



RESEARCH PAPER

Financial contagion of the global financial crisis from the US to other developed countries

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Abstract. With the global integration of financial markets, the international capital flows have become one of the main factors playing a significant role in determining adjustments of domestic financial markets. This study examines the co-movement of exchange rates and stock market indexes among those of the US, Canada, UK, Germany, Italy, France and Spain. Specifically the correlation and Vector Auto-Regression (VAR) are applied to investigate the relationship. The correlation analysis shows that there exist the statistically significant co-movements only during the period of Global Financial Crisis. Also the result obtained from VAR indicates that the US has been the origin of causality influencing the directions of variations of exchange rates and stock market indexes of other countries, except the case of UK. These findings identify the dominance of the US on adjustments of financial markets in other developed countries, especially during the Global Financial Crisis, and also suggest the necessity for all countries on formulating appropriate policies to mitigate impacts on the local economy.

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INTRODUCTION

The Global Financial Crisis during 2007-2008 is arguably the most severe financial crisis after the Great Depression. Its effect was a general decline in the world economy or as the economists dubbed "Great Recession". GDP growth rates in the US and EU were around negative 2-3%. (Eurostat). The economic downturn also played a partial role in causing Eurozone Crisis. As documented by Lane (2012), Whalen (2008) and Crotty (2009) the crisis started in the US with Subprime Mortgage Crisis, where home ownerships were encouraged using mortgage-backed securities (MBS) and collateralized debt obligations (CDO). The crisis struck when housing prices declined sharply

after it reached the peak in 2006. Massive defaults on loans caused the collapse of many financial institutions. Even when some of the financial institutions were bailed out by the government, erosion in confidence of investors was evident globally. The causes of the crisis are yet to be agreed upon. However, one prominent cause is the failure in regulation in banking system as well as financial institutions themselves. The other view is that crisis happened because of dysfunctional monetary arrangement where the country cannot adjust to high level of indebtedness. Many banking and financial crises are caused by rapid increase in securities' price from large investment inflows. This high level of asset prices leads to the higher private consumption and also the expansion of lending. Ultimately the correction of asset prices induces the economy-wide contraction and finally becomes the

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crisis. Suggested by (Chiang, Jeon & Li, 2007) the financial contagion is the case of instability in one market transmitted to other markets, and this situation usually occurs during the financial crisis. Contagion can be measured by significant increases in cross-country correlations of stock returns and/or volatility in the region. Exchange rate, interest rate, or sovereign spread can also be used to measure contagion. Transmission can be caused by trade linkages or financial linkages (Hernandez & Valdes, 2001). For trade linkages, macroeconomic similarities and competitive devaluations can be used to explain contagions. Macroeconomic similarities can cause investors to pull out funds from countries with similar macroeconomic conditions because they believe the same problems would arise in those countries as well. As noted by Caramazza (2000) trade spillovers can occur from the crisis countries to other neighboring countries due to improve in competitiveness from currency devaluation. As for financial linkages, the causes can be investment loss, liquidity constraint, and irrational investors' behaviors. Loss of European and other developed countries' multinational firms that have portfolios or invest directly in the US can cause stock returns to correlate. US firms and investors facing liquidity constraint withdraw funds from other developed countries. Investors may change their behaviors and rebalance their portfolios according to risk profiles and liquidity. As they become more risk averse, funds are withdrawn from the market.

Forbes & Rigobon (2001) argued that one of the most striking features of the past crisis is that how a country-specific shock can quickly spread across the globe to many other countries with different structure and size. One of the examples most cited by experts is Asian Financial Crisis in which the crisis had spread all over Asia via financial linkages. This paper aims to find if there was financial contagion among developed countries during the Global Financial Crisis of 2007-2009 through stock returns and exchange rate channels. Developed countries are selected because they share similar macroeconomic structure and should be affected the same way. Financial markets of developed countries are also deeply intertwined and are vulnerable to contagion.

LITERATURE REVIEW

In literature concerning financial contagion, many dated back to Asian financial crisis in 1997. In the research by (Baig & Goldfajn, 1998) on Asian financial crisis in 1997, the correlation coefficients of daily changes in nominal

exchange rates, stock prices, interest rates, and sovereign spread were calculated among Asian countries. VAR model was also set up to observe impulse response function of one country to another. There are strong evidences of contagion in equity market and sovereign spread while currencies market offered mixed results. Another research done by (Chiang *et al.*, 2007) also confirms the contagion effect. Correlations of daily stock returns during 1990-2003 in nine Asian countries were measured in dynamic conditional-correlation model. Not only that the evidence of contagion is confirmed, in the second phase, the correlation remains high, indicating herding behaviors.

Some researchers chose to develop their own model of rational expectation such as those of (Kodres & Pritsker, 2002; Rodriguez, 2007). In (Kodres & Pritsker, 2002) rational expectation model was used to predict the behaviors of informed and uninformed investors. For Rodriguez (2007) Copula model was developed to examine this relationship. There are many who found evidences of contagion during 2008 crisis using different sets of countries. Kuusk & Paas (2011) studied contagion from the US to the Baltic States using correlation coefficient as well as ARCH-GARCH framework. Contagion effect was confirmed for stock returns but not for volatility. Syllignakis & Kouretas (2011) did a research on contagion to new European member states and found an increase in correlation pattern during the crisis. Mistrulli (2011) studied another contagion channel through interbank linkages in Italy and also found evidence of contagion as well. Longstaff (2011) focused on cross-market linkages by using VAR model. His work identifies the strong evidence of financial contagion in ABX indexes of subprime asset-backed CDOs. Most previous studies have relied on the use of correlation coefficients and VAR to determine if the contagion exists. This paper attempts to apply the similar methodologies for stock returns and exchange rates as well as add models to further validate the results. One contribution of this paper is that it uses wider range of data available to compare pre-crisis and post-crisis. Former researches have a problem of data limitation because they included data which were only 2-3 years after the crisis. Therefore, this paper aims to offer a more complete analysis using larger data set.

METHODOLOGY

This paper will use two main methods which are correlation coefficient and VAR analysis. Data used are monthly stock returns (2003-2015) and rate of change of Real Effective Exchange Rates (REER) (1994-2014) from

United States, Canada, United Kingdom, Germany, France, Italy, and Spain. Monthly data would be used to prevent the problem of heteroskedasticity. The analysis will still be valid as relationships are still observable over the long period of time. Stock returns and REER are used as the interpretation of theoretical definition of contagion as well as REER can be used to measure real competitiveness of a country and is more meaningful than nominal exchange rates. The data for REER dates back longer than stock returns due to data limitation. All data are obtained from CEIC database. Summary statistics of the data used is presented in the appendix.

Correlation Coefficient

In the first method, correlation coefficient will be used as a measure of the degree of co-movement in stock returns and exchange rates. The correlation coefficient will be estimated among six country Pairs—US-UK, US-Canada, US-Germany, US-Italy, US-Spain and US-France. For each country pair, the periods will be separated as follows:

Stock returns Real Effective Exchange Rates

Stock Returns	Real Effective Exchange Rates
<ul style="list-style-type: none"> • Before the crisis (2003-2006) n=48 • During the crisis (2007-2009) n=36 • After the crisis (2010-2015) n=72 	<ul style="list-style-type: none"> • Before the crisis (1994-2006) n=156 • During the crisis (2007-2009) n=36 • After the crisis (2010-2014) n=59

The hypothesis is that there exists financial contagion among the previously mentioned countries. If contagion existed, we would find correlation coefficients to be significantly higher during the course of the crisis and reduced during tranquil times. Mathematically, null and alternative hypotheses can be written as follows:

H₀: $\rho_{(US,j)}^0 \geq \rho_{(US,j)}^1$

H₁: $\rho_{(US,j)}^0 < \rho_{(US,j)}^1$

$\rho_{(US,j)}^t$ measures correlation coefficient between US and country j and T=0 means tranquil period (Before and after the crisis) and T=1 means crisis period. The paper

hypothesized that there is evidence of financial contagion and we would reject H₀.

VAR Analysis

Correlation coefficient analysis by itself might not be complete as it does not take into account the interconnectedness between markets. During the crisis, it is also hard to isolate the magnitudes of shocks originating in one market to another. Vector auto-regression comes in because it recognizes endogenous property of the variables and allows lagged terms to be included in the model. The model can be written as follows with data from during the crisis period (2007-2009):

$[[Ret]]_t = A_0 + A_1(L) [[Ret]]_{t-4} + \alpha_t$ (1)

$[[REER]]_t = A_0 + A_1(L) [[REER]]_{t-4} + \alpha_t$ (2)

where, $[[Ret]]_t(7 \times 1)$ is the stock returns vector for the seven countries. $A_0(7 \times 1)$ is the vector of constants for the seven countries. $A_1(7 \times 7)$ is the matrix of interactive stock returns. $\alpha_t(7 \times 7)$ represents random shock. Akaike Information Criteria (AIC) is used in finding optimal lagged term as it best fits the data, in which optimal lagged term is 3-4 periods. Before running VAR, Augmented Dickey-Fuller test (ADF) was performed to find if there are unit roots. For all the data, we find that the stationary condition is satisfied and the data can be used to run VAR models. Stability conditions are also satisfied for all the models. Orthogonal impulse response functions are then generated to see the effects of shocks from the US imposing to other countries. The research uses OIRF instead of normal IRF because the origin of shocks can be defined so that it is according to the theory. Expected results are separated into stock returns and REER. For stock returns, impulse response functions from the US to other countries should be positive, indicating that both were moving in the same direction. This can be interpreted as other countries react negatively to the decrease in US stock returns. For REER, impulse response functions from the US to other countries should be negative (i.e. moving in the opposite direction) as when USD depreciated, other countries' currencies should appreciate in real terms.

RESULTS

Correlation Coefficient

For stock returns, the empirical data showed that the correlations between these countries' stock returns are already high pre-crisis as they are in similar state of development as well as have advanced and efficient stock market. All correlations are positive as expected. What we found most striking is that during the crisis correlation is

significantly increased among all countries in the sample. The correlation during the crisis is around 0.82-0.89 while pre and post-crisis values are lower. However, after testing for statistical significance using both Z-test and F-test, the

results show that all countries except Canada and UK are statistically significant at 5% level of confidence. (For Canada, the result is significant at 10%). We reject H_0 and conclude the evidence of contagion in stock market.

TABLE 1: Correlation coefficient of return on stock market index between country-pair

	Canada	UK	Germany	France	Italy	Spain
BEFORE (2003-2006)	0.821	0.681	0.753	0.691	0.558	0.666
DURING (2007-2009)	0.878*	0.895	0.913**	0.901**	0.877**	0.864**
AFTER (2010-2015)	0.771	0.873	0.706	0.796	0.675	0.643

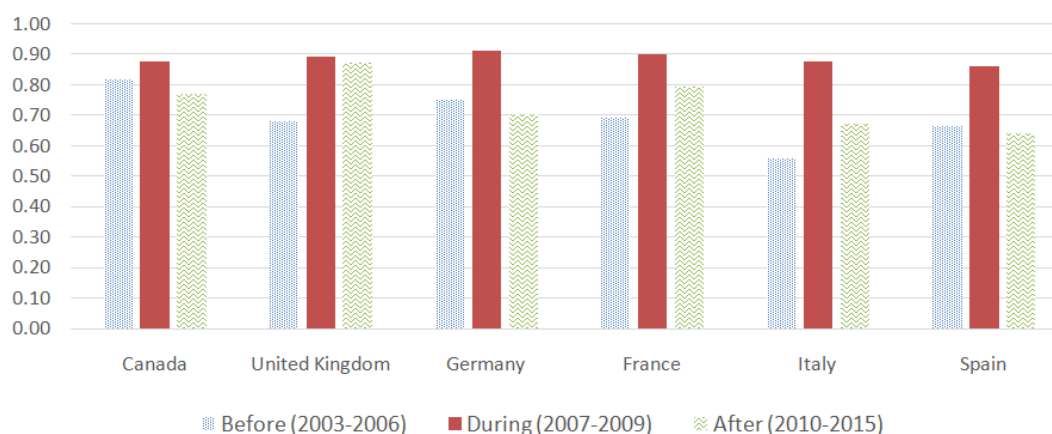


FIGURE 1. Correlation coefficient of return on stock market index between country-pair

For UK, correlation coefficient went up during the crisis but remained high even after the crisis. One of the explanations why it is not significant is that the investors have herding behaviors whereby even after the crisis, correlation remains high. For exchange rates, all countries' signs are negative as expected except UK. This indicates that the countries react in the different directions to change in USD. When USD depreciates, other countries' currencies appreciate. For UK pound sterling, the result is

unexpected as the sign is positive and correlation is very low. This obtained result is similar to the study (Sentence, Taylor & Wieladek, 2012) showing that the initial rebound of output of the UK had outpaced its peer group. One of the main explanations on this adjustment is because UK has retained the right to operate independent currencies within the European Union. Hence the obtained positive values of correlation coefficients feature the independency of British pound sterling from others.

TABLE 2. Correlation coefficient of REER between country-pair

		Canada	UK	Germany	France	Italy	Spain
BEFORE	(1994-	-0.304	0.157	-0.461	-0.439	-0.097	-0.407
2006)							
DURING	(2007-	-0.669**	0.039	-0.558	-0.625	-0.5434**	-0.503
2008)							
AFTER	(2009-2014)	-0.469	0.130	-0.546	-0.617	-0.548	-0.475



FIGURE 2. Correlation coefficient of return on stock market index between country-pair

After testing for statistical significance, only Canada and Italy show significance at 5% level of confidence. It is not significant because in periods after the crisis, the correlation remained high in all of the countries with changes less than 0.1. This can be accounted for as herding behaviors of the countries. The evidence of contagion is not as clear in exchange rates channel.

VAR analysis

Orthogonal impulse response functions are shown in Figure 3-4 in the appendix for stock returns and REER respectively. For stock returns, all initial shocks have

positive direction meaning negative stock returns from the US caused negative returns in other countries. In the long run the impact wears off and becomes zero. For UK, the long run impacts still cause returns to jump even after initial shock. The magnitude of impact is 0.05 which is quite large since the mean stock returns are around 0.02-0.04 in all countries. Causation can be implied that the shocks are caused from the US to other countries as OIRF from other countries to the US yield much lower response from the US meaning that the US was not affected much by other countries. The evidence of contagion was confirmed.

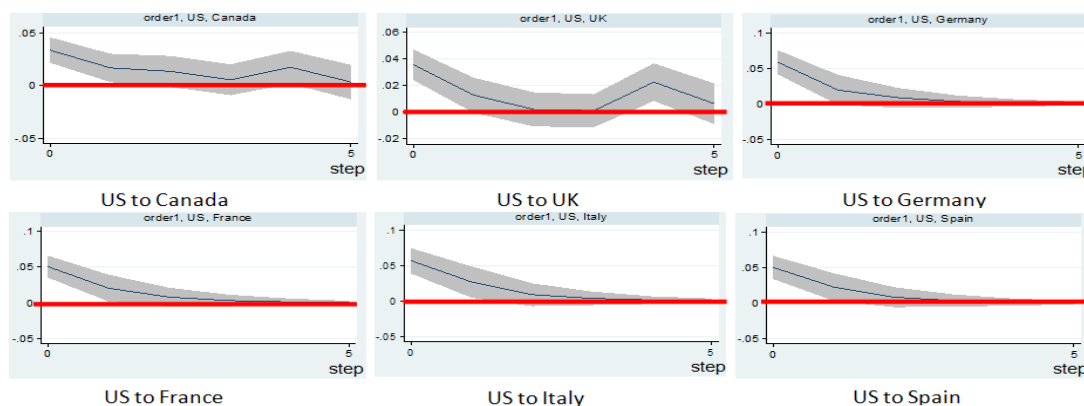


FIGURE 3. Orthogonal impulse response functions generated from imposing 1 S.D. shock from the US to other countries (the return of stock market)

For exchange rates, all initial shocks (except UK) have negative direction meaning depreciation from the US

caused appreciation in other countries. In the long run the impact wears off and becomes zero. For UK, the currency

appreciates after some time passed. Even though the response is slow, it is still consistent with our theory. The magnitude of impact for Canada is the greatest while that for Germany is the lowest.

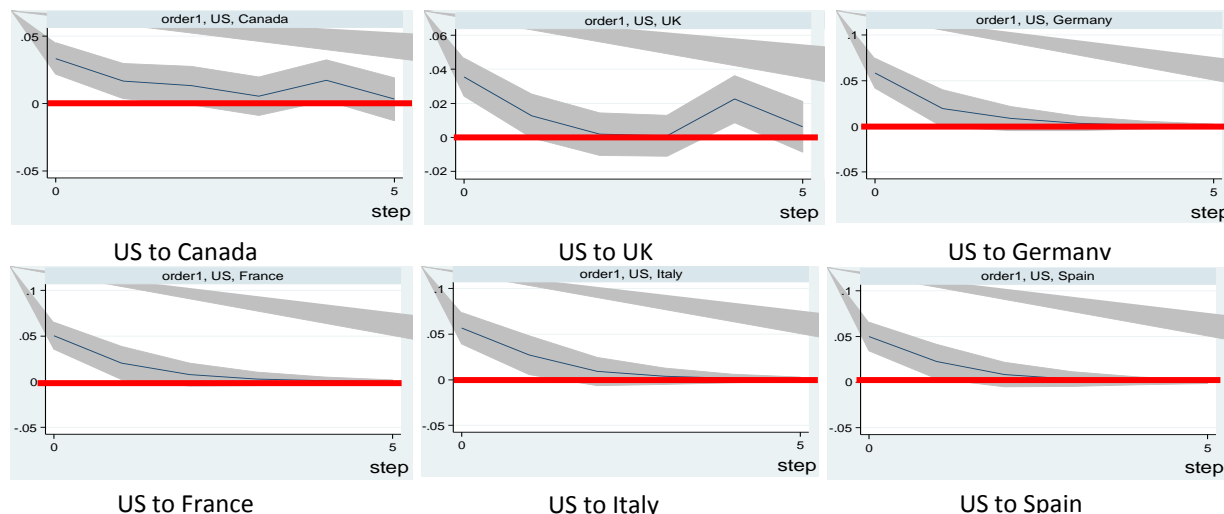


FIGURE 4. Orthogonal impulse response functions generated from imposing 1 S.D. shock from the US to other countries (the REER)

The evidence supports financial contagion in both markets but with different degrees and magnitudes. The signs appeared as expected and the magnitudes were large, indicating that the shocks originating in the US spread to other countries significantly especially in the short run. In comparison, the different sets of impulse response functions were done on other countries to other countries. The results show that the magnitude is relatively smaller than that originating from the US. Hence, we can conclude that the direction is stronger from the US. This supports our hypothesis of financial contagion.

CONCLUSION AND POLICY RECOMMENDATIONS

Financial contagion makes the country vulnerable to external shocks when the countries are becoming more globalized and integrated. We need to design a policy that maximizes benefit of globalization while minimizing risks. To minimize the risk of financial contagion, all developed countries should work together to develop a sound architecture to improve supervision and regulation of their financial markets and institutions. It must be based on a thorough understanding of the causes and consequences of contagion in financial markets. In this research, we propose three recommendations which are capital control, investors' behavior management, and risk management.

Firstly, this proposed capital control here does not imply the full control where the outflows and inflows of capital are greatly restricted but rather a selective capital control like the case of Chile. As documented by Gallego (2002)

Chilean government introduced the quantitative restrictions on unremunerated reserve requirement (URR) in 1991. The effects of the policy were that the inflows' maturity became more long term and monetary policy became more independent. There are still some controversies on the assessment of the policy effectiveness. However, having some forms of capital control would help contain the spread of the contagion. It would lessen vulnerability to outside shocks and excessive risks. Also the government can mitigate the cost of volatile capital inflows. There are some drawbacks from this policy as well so the countries must make careful assessments. Some of the drawbacks are high administrative costs, it might cause panic to investors, and capital controls might reduce a country's ability to receive multifaceted benefits (e.g. technology transfer, access to international network etc.). Secondly, management of investors' behavior could curb the contagion especially in financial markets. As mentioned earlier that herding behaviors can cause stock market to crumble along with the origin country, better information management can directly solve this problem. Credible policy action to sooth the market sentiments should be the priority when the contagion is caused from panic and herding behaviors. Clear communication that the financial markets and institutions are regulated and safe is also important. This could prevent contagion from macroeconomic similarity channel because the investors can see that their countries have better policy measures and this would regain their confidences. Thirdly, risk

management of financial institutions could be another channel to prevent contagion. Improvement in supervision and regulation of financial markets and institutions could improve the country's fundamentals as well as prevent another crisis. However, there might be barriers in changing system as there are some vested interest groups. The policy also has to be concerned about which type of behaviors the policy is encouraging and also which financial institutions would be discouraged. In sum, this paper identifies that financial contagion has existed among the aforementioned developed countries. The evidence is stronger in the case of stock market compared to the exchange rate channel, and it is suggested that strong policy actions are required as the measure of prevention.

There are some limitations in this study that could be improved in the future research. Firstly, the research focuses only on two measures of contagion which are stock returns and exchange rates. Interest spread and sovereign spreads can be analyzed further to establish other possible contagion channels. Secondly, the research only identifies the existence of contagion, but does not further establish the causes of such contagion. Thirdly, the research uses monthly data which yield quite a small sample size. The model might be improved by using wider range of samples such as switching to use daily data and using the alternative methodologies such as E-GARCH or Markov-Switching VAR.

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APPENDIX
SUMMARY STATISTICS

Variable	Obs	Mean	Std. Dev.	Min	Max
Stock_US	138	.0057892	.0444992	-.1953736	.1136292
Stock_Canada	138	.0058253	.0385757	-.1693318	.1120909
Stock_UK	138	.0043816	.0378816	-.1302485	.0845216
Stock_Germ~y	138	.0108263	.0516665	-.1919212	.1676206
Stock_France	138	.0045451	.0468423	-.1351727	.1255673
Stock_Italy	138	.001295	.0587778	-.1627105	.208
Stock_Spain	138	.0054837	.0555933	-.1703299	.1662452
REER_US	251	.0000685	.0121186	-.0395308	.0559399
REER_Canada	251	.0001959	.0157045	-.0911645	.0552377
REER_Germany	251	-.0004874	.0086427	-.0193296	.040277
REER_France	251	-.0003224	.0069546	-.0243519	.0283628
REER_Italy	251	.0002649	.0104419	-.0802139	.0569462
REER_Spain	251	.0003769	.0076037	-.0225587	.0219325
REER_UK	251	.0008189	.0148703	-.0862532	.0424862