THE GLOBAL FINANCIAL CRISIS AND TRANSMISSION CHANNELS: AN INTERNATIONAL NETWORK ANALYSIS[1]

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Abstract

This paper analyzes the effects of trade and financial networks on the real economy during the 2008-2009 global financial crisis. We construct cross-country trade and financial networks for 61 countries and then fit the country centrality measures in the econometric analysis. We find some important results regarding the network effects on the crisis propagation. Firstly, both the trade and financial networks play an important role in the propagation of the global crisis. Secondly, higher levels of trade network increase the allocative efficiency and lessen the negative contagion effect of the global financial crisis. Thirdly, the financial network has a negative contagion effect in the propagation of the global financial crisis. Finally, the absolute level of network effects becomes even bigger especially within Asia-Pacific (or Chiang Mai Initiative) countries, suggesting that Asia-Pacific region is interconnected efficiently in trade but not in finance.

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1. Introduction

The global financial crisis has shown diverse effects across countries. This paper investigates the possible channels through which the global financial crisis of 2008 was transmitted across countries. The world has observed a rapid increase in trade and financial linkages across countries since 1980s, especially in the emerging market economies (Kose, et al., 2012). Increase in international economic linkages may increase the sensitivity of external shocks and heighten the degree of negative contagion effects that individual countries face. The question arises whether countries have become more interdependent to common shocks with the rapid increase in economic linkages. This question leads us to investigate the trade and financial channels through which the global crisis is propagated.

The empirical findings on the relationship between economic linkages and output co-movement are not clear. Baxter and Kouparitsas (2005) show that the level of bilateral trade linkages is positively associated with output co-movement via spillover effects across economies. Imbs (2006) shows that financial integration among countries is also positively associated with business cycle co-movement through the wealth effects. Berkmen, et al. (2009) and World Bank (2009) suggest that the levels of trade and financial exposure are the causes of the different degrees of output declines among economies after the 2008 global crisis. Trancoso (2014) finds that the rapid propagation of global recession in 2009 was mainly due to high levels of real and financial interdependence between economies. Kose, et al. (2008, 2012) find that there has been a convergence of business cycles only within the group of advanced economies and of emerging market economies.

However, other studies find real decoupling and financial recoupling between advanced economies and emerging market economies (Levy-Yeyati and Williams, 2012; Park and Shin, 2009). Rose and Spiegel (2010, 2012) find no evidence that international trade and financial dependence can be associated with 2008 crisis incidence. They also suggest that it is impossible to predict future crisis incidences with the help of early warning systems. In sum, there seems to be no consensus on the determinants of crisis propagation. Furthermore, the question of whether the higher levels of trade and financial linkages increase contagion effects of the crisis also needs further empirical investigation.

We use a new methodology that incorporates a dynamic network approach into econometric analysis, which is one of the first attempts in identifying the crisis transmission channels. With the high international economic linkages and constantly occurring global crisis, network models are becoming useful tools in the investigation of the complex crisis incidence (Caballero and Simsek, 2009). Our main contribution is made by the following method. First, we construct the trade and financial networks and provide a fine visualization of the structures of the trade and financial networks for the first time. This enables us to discern the world economic structures and linkages at one glance. Second, we combine the trade and financial networks with crisis incidence and investigate the dynamic nature of the crisis effect along the networks. Third, we incorporate the network analysis into the econometric approach and identify the network effects, that is, whether and to what extent trade and financial networks affected the real GDP performance. Furthermore, we can also identify whether the network effects are found worldwide or within some specific country group. Finally and most importantly, our approach includes not only the direct but also the indirect dependency of other countries in the procedure. This is the main difference from the existing studies which use the bilateral dependence between two countries.

This paper is organized as follows. Section 2 constructs a network structure for the trade and financial linkages by using the minimum spanning tree (MST). This provides us with a fine visualization of the trade and financial networks during the 2001-2012 period. Section 3 analyzes the transmission of crisis incidence along with the trade and financial networks. Among the major crisis incidence, the response of real GDP after the global financial crisis is the main focus. Section 4 provides the robustness check of the network analysis by incorporating the network analysis into the econometric analysis. This will strengthen and corroborate the result of the network analysis. Section 5 concludes the analysis.

2. Constructing the Trade and Financial Networks

We construct a network structure for investigating the trade and financial channels by using the minimum spanning tree (MST) method. The MST method has been applied to

the stock market (by Mantegna, 1999; Onnela et al., 2003; Bonanno et al., 2004; and Rea and Rea, 2014), and to the foreign exchange market (by Naylor et al., 2007; and Keskin et al., 2011). Most of the existing studies apply the MST method directly to the financial market indices and analyze the topological properties.

This paper adopts a different approach. First, we construct a dynamic network structure for trade. This allows us to obtain a much clearer visualization of the trade linkages such as the hub, secondary-hub, and clusters in the structure. Second, we also construct a dynamic network structure for financial portfolio investment flows, which provides us with a clear visualization of the network out of complex financial asset movements. By combining these networks with crisis incidence, we can assemble the crisis transmission pattern.

The data set we use is mainly collected from the IMF and BIS, and comprises quarterly data starting from the first quarter of 2001 to the fourth quarter of 2012 for 61 countries. The element of the trade matrix for the trade network is the total trade (exports plus imports) between country i and country j. The element of the financial matrix for the financial network is the total portfolio asset flows (outflows plus inflows) between country i and country j. The total number of countries in the data set is 61. The macroeconomic variable which represents the crisis incidence is the rate of change in real GDP of each country. We also divide the countries into several groups according to various criteria such as monetary policy regime, regional group, the degree of economic development, and the level of integration into global trade and finance. For example, we can divide the countries into two groups: one group with the inflation targeting system and the other group without (see Table 1).

The MST method considers all the pairwise distances between the nodes and joins the two that are closest to each other using the distance as the weight. We use the matrix of total trade for constructing the trade network, and the matrix of total portfolio asset flows for constructing the financial network. The procedure partitions the data into two groups, one that is part of the tree and the other which is not. Then the procedure also finds the closest node to the tree from the unattached ones and attaches that to the tree. This procedure continues until the unattached node is exhausted (Rea and Rea, 2014).

We need to estimate all the pairwise distances from the trade (and the portfolio asset flows) matrix of the countries in the data set. We define the metric distances between two economies as equation (1). The bigger is the trade between the two countries, the closer the distance between the two countries becomes. We then construct the distance matrix as equation (2), and the adjacency matrix as equation (3) by applying MST method to the distance matrix.

As we have 61 countries in the matrix, the number of links in the network is $61(61-1)/2$. The MST shows a graph of 61 countries connected by the most important 61-1 links, and thus has the advantage of simplification. We also construct the size of country, ranging from 0.1 to 4.1, by using the size of trade (or of total portfolio asset flows) of each economy as equation (4) indicates. The procedure is as follows:

(1) $D_{i,j} = \frac{1}{X_{i,j}+X_{j,i}}$, where $X_{i,j}$ represents the total exports (or total portfolio outflows in absolute value) from country i to country j .

(2) $(D_{i,j})_{i,j=1,2,\ldots,N}$ is the distance matrix with the elements of pairwise distances.

(3) $(L_{i,j})_{i,j=1,2,\ldots,N}$ is the adjacency matrix computed by applying MST method to the distance matrix.

(4) $W_i = 4\frac{w_i - min_j w_j}{max_j w_j - min_j w_j} + 0.1$, where $w_i = \sum_{j=1}^{N}(X_{i,j} + X_{j,i})$ is the total trade flows (or total portfolio flows in absolute value) between country i and all the other countries in the matrix.

Table 1
Consequences of the Global Crisis over the Period Q1 2008 – Q1 2009

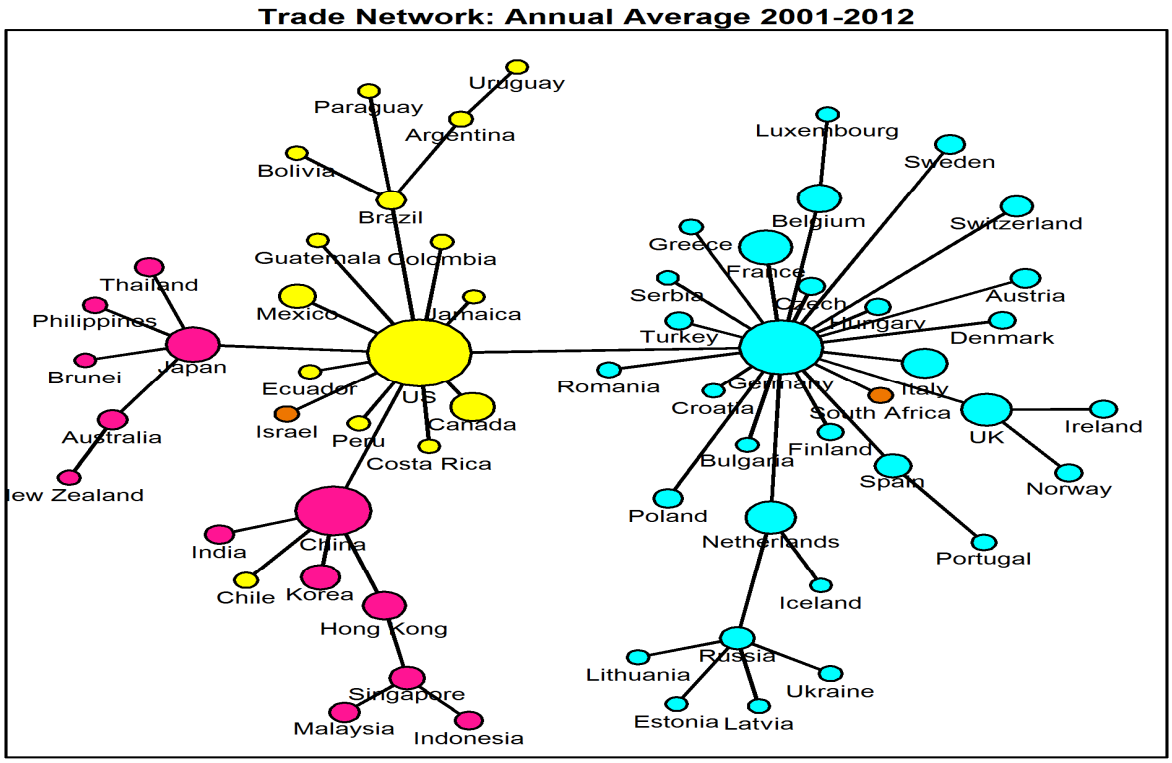
Country	Group	Real GDP growth rate (%)	Country	Group	Real GDP growth rate (%)
Argentina	c, f	0.88	Jamaica	c	-1.79
Australia	b, d,	0.55	Japan	b, e,	-4.19
Austria	a	-2.58	Korea, Republic of	b, d, e, f	-1.86

Belgium	a	-1.78	Latvia	f	-8.83
Bolivia	c	1.26	Lithuania	f	-6.47
Brazil	c, d, f	-1.22	Luxembourg	a	-3.01
Brunei Darussalam	b, e	-1.22	Malaysia	b, e, f	-2.57
Bulgaria		-2.19	Mexico	c, d, f	-2.34
Canada	d	-0.96	Netherlands	a	-1.62
Chile	c, d, f	-1.38	New Zealand	b, d	-0.96
China, P.R.	b, e, f	2.74	Norway	d	0.43
Colombia	c, d, f	0.56	Paraguay	c	2.58
Costa Rica	c	-2.06	Peru	c, d, f	0.82
Croatia		-3.76	Philippines	b, d, e, f	0.42
Czech Republic	d, f	-1.63	Poland	d, f	0.25
Denmark		-2.26	Portugal	a	-1.83
Ecuador	c, f	1.67	Romania	d, f	-2.79
Estonia	f	-6.17	Russian Federation	f	-4.19
Finland	a	-4.11	Serbia, Republic of	d	-1.64
France	a	-1.91	Singapore	b, e, f	-3.92
Germany	a	-3.06	South Africa	d, f	-0.22
Greece	a	-1.87	Spain	a	-1.50
Guatemala	c, d, f	-0.36	Sweden	d	-2.88
Hong Kong SAR	b, e, f	-3.51	Switzerland		-1.19
Hungary	d, f	-3.23	Thailand	b, d, e, f	-3.17
Iceland	d	-2.43	Turkey	d, f	-6.93
India	b, f	3.12	Ukraine	f	-9.47
Indonesia	b, d, e, f	1.92	United Kingdom	d	-2.74
Ireland	a	-2.79	United States		-1.55
Israel	d, f	0.27	Uruguay	c	0.84
Italy	a	-3.15			

Notes: a) refers to the Eurozone countries before the 2008 crisis, b) refers to Asia-Pacific economies, c) refers to Latin American economies, d) refers to the inflation-targeting countries, e) refers to the participants of the Chiang Mai Initiative (CMI), and f) refers to emerging market economies, respectively.

Figure 1

Trade and Financial Networks during 2001-2012



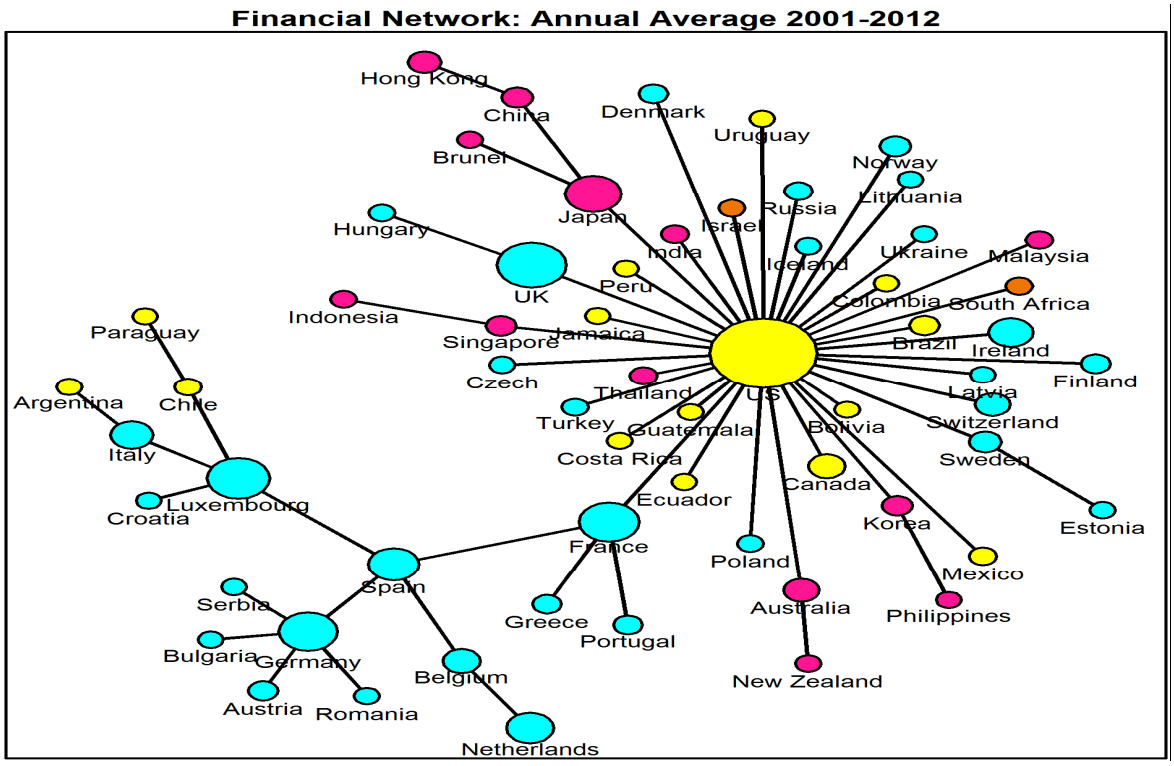


Figure 1 shows the trade and financial networks of the 61 economies. The size of country represents the adjusted relative size of trade (or of total portfolio asset flows) of each

country. Uruguay, for example, is on the top left hand side of the trade network. Among the 60 links between Uruguay and the other countries, only the link to Argentina that is the most important is retained while the remaining links are abandoned. In spite of the simplifying procedure, useful information is still retained.

We find there are some important countries which form hubs and clusters. The trade network comprises two main hub economies (United States and Germany) and 5 secondary-hub economies (Japan, China, Brazil, Russia, and the United Kingdom). Each secondary-hub comprises a cluster that is connected to main hubs with a smaller scale than the main hub. The United States, one of the main hubs, has trade linkages with the Japan cluster (around which Australia, New Zealand, Philippines, Thailand, Brunei Darussalam are clustered as leaves), the China cluster (around which Hong Kong SAR, Singapore, Malaysia, Indonesia, India, Korea and Chile are clustered as leaves), and the Brazil cluster (around which Argentina, Bolivia, Paraguay, Uruguay are clustered as leaves). Germany, the other main hub, has also trade linkages with the Russian Federation cluster (around which Ukraine, Lithuania, Latvia, Estonia are clustered as leaves), and the United Kingdom cluster (around which Ireland and Norway are clustered as leaves.

The financial network reveals a substantially different structure from the trade network. There is one main hub (United States) and a few secondary-hubs (United Kingdom, France, Spain, Germany, Luxembourg and Japan). The European countries constitute a slightly more complicated structure, in which all the clusters are connected with Spain. Spain is in the center of several routes that are connected to the Germany cluster (Austria, Bulgaria, Romania and Serbia), the Luxembourg cluster (Croatia, Italy, Argentina, Chile and Paraguay), the France cluster (Greece and Portugal), and the Belgium-Netherlands route. All of the European clusters are connected to the United States hub through France. The Japan cluster (China, Hong Kong SAR and Brunei Darussalam) is the only secondary-hub connected to the United States. Countries like China and Brazil which act as secondary hubs and show independent response in the trade network are no longer important players in the financial network. They are all integrated into the financial network as countries on the route or as independent leaves.

The two network structures suggest some interesting findings, i.e., geographical

cluster plays an important role in the trade network, but disappears in the financial network. Also, the countries are more integrated around the United States in the financial network than in the trade network. This result also corroborates the Park's (2013) finding that while the pace of financial integration among Asian economies has accelerated in recent years, these markets remain more integrated with global financial hub than with other financial markets in the Asia region.

3. Crisis Transmission Channel: Trade vs. Financial

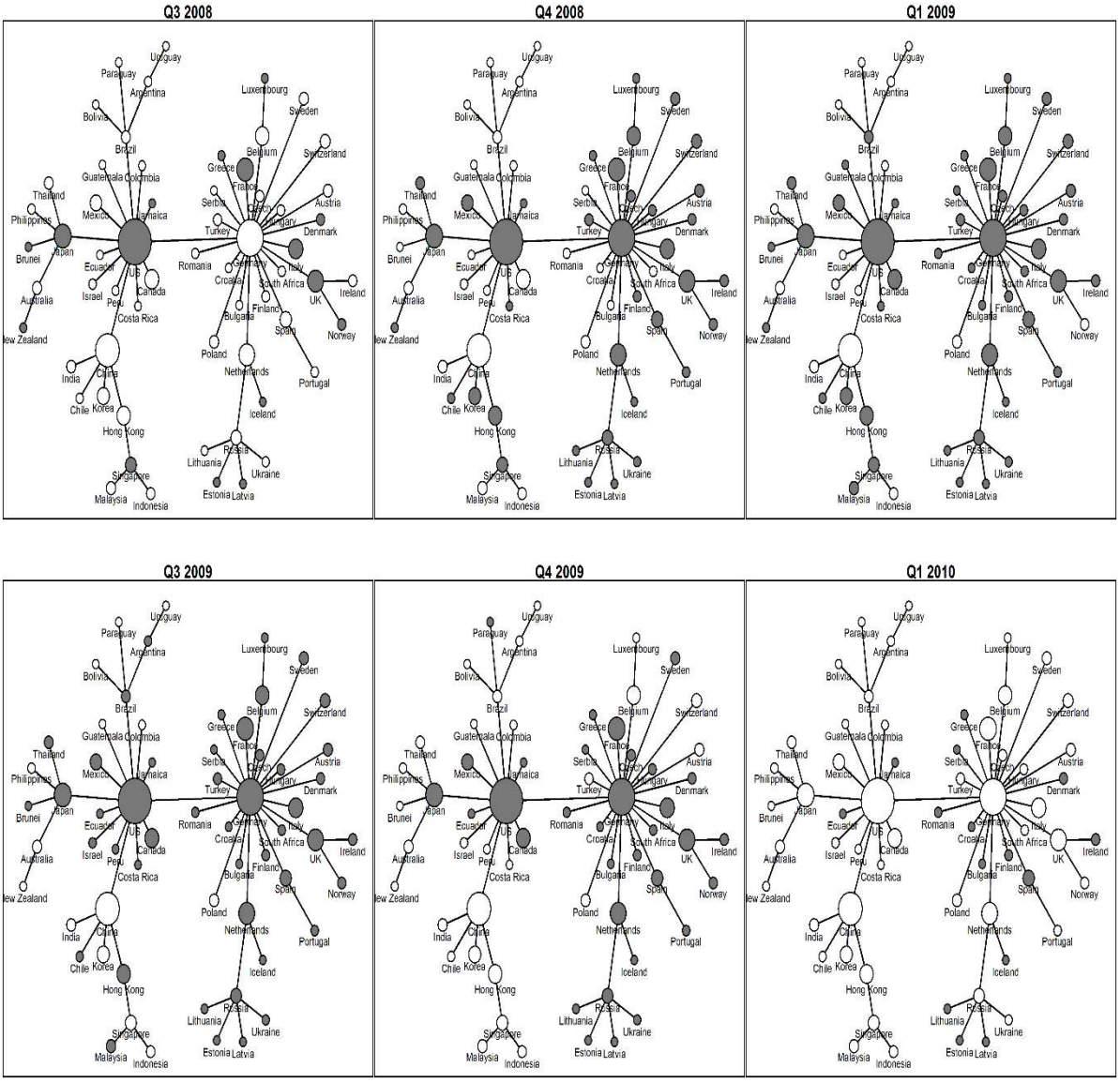
The 2008 crisis effects defined in the literature are variables such as the rate of exchange rate depreciation (Obstfeld, et al., 2009; 2010), a combination of changes in real GDP, stock prices, country credit ratings and the exchange rate (Rose and Spiegel, 2010; 2012) and the change in growth forecasts before and after the crisis (Berkmen et al., 2009). The focus of our paper is on the crisis effect on the growth rates of real GDP in the crisis propagation.

3.1 Trade Network

The convergence hypothesis suggests that business cycles are getting more synchronized across countries with closer economic integration. Figure 2 presents the transmission procedures of output decline and recovery along the trade network. The shaded circle in each network indicates the negative rate of change in real GDP. The real GDP growth rate in the United States turns negative from the third quarter of 2008. The output decline is also observed partly in Japan cluster which includes Japan, Brunei Darussalam, and New Zealand. Although some of the United Kingdom and Russian clusters show negative real growth rates in the same quarter, they are not directly connected with the United States. Germany, the European hub, still shows a positive real growth rate in the third quarter of 2008. The remaining China cluster, Brazil cluster, and half of the Japan and Russian clusters do not enter into a recession in the third quarter of 2008.

Figure 2

The Trade Network and Changes in Real GDP



In the following two quarters (Q4 2008-Q1 2009), however, the European hub and secondary hub countries enter into a recession simultaneously. Germany, the United Kingdom clusters (with Norway and Ireland), the Netherlands cluster (with Ireland), the Russian cluster (with Ukraine, Lithuania, Estonia, and Latvia) are countries showing output decline. France, Italy, and Spain which are directly connected to Germany, also show output decline. One important observation is that developing economies such as the China cluster (with India and Indonesia), the Brazil cluster (Argentina, Bolivia, Paraguay, and Uruguay), the Japan cluster

(Australia and the Philippines), Colombia, Ecuador, Peru, and Israel do not enter into a recession. These developing economies are much less affected and recover more rapidly than advanced economies. The process of output recovery (Q3 2009-Q1 2010) tells us a similar story in the opposite direction.

3.2 Financial Network

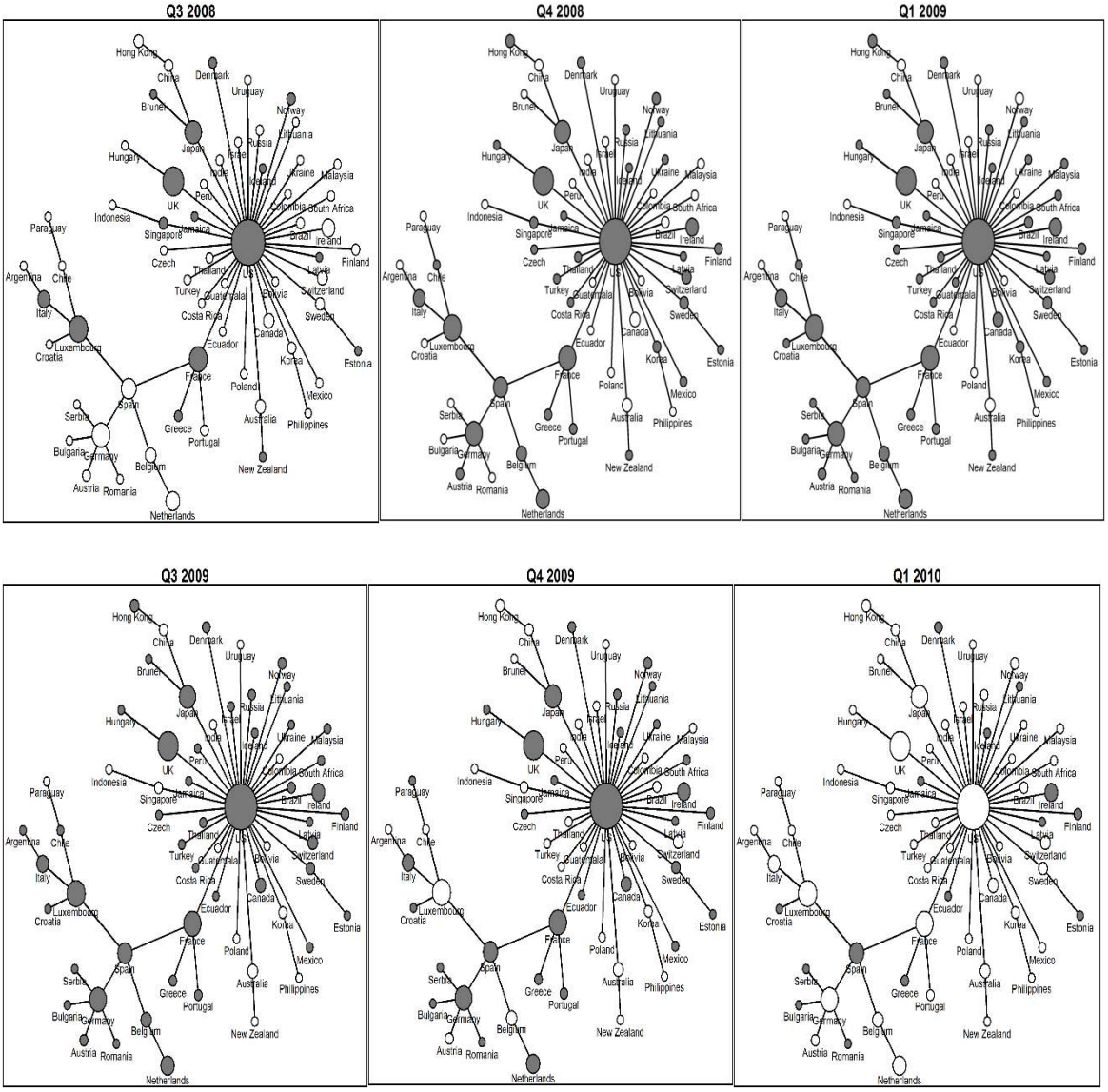
Figure 3 shows a slightly different procedure of output decline and recovery along the financial network. Reflecting the financial crisis from the third quarter of 2008, the real GDP growth rate in the United States turns negative with several secondary hubs. The output decline which started in the United States is transmitted to the secondary financial hub economies such as the United Kingdom, France, Japan, Luxembourg, and Italy.[2] The Germany cluster, however, is not affected and independent of the crisis effect in the same quarter.

Even in the first quarter of 2009 when most European countries enter into a recession, some Asia and Latin American economies do not enter into a recession. Although more countries are directly connected to the United States in the financial network, there is still some divergence in the crisis propagation depending on regional groups. The recovery process is in the reverse order, except for Luxembourg which initiates the recovery process. By the first quarter of 2010, most economies have recovered from the crisis.

Figure 3

[2] The big players in portfolio investment assets are the United States, the United Kingdom, Japan, Luxembourg, Germany, France, Ireland, Netherlands, Switzerland, and Italy.

The Financial Network and Changes in Real GDP



3.3 Country Group

Asia-Pacific Economies and the Chiang Mai Initiative

How are Asia and Pacific economies affected by the global financial crisis of 2008? Asia has experienced two strands of change: the rise of China in its trade on the one hand, and the regional monetary policy cooperation after the Asian crisis of 1997 on the other.

Figure 4 shows how each country group, marked with lozenge, is affected by the global crisis.

The output decline is observed only in Japan, Brunei Darussalam, New Zealand, and Singapore in the third quarter of 2008. Most of the other Asia-Pacific economies are not much affected, showing positive real GDP growth rates. Figure 4 (left panel) shows that even in the deep recession of the first quarter of 2009, some Asia-Pacific countries do not enter into a recession. The rebound from the recession has also been more significant in Asia-Pacific economies in the following quarters of 2009. The countries hit by the Asian crisis in 1997 (especially Indonesia, Korea, Malaysia, Philippines, and Thailand) show substantially sound response in the wake of the global crisis.

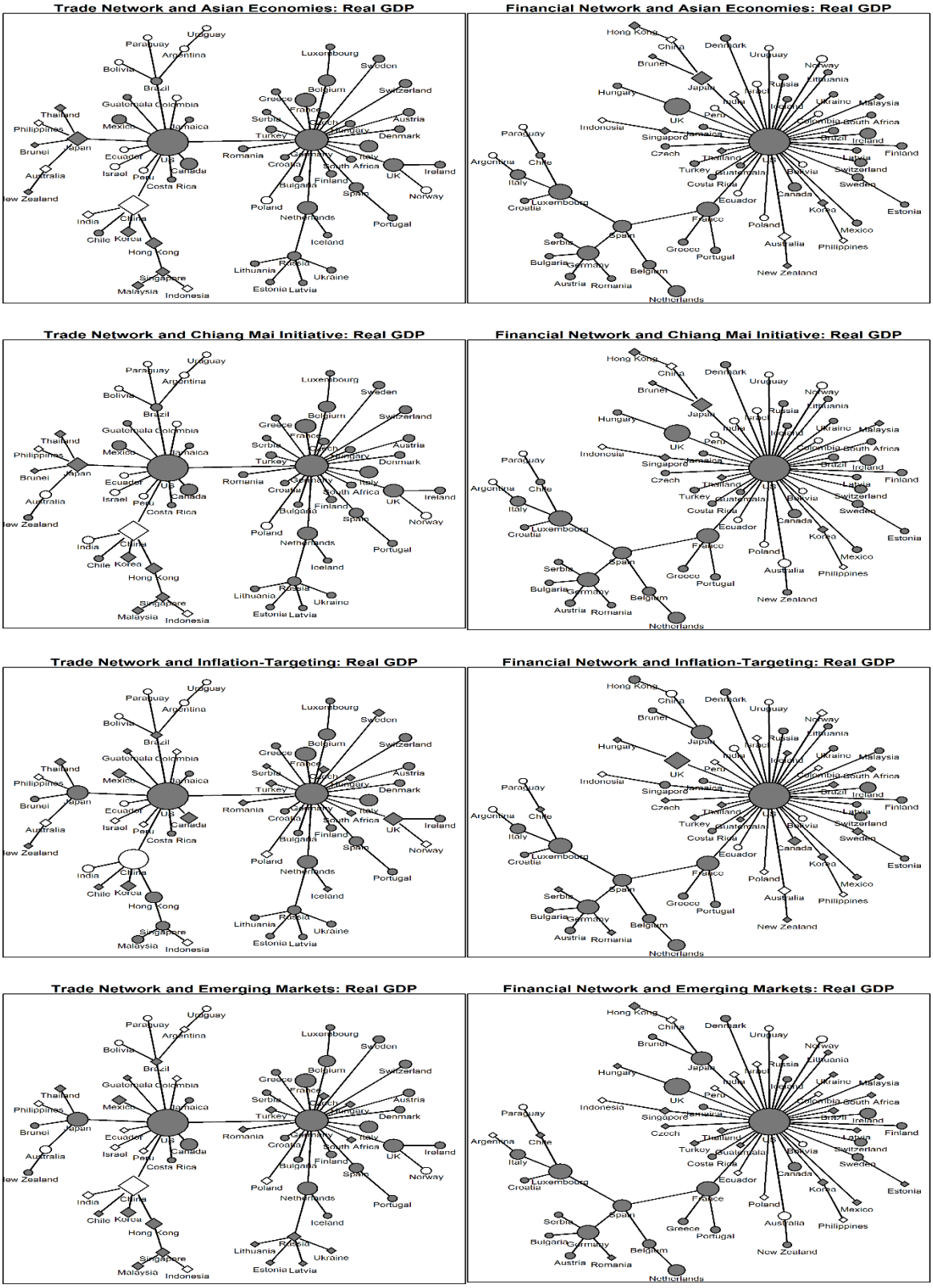
This result suggests two important possible explanations. One is that regional factors are still more important in the process of crisis transmission. The rising role of China in regional and global trade may have helped in slowing down the propagation of the global crisis of 2008. China has emerged as a regional economic hub and absorbed external shock as a big purchaser of manufacturing goods and a big supplier of surplus capital. The other possible explanation is that financial policy coordination in the Asia-Pacific region may have also helped in slowing down the crisis propagation. The Asian crisis of 1997 has driven Asian economies into stronger regional financial policy coordination[3]. The main objective of the Chiang Mai Initiative, for example, is to provide financial support through currency swap transactions to the participants facing balance-of-payments and short-term liquidity difficulties. This has contributed in strengthening the resilience of Asian countries to the global economic crisis.

Inflation Targeting Economies

The global financial crisis has casted an open-ended question as whether inflation-targeting is an appropriate policy tool for the purpose of financial stability. Several inflation-targeting countries such as Hungary, Iceland, Romania, and Serbia, have been hit by the

[3] Examples of such cooperation include the ASEAN+3 Economic Review and Policy Dialogue, the Chiang Mai Initiative (CMI), the Asian Bond Market Initiative (ABMI), and the Asian Bond Fund Initiative (ABF1 and ABF2).

Figure 4
Two Alternative Networks and Country Groups: Q1 2009



global crisis and have entered into IMF-supported programs (Roger, 2010). The inflation targeting system faces a severe challenge that it may not be an appropriate policy tool in the event of a financial crisis. It is not proven or clear whether the rigid application of inflation targeting has made these countries more susceptible to crises compared to other economies with other policy regimes.

As Figure 4 (left panel) reveals, inflation-targeting countries seem to be less affected by the global crisis. The inflation-targeting emerging economies, especially in Asia and Latin America, are less adversely affected by the global financial crisis. In the third quarter of 2008, only high-income inflation-targeting countries enter into negative output growth. The United Kingdom, Norway, Iceland, and New Zealand took the lead with other inflation-targeting countries following.

Emerging Market Economies

If we restrict our discussion to the trade network, the finding that regional factors are more important in the process of crisis transmission seems also true to emerging market economies. Figure 4 (left panel) reveals that emerging market economies show output co-movement by regional country groups such as Asia-Pacific, but not as a whole emerging market. Therefore, the co-movement of the whole emerging market economies needs to be tested in more detail in the next section.

4. Regression Analysis: Robustness Check

We have analyzed, so far, the trade and financial networks through which the global crisis is propagated. In addition to the network approach, we also want to investigate the robustness of the results of the network analysis. In order to incorporate the network approach into econometric analysis, we need to go a few more steps. First, we have to calculate indices that represent the nature of the trade network and financial network. Second, we also have to define and collect additional pre-crisis fundamentals. Then, we can simultaneously investigate the effects of the economic networks as well as the additional pre-crisis fundamentals on the crisis propagation.

We calculate two kinds of network measures for each network. $Trade_i$ is the measure of trade network of country i, which is the degree of trade integration of country i with the rest of the world. Likewise, $Finance_i$ is the measure of financial network of country i, which is the degree of financial integration. The network measure is calculated by both the eigenvector centrality method and the geodesics from the US. Each network measure is the average for the pre-crisis period over 2001-2007, since the main focus in this study is to investigate the effects of the pre-crisis factors on the global crisis. The eigenvector centrality score (S_i) for the trade network ($Trade_i$) and the financial network ($Finance_i$) for country i is given by equation (5):

(5) $S_i = \frac{1}{\lambda}\sum_j A_{ij}S_j$

where, λ is the eigenvalue of the matrix $\left(A_{ij}\right)_{i,j=1,2,\ldots,61}$

$A_{ij} = \frac{1}{7}\sum_{t=2001}^{t=2007} X_{ij}(t)$ is the weight of the link between country i and j,

$X_{i,j}(t)$ is the total trade flows (exports+imports) between country i and j

in the trade network ($Trade_i$),

and total portfolio asset flows (outflows+inflows) between country

i and j in the financial network ($Finance_i$)

Also, the network measures by using the geodesics from the United States are also calculated. The R-package calculates the geodesics by using the inverse of the weight of the link between country i and j (A_{ij}^{-1}) as the distance of the link.

The effects of the economic networks as well as the additional pre-crisis fundamentals on the macroeconomic shocks can be traced using the following relationship. The shock on the macroeconomic variable j in country i is a function of a country's level of trade and financial networks with the rest of the world. The pre-crisis fundamentals are also included as explanatory variables.

(6) $Crisis_i^j = F(Trade_i,\ Finance_i,\ Fundamental_i)$

The crisis effect ($Crisis^j$) in our study is the growth rate of real GDP in each economy, over the crisis period of the first quarter of 2008 and the first quarter of 2009. The above crisis period is selected because the first and second quarters of 2009 are the bottom of the crisis and the recovery starts from the third quarter of 2009 as a whole.

In addition to the network measures, we include the constant dummy and slope dummy variables. The constant dummies represent several country groups such as countries with inflation targeting system (TARGET), participants in the Chiang Mai Initiative (CMI), Eurozone countries (EURO), Asia-Pacific economies (ASIA), Latin American economies (LATIN), and emerging market economies (EME). These constant dummy variables are included to capture differences in the growth potential or initial condition in real GDP among different country groups.[4] The slope dummy variables in the form of interaction terms are also included for both the trade and the financial networks. These slope dummy variables are included to test whether the trade and financial networks play different roles in transmitting crisis effects among different country groups.

$Fundamental_i$ represents all other pre-crisis fundamentals that could affect transmission of global shocks to country i. Several country-specific variables such as the current account/GDP ratio, the foreign reserve/GDP ratio, and the real effective exchange rate (REER) overvaluation are also tested for their significance. The current account/GDP ratio and the reserve assets/GDP ratio are measured by the data in pre-crisis year 2007. The REER overvaluation in Q4 2007 is proxied by the detrended cyclical component of the REER in the fourth quarter of 2007, by using the Hodrick-Prescott filter over the period Q1 2000 and Q1 2014. We examine all countries, where the quarterly real GDP statistics are available from the International Financial Statistics. The total number of countries in this study is 61.

[4] In order to overcome the possible problem due to the different growth potential and timing of entering into a recession across countries, we also use the rate of change in terms of the deviation from the trend, namely the shocks in the growth rates of real GDP. However, this did not change the estimation results substantively.

Table 2
Crisis Effects on the Rate of Growth in Real GDP
(Eigenvector Centrality Method)

	(1)	(2)	(3)	(4)
Trade (Trade Network)	0.02***	0.02	0.02**	0.02
	(0.00)	(0.20)	(0.02)	(0.25)
Trade×ASIA	0.06*	0.07*		
	(0.05)	(0.09)		
Trade×CMI			0.08**	0.09**
			(0.02)	(0.02)
Trade×LATIN	0.09	-0.09***	0.09	-0.08***
	(0.63)	(0.00)	(0.66)	(0.00)
Trade×EME	-0.18		-0.18	
	(0.33)		(0.37)	
Trade×TARGET		-0.02		-0.02
		(0.54)		(0.49)
Finance (Financial Network)	-0.01*	0.01	-0.02	-0.00
	(0.10)	(0.95)	(0.13)	(0.98)
Finance×ASIA	-0.12***	-0.11***		
	(0.00)	(0.00)		
Finance×CMI			-0.12***	-0.12***
			(0.00)	(0.00)
Finance×LATIN	-0.65	-0.33***	-0.72	-0.34**
	(0.21)	(0.01)	(0.22)	(0.01)
Finance×EME	0.50		0.57	
	(0.37)		(0.36)	
Finance×TARGET		-0.01		-0.01
		(0.84)		(0.82)
Reserve/GDP 2007	-0.02**	-0.01***	-0.02**	-0.01***
	(0.03)	(0.00)	(0.03)	(0.00)
ASIA (Asia-Pacific)	3.39***	2.84**		
	(0.01)	(0.02)		
CMI (Chiang Mai Initiative)			2.21**	1.47**
			(0.04)	(0.02)
LATIN (Latin Countries)	3.71***	3.80***	3.39***	3.44***
	(0.00)	(0.00)	(0.00)	(0.00)
EME (Emerging Market)	-0.66		-0.70	
	(0.58)		(0.59)	
TARGET (Inflation-Targeting)		1.22*		1.39*
		(0.09)		(0.08)
Constant	-2.04***	-2.95***	-1.67***	-2.77***
	(0.00)	(0.00)	(0.01)	(0.00)
R-squared	0.43	0.44	0.34	0.36

Notes: The growth rates in real GDP (the dependent variable) are measured over the crisis period between Q1-2008 and Q1-2009. Newey-West HAC method is used to correct the heteroskedasticity and autocorrelation, and the associated probabilities are in parentheses. ***, ** and * indicate the significance level at 1%, 5% and 10% respectively. The network measure is calculated by the eigenvector centrality method, and is the average for the pre-crisis period over 2001-2007.

Table 3
Crisis Effects on the Rate of Growth in Real GDP
(Geodesics from the US Method)

	(1)	(2)	(3)	(4)
Trade (Trade Network)	0.04***	0.24	0.02	0.13
	(0.00)	(0.14)	(0.20)	(0.44)
Trade×ASIA	0.10	-0.03		
	(0.49)	(0.88)		
Trade×CMI			0.26***	0.20
			(0.01)	(0.28)
Trade×LATIN	-0.02	-0.13***	0.08	-0.12***
	(0.97)	(0.00)	(0.86)	(0.00)
Trade×EME	-0.15		-0.20	
	(0.75)		(0.68)	
Trade×TARGET		-0.23		-0.12
		(0.17)		(0.49)
Finance (Financial Network)	-0.04	-0.09	-0.01	0.07
	(0.39)	(0.46)	(0.94)	(0.62)
Finance×ASIA	-0.31**	-0.28*		
	(0.04)	(0.07)		
Finance×CMI			-0.49***	-0.53***
			(0.00)	(0.00)
Finance×LATIN	-1.38	-0.94***	-1.82	-1.00***
	(0.28)	(0.01)	(0.22)	(0.01)
Finance×EME	0.99		1.37	
	(0.46)		(0.37)	
Finance×TARGET		0.09		-0.06
		(0.50)		(0.68)
Reserve/GDP 2007	-0.02***	-0.01***	-0.02***	-0.01***
	(0.01)	(0.00)	(0.01)	(0.00)
ASIA (Asia-Pacific)	3.36***	3.28**		
	(0.01)	(0.01)		
CMI (Chiang Mai Initiative)			1.89**	1.68**
			(0.04)	(0.03)
LATIN (Latin Countries)	3.80***	3.84***	3.55***	3.60***
	(0.00)	(0.00)	(0.00)	(0.00)
EME (Emerging Market)	-0.91		-0.76	
	(0.45)		(0.56)	
TARGET (Inflation-Targeting)		1.31		1.55*
		(0.11)		(0.08)
Constant	-2.06***	-3.11***	-1.89***	-3.07***
	(0.00)	(0.00)	(0.00)	(0.00)
R-squared	0.41	0.43	0.35	0.37

Notes: The growth rates in real GDP (the dependent variable) are measured over the crisis period between Q1-2008 and Q1-2009. Newey-West HAC method is used to correct the heteroskedasticity and autocorrelation, and the associated probabilities are in parentheses. ***, ** and * indicate the significance level at 1%, 5% and 10% respectively. The network measure is calculated by the inverse of the geodesic distance from the US, and is the average for the pre-crisis period over 2001-2007.

We estimate the crisis effect on the growth rate of real GDP by using the Newey-West HAC (heteroskedasticity and autocorrelation consistent) estimator. We also use two alternative measures of network, the eigenvector centrality and the geodesic distance from the US. Table 2 summarizes the results which use the eigenvector centrality measures of the networks, and Table 3 shows the results that use the geodesic distance measures of the networks. The two methods provide almost the same results.

Since the member countries in the Chiang Mai Initiative (CMI) are also included in Asia-Pacific economies (ASIA), we do not put them together at the same time in the estimation process. Since the case of emerging market economies (EME) and countries with inflation targeting system (TARGET) is similar, we also do not put them together at the same time. While ASIA is included in columns (1) (Asia-LATIN-EME) and (2) (Asia-LATIN-TARGET), CMI is included in columns (3) (CMI-LATIN-EME) and (4) (CMI-LATIN-TARGET). Similarly, columns (1) and (3) include EME while columns (2) and (4) include TARGET. In doing so, we can avoid any possible problem that could arise from putting similar variables together. Finally, we do not include the constant and slope dummy variables for Eurozone countries (EURO) since they do not change the results in any significant way.

When we focus on the eigenvector centrality measures of the networks (Table 2), both the trade and the financial networks have significant effects on the growth rate for the whole sample countries. Column (1) shows that the trade network has a significant positive effect on real GDP growth rate. In addition, the interaction term of the trade network and ASIA dummy shows even higher positive effect on real GDP growth rate. Column (3) shows that the same is also true if we replace ASIA with CMI. This result suggests that higher levels of trade linkages increase the allocative efficiency and exert a positive effect on real GDP growth rate.[5] This result also corroborates the result of the network graphical analysis of the

[5] On the contrary, the slope dummies for LATIN reveal significant negative effects on real GDP growth rate even though the trade and financial networks have no effect, as shown in column (2) and (4). This result implies that many Latin American economies are not interconnected in terms of trade and finance but are instead directly linked to the US as shown in Figure 1, thus precluding achievement of allocative efficiency.

previous section.

However, we find significant but opposite signs in the case of the financial network. Column (1) shows that the financial network has a significant negative contagion effect on real GDP growth rate. The negative contagion effect of the financial network becomes even bigger within Asia-Pacific (or CMI) countries. This implies that the financial network plays a negative transmission channel in the propagation of the global financial crisis.

Regarding the country-specific fundamentals, we find that the total reserve/GDP ratio plays a negative effect on real GDP growth rate. The building-up of too much reserve relative to GDP also seems vulnerable to the crisis. The adequacy of international reserve should be investigated in more detail in future research. However, the current account/GDP ratio and the real effective exchange rate (REER) overvaluation ratio are not found to be significant in any form of specification.

Since the United States is the epicenter of the 2008 global financial crisis, we also analyze the effects of networks measured by the inverse of the geodesic distance from the US (Table 3). The results are not very different from those of networks measured by the eigenvector centrality method.

In contrast to Rose and Spiegel (2010, 2012) who find no evidence of relationship between trade (and financial) dependence and 2008 crisis incidence, we can suggest a few important findings by using a new network analysis. Firstly, both the trade and financial networks play an important role in the propagation of the global crisis. Secondly, higher levels of trade network increase the allocative efficiency and lessen the negative contagion effect of the global crisis. Thirdly, the financial network has a negative contagion effect in the propagation of the global crisis. Finally, the absolute level of network effect becomes even bigger especially within Asia-Pacific (or CMI) countries, suggesting that Asia-Pacific region is interconnected efficiently in trade but not in finance.

5. Conclusion

This paper investigates the possible network effects on the propagation of the 2008

global financial crisis. The question arises as to whether or not countries have become more vulnerable to common shocks through the trade and financial networks.

We use a new approach that incorporates the dynamic network approach into econometric analysis in identifying the crisis transmission channels. The main premise of this paper is made by using the following steps. First, we construct the trade and financial networks and provide clear economic linkages among countries. Second, we combine the trade and financial networks with crisis effects on real GDP growth rate. Third, we re-incorporate the measures of network into cross-country regression analysis to identify the network effects.

We find some interesting and important results regarding the network effects on the crisis incidence. First, both the trade and financial networks play an important role in the propagation of the global crisis. Second, higher levels of trade network increase the allocative efficiency and lessen the negative contagion effect of the global financial crisis. Third, the financial network has a negative contagion effect in the propagation of the global financial crisis. Finally, the absolute level of network effect becomes even bigger especially within Asia-Pacific (or CMI) countries, suggesting that Asia-Pacific region is interconnected efficiently in trade but not in finance.

This result implies that the trade network helps countries to demonstrate resilience to impacts of the global crisis, and contributes a less severe impact on real GDP growth rate. On the other hand, the financial network contributes a negative contagion effect on real GDP growth rate. This result also corroborates the result of the network graphical analysis of the previous section.

Regarding the country-specific fundamentals, we find that only the total reserve/GDP ratio plays a negative effect on real GDP growth rate. The adequacy problem of international reserve should be investigated in more detail in future research.

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