Table 5a, 5b, 5c, 5d, and 5e. The results show that there exists a bidirectional and unidirectional short run relationship between the stock price indices and exchange rates in G7 countries. In Canada, Italy, and U.S.A, the relationship is bidirectional. The bidirectional quantile causality effects in Canada are asymmetric at different quantiles: the rising of the stock price index will cause the depreciation of CAD/USD at low and median quantiles and the depreciation of CAD/USD will cause the rising of the stock price index at high quantile. The bidirectional quantile causality effects in Italy are also asymmetric at different quantiles that the rising stock price index will cause the depreciation of ITL/USD at low and high quantiles and the depreciation of ITL /USD will cause the rising of the stock price index at median quantile. The bidirectional quantile causality effects in U.S.A. are both asymmetric at different quantiles. For example, a higher stock price index will cause the depreciation of USD at median and high quantiles, but the appreciation of USD will cause the rising of the stock price index at high quantile.

In other words, the bidirectional quantile causality effects exist in Canada, Italy, and U.S.A. But the three countries have the asymmetric effect at different quantiles. In particular, U.S.A has the asymmetric effect between from the stock price index to the exchange rate and in the opposite direction.

There exists a unidirectional relationship from the stock price index to the exchange rate in France and Japan. The quantile causality effect in France and Japan shows that the rising of the stock price index will cause the appreciation of FRF/USD and JPY/USD respectively at high quantile. On the other hand, the quantile causality effect in Germany is that the appreciation of DEM/USD will cause the rising of the stock price index at low and median quantiles, but the quantile causality effect in U.K. is the depreciation of GBP /USD will cause the rising of the stock price index at low quantile.

Identically, aforementioned theory finding shows that international trading effects at different quantiles exist in Canada (at high quantile), Italy (at median quantile), and U.K (at low quantile). On the other hand, portfolio balance effects at different quantiles exist in Germany (at low and median quantiles) and U.S.A (at high quantile). Table 6 summarizes the results of Granger causality test in quantiles for G7.

Table-5a. Results of Granger causality test

Country	Quantile	Coefficient	Std. Error	t-Statistic	Prob.
Canada STP(-6)	0.100	0.041368	0.022633	1.827749*	0.0677
	0.200	0.036999	0.014616	2.531348**	0.0114
	0.300	0.025159	0.009143	2.751771***	0.0060
	0.400	0.025311	0.008517	2.971738***	0.0030
	0.500	0.023565	0.008625	2.732103***	0.0063
	0.600	0.018471	0.008984	2.055852**	0.0399
	0.700	0.013986	0.010296	1.358392	0.1744
	0.800	0.013615	0.007949	1.712823*	0.0868
	0.900	0.016746	0.010643	1.573407	0.1157
Canada EX(-6)	0.100	-0.052472	0.067838	-0.773498	0.4393
	0.200	0.008711	0.043236	0.201481	0.8403
	0.300	0.044512	0.036796	1.209674	0.2265
	0.400	0.029083	0.029115	0.998896	0.3179
	0.500	0.034335	0.027700	1.239526	0.2152
	0.600	0.056943	0.032006	1.779113*	0.0753
	0.700	0.108052	0.037722	2.864412***	0.0042
	0.800	0.065045	0.039502	1.646641*	0.0997
	0.900	-0.008844	0.045169	-0.195790	0.8448
France STP(-7)	0.100	0.009421	0.012120	0.777288	0.4370
	0.200	-0.000533	0.011940	-0.044607	0.9644
	0.300	0.004662	0.006983	0.667639	0.5044
	0.400	0.002738	0.007758	0.352935	0.7242
	0.500	0.010710	0.007640	1.401986	0.1610
	0.600	0.007850	0.008322	0.943310	0.3456
	0.700	0.004519	0.007889	0.572862	0.5668
	0.800	-0.003310	0.011087	-0.298553	0.7653
	0.900	-0.030736	0.011385	-2.699764***	0.0070
France EX(-7)	0.100	-0.077308	0.065267	-1.184481	0.2363
	0.200	-0.006400	0.050176	-0.127558	0.8985
	0.300	0.023099	0.039400	0.586271	0.5577
	0.400	0.058381	0.040061	1.457284	0.1451
	0.500	0.045349	0.039980	1.134284	0.2567
	0.600	0.029864	0.043977	0.679090	0.4971
	0.700	0.013087	0.037766	0.346521	0.7290
	0.800	-0.010790	0.045922	-0.234973	0.8142
	0.900	0.059602	0.072416	0.823054	0.4105

Entry in parenthesis stands for the optimal lag length chosen by the SIC with the maximum lag set to be 30. *** Significant at 1%, ** Significant at 5%, * Significant at10%.

4. CONCLUSION

The daily data of the stock price index and the foreign exchange rate in G7 was used for the period between January 4, 1999 and June 30 2015. From the empirical study of Granger causality test in quantiles, it shows that a bidirectional quantile causality effects exist in Canada, Italy, and U.S.A. The effects show asymmetry at different quantiles for three countries. In particular, there exists the asymmetric effect between from the stock price index to the exchange rate and in the opposite direction in U.S.A. There exists a unidirectional relationship in France, Japan, Germany and U.K. The quantile causality effect in France and Japan is that the higher stock price index will cause the appreciation of FRF/USD and JPY/USD respectively at high quantile. On the other hand, the quantile causality effect in Germany is that the appreciation of DEM/USD will cause the rising of the stock price index at low and median quantiles, but the quantile causality effect in U.K. is that the depreciation of GBP /USD will cause the rising of the stock price index at low quantile.

In general, there are three main findings. Firstly, there exists no significant long-run relationship between the stock price index and exchange rate in G7. Secondly, different types of short-run relationships exist between the stock price index and the exchange rate for the G7 countries. There exists a bidirectional relationship and the asymmetric effect is at different quantiles in Canada, Italy, and U.S.A. Besides, there exists a unidirectional relationship at different quantiles from the stock price index to the exchange rate in France and Japan. On the contrary there also exists a unidirectional relationship at different quantiles in the opposite direction for Germany and U.K. Thirdly, there exists international trading effects at different quantiles in Canada (at high quantile), Italy (at median quantile), and U.K. (at low quantile). On the other hand, there exists portfolio balance effects at different quantiles in Germany (at low and median quantiles) and U.S.A. (at high quantile). There exists neither effect in France and Japan. The empirical findings in this paper have important implications for academicians, international institutional investors, and policymakers on the G7 markets.

Table-5b. Results of Granger causality test

Country	Quantile	Coefficient	Std. Error	t-Statistic	Prob.
Germany STP(-1)	0.100	-0.008412	0.015958	-0.527157	0.5981
	0.200	-0.010643	0.008477	-1.255520	0.2094
	0.300	-0.002978	0.008234	-0.361669	0.7176
	0.400	-0.001231	0.007637	-0.161146	0.8720
	0.500	-0.001236	0.007356	-0.167975	0.8666
	0.600	-0.001291	0.006418	-0.201149	0.8406
	0.700	0.006358	0.006506	0.977296	0.3285
	0.800	0.007648	0.010397	0.735570	0.4620
	0.900	0.014096	0.015310	0.920726	0.3572
Germany EX(-1)	0.100	-0.185961	0.070847	-2.624812***	0.0087
	0.200	-0.137623	0.066801	-2.060186**	0.0394
	0.300	-0.125120	0.039948	-3.132038***	0.0017
	0.400	-0.073979	0.038905	-1.901566*	0.0573
	0.500	-0.065904	0.035790	-1.841417*	0.0656
	0.600	-0.049333	0.035810	-1.377600	0.1684
	0.700	-0.072723	0.034723	-2.094395**	0.0363
	0.800	0.010751	0.044819	0.239864	0.8104
	0.900	0.016400	0.055291	0.296605	0.7668
Italy STP(-2)	0.100	0.035575	0.014372	2.475260**	0.0134
	0.200	0.031608	0.014867	2.126015**	0.0336
	0.300	0.016647	0.009812	1.696648*	0.0898
	0.400	0.007368	0.009712	0.758637	0.4481
	0.500	-0.002314	0.010213	-0.226593	0.8208
	0.600	0.002471	0.008954	0.276018	0.7825
	0.700	-0.000450	0.008944	-0.050328	0.9599
	0.800	0.011797	0.013759	0.857432	0.3913
	0.900	0.016573	0.008366	1.980984	0.0477
Italy EX(-2)	0.100	-0.067992	0.082977	-0.819415	0.4126
	0.200	0.012193	0.049230	0.247664	0.8044
	0.300	0.038072	0.029497	1.290710	0.1969
	0.400	0.049808	0.027328	1.822617	0.0684
	0.500	0.022273	0.026091	0.853658	0.3933
	0.600	0.003219	0.029536	0.108994	0.9132
	0.700	0.005692	0.031748	0.179282	0.8577
	0.800	-0.011667	0.032728	-0.356474	0.7215
	0.900	0.004884	0.059220	0.082478	0.9343

Entry in parenthesis stands for the optimal lag length chosen by the SIC with the maximum lag set to be 30. *** Significant at 1%, ** Significant at 5%, * Significant at10%.

Table-5c. Results of Granger causality test

Country	Quantile	Coefficient	Std. Error	t-Statistic	Prob.
Japan STP(-3)	0.100	-0.005358	0.013714	-0.390714	0.6960
	0.200	0.006171	0.013237	0.466166	0.6411
	0.300	-0.006822	0.010780	-0.632857	0.5269
	0.400	-0.004202	0.008334	-0.504144	0.6142
	0.500	-0.011562	0.008088	-1.429597	0.1529
	0.600	-0.011417	0.008532	-1.338225	0.1809
	0.700	-0.017572	0.008182	-2.147515**	0.0318
	0.800	-0.008953	0.009708	-0.922203	0.3565
	0.900	-0.007048	0.010029	-0.702771	0.4822
Japan EX(-3)	0.100	0.025856	0.078903	0.327697	0.7432
	0.200	0.048101	0.056681	0.848631	0.3961
	0.300	0.036691	0.042692	0.859428	0.3902
	0.400	0.043290	0.035908	1.205592	0.2280
	0.500	0.057635	0.035275	1.633847	0.1024
	0.600	0.033802	0.040281	0.839166	0.4014
	0.700	0.047055	0.050804	0.926203	0.3544
	0.800	-0.012957	0.055697	-0.232640	0.8161
	0.900	0.042279	0.049017	0.862544	0.3884
U.K STP(-7)	0.100	0.002103	0.014309	0.146984	0.8832
	0.200	-0.004894	0.010410	-0.470098	0.6383
	0.300	0.002501	0.009795	0.255346	0.7985
	0.400	-0.003370	0.010033	-0.335885	0.7370
	0.500	-0.001499	0.008771	-0.170918	0.8643
	0.600	-0.003251	0.007927	-0.410044	0.6818
	0.700	-0.005084	0.009412	-0.540156	0.5891
	0.800	-0.004732	0.011703	-0.404357	0.6860
	0.900	-0.018267	0.013806	-1.323157	0.1859
U.K EX(-7)	0.100	-0.101145	0.053513	-1.890106*	0.0588
	0.200	-0.045709	0.047418	-0.963949	0.3351
	0.300	0.004099	0.040613	0.100918	0.9196
	0.400	0.002813	0.037165	0.075681	0.9397
	0.500	-0.015603	0.033394	-0.467243	0.6404
	0.600	0.008006	0.035226	0.227289	0.8202
	0.700	0.009371	0.035838	0.261490	0.7937
	0.800	0.040007	0.040942	0.977163	0.3285
	0.900	0.023887	0.072326	0.330273	0.7412

Entry in parenthesis stands for the optimal lag length chosen by the SIC with the maximum lag set to be 30. *** Significant at 1%, ** Significant at 5%, * Significant at 10%.

Table-5d. Results of Granger causality test

Country	Quantile	Coefficient	Std. Error	t-Statistic	Prob.
U.S STP(-8)	0.100	-0.000897	0.007811	-0.114873	0.9086
	0.200	0.003992	0.005959	0.669902	0.5030
	0.300	-0.002610	0.005310	-0.491596	0.6230
	0.400	-0.008541	0.004465	-1.913021*	0.0558
	0.500	-0.005153	0.004460	-1.155193	0.2481
	0.600	-0.005429	0.005017	-1.082310	0.2792
	0.700	-0.012249	0.005706	-2.146743**	0.0319
	0.800	-0.009809	0.006901	-1.421261	0.1553
	0.900	-0.011433	0.004420	-2.586716***	0.0097
U.S EX(-8)	0.100	-0.117716	0.099124	-1.187562	0.2351
	0.200	-0.075023	0.107381	-0.698665	0.4848
	0.300	-0.047805	0.076357	-0.626070	0.5313
	0.400	-0.032138	0.068401	-0.469846	0.6385
	0.500	-0.005017	0.062448	-0.080334	0.9360
	0.600	-0.011186	0.058912	-0.189871	0.8494
	0.700	0.021056	0.071990	0.292487	0.7699
	0.800	0.073907	0.099959	0.739370	0.4597
	0.900	0.225201	0.075474	2.983803***	0.0029

Entry in parenthesis stands for the optimal lag length chosen by the SIC with the maximum lag set to be 30. *** Significant at 1%, ** Significant at 5%, * Significant at 10%.

Table-5e. Results of Granger causality test

Country	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Canada									
STP	(+)*	(+)**	(+)***	(+)***	(+)***	(+)**	(+)	(+)*	(+)
EX	(-)	(+)	(+)	(+)	(+)	(+)*	(+)***	(+)*	(+)
France									
STP	(+)	(-)	(+)	(+)	(+)	(+)	(+)	(-)	(-)***
EX	(-)	(-)	(+)	(+)	(+)	(+)	(+)	(-)	(+)
Germany									
STP	(-)	(-)	(-)	(-)	(-)	(-)	(+)	(+)	(+)
EX	(-)***	(-)***	(-)***	(-)*	(-)*	(-)	(-)**	(+)	(+)
Italy									
STP	(+)**	(+)**	(+)*	(+)	(-)	(+)	(-)	(+)	(+)
EX	(-)	(+)	(+)	(+)*	(+)	(+)	(+)	(-)	(+)
Japan									
STP	(-)	(+)	(-)	(-)	(-)	(-)	(-)**	(-)	(-)
EX	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(-)	(+)
U.K.									
STP	(+)	(-)	(+)	(-)	(-)	(-)	(-)	(-)	(-)
EX	(-)*	(-)	(+)	(+)	(-)	(+)	(+)	(+)	(+)
U.S.									
STP	(-)	(+)	(-)	(-)*	(-)	(-)	(-)**	(-)	(-)***
EX	(-)	(-)	(-)	(-)	(-)	(-)	(+)	(+)	(+)***

*** Significant at 1%, ** Significant at 5%, * Significant at10%.

Table-6. The summary results of Granger causality test

Country
A. From the stock price index(STP) to the exchange rate(EX)
Canada The rising of STP will cause the depreciation of CAD/USD at low and median quantiles.
France The rising of STP will cause the appreciation of FRF/USD at high quantile.
Germany Insignificant relation
Italy The rising STP will cause the depreciation of ITL/USD at low and high quantiles.
Japan The rising STP will cause the appreciation of JPY/USD at high quantile.
U.K. Insignificant relation
U.S.A. The rising of STP will cause the depreciation of USD at median and high quantiles.
B. From the exchange rate(EX) to the stock price index(STP)
Canada The depreciation of CAD/USD will cause the rising of STP at high quantile, it shows the international trading effect.
France Insignificant relation
Germany The appreciation of DEM/USD will cause the rising of STP at low and median quantiles, it shows the portfolio balance effect.
Italy The depreciation of ITL /USD will cause the rising of STP at median quantile, it shows the international trading effect.
Japan Insignificant relation
U.K. The depreciation of GBP /USD will cause the rising of STP at low quantile. It shows the international trading effect.
U.S.A. The appreciation of USD will cause the rising of STP at high quantile. It shows the portfolio balance effect.
C. Dynamic short run relationship between the stock price index and exchange rate
C1. Bidirectional relationship
Canada: The rising of STP will cause the depreciation of CAD/USD at low and median quantiles. Meanwhile, the depreciation of CAD/USD will cause the rising of STP at high quantile. It shows the international trading effect.
Italy: The rising STP will cause the depreciation of ITL/USD at low and high quantiles. Meanwhile, the depreciation of ITL /USD will cause the rising of STP at median quantile. It shows the international trading effect.
U.S.A.: The rising of STP will cause the depreciation of USD at median and high quantiles. Meanwhile, the appreciation of USD will cause the rising of STP at high quantile, It shows the portfolio balance effect.
C2. Unidirectional relationship
1. From the stock price index(STP) to the exchange rate (EX)
France: The rising of STP will cause the appreciation of FRF/USD at high quantile.
Japan: The rising STP will cause the appreciation of JPY/USD at high quantile.
2. From the exchange rate (EX) to the stock price index (STP)
Germany: The appreciation of DEM/USD will cause the rising of STP at low and median quantile .It shows the portfolio balance effect.
U.K.: The depreciation of GBP /USD will cause the rising of STP at low quantile, it shows the international trading effect.
D. From the exchange rate(EX) to the stock price index(STP)
1. International trading effect: Canada (at high quantile), Italy (at median quantile), and U.K (at low quantile).
2. Portfolio balance effect: Germany (at low and median quantiles) and U.S.A (at high quantile).
3. No relationship: France and Japan.

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