Trade Linkages and Crisis Spillovers*

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Abstract
Many empirical studies find little evidence to support trade linkages as a channel for crisis spillovers during the 2008–09 global financial crisis, although trade linkages were one of the most important crisis transmission channels during 1971–97. A reason that may explain why trade linkages play a less important role in recent years is the changing composition of trade. In particular, the increasing formation of international production networks implies that trade increasingly involves indirect trade linkages. As a result, direct trade statistics may fail to accurately to capture the total trade exposure. In our study, we estimate total trade linkages by including indirect trade linkages obtained from the construction of a trade matrix. When we account for indirect trade linkages, we find that export dependency on the U.S. market still helps to explain crisis severity for developed countries.

1. Introduction

The sub-prime crisis that originated in the United States in 2008 initiated a financial crisis that spread globally, and has been deemed the worst financial catastrophe since the Great Depression. Indeed, due to strong financial and economic linkages between the United States and many countries all over the world, as well as the relatively large size of the U.S. economy, the U.S. sub-prime crisis was transmitted worldwide. One feature of the downturn was a sharp contraction in global trade. Many presume that trade linkages provide the most important transmission channel of the sub-prime crisis to many developing countries.

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Surprisingly, recent empirical studies of the 2008–09 global financial crisis (GFC) find little evidence to support trade linkages as a channel for crisis spillovers. Rose and Spiegel (2011) show that the countries with high export dependence on the U.S. market experienced significantly less severe crises than did other countries when they use the level of export dependency on the U.S. destination as an explanatory variable for crisis transmission. This result implies that trade linkages with the U.S. market played no role or a mitigating role in crisis transmission. Similarly, Berkmen et al. (2012) do not find evidence that trade channels were an important crisis transmission channel for emerging markets during the sub-prime crisis. In fact, when their the study includes interaction terms between the share of exporting manufacturing goods to those shipped to advanced economies and a dummy for emerging markets to explain crisis severity, the negative coefficient on the interaction term yields an opposite-sign (negative) coefficient in explaining crisis severity. Similarly, the economic analysis of Berkmen et al. is unable to find statistically significant evidence linking the degree of trade openness with the transmission of the sub-prime crisis to emerging markets. The lack of connection is also noted by Blanchard, Das, and Faruqee (2010), as their study does not find a connection between country export to GDP ratios and country GDP growth disruption during the GFC.

Apart from trade dependency, the international trade literature points out that both geographical and commodity trade concentrations are considered to be important factors that may amplify the effect of crisis transmission via an international trade channel. Da Costa Neto and Romeu (2011) consider the impact of export, destination, and intra-industry concentration on export performance of Latin American countries during the sub-prime crisis using a gravity model and finds that export concentration significantly amplifies trade collapse during the crisis whereas destination concentration insignificantly helps relieve the impact of crisis spillovers on trade.

The general message of recent work on the transmission of the sub-prime crisis is that it cannot be explained by the degree of openness, trade dependency on the U.S. market, or export destination concentration. In short, trade linkages have not been implicated as important transmission channels of the GFC. In contrast, the empirical studies explaining the causes of crises during 1971–97 find that trade linkages are one of the most important crisis transmission channels. Eichengreen, Rose, and Wyplosz (1997) and Glick and Rose (1999) find that international trade is one of the most important explanations of crisis transmission in the years from 1971 to 1997. In fact, many empirical studies during the 1990s concluded that the financial crises during 1971–97 tended to be regional phenomena because trade linkages were among the major transmission channels. Kali and Reyes (2005) also find that the

country that is a center of trade network experiences more severe effects from the crisis. Perry and Lederman (1998) studied the crisis transmission via international trade and found that demand contraction and substitution effect played an important role in the spillover of the crisis from one country to another when the originator's counterparts were export-dependent. Demand contraction in the country experiencing the crisis leads to a decrease in imports and affects its trading partners' current account, especially when those partners are export-oriented. In addition, the crisis may lead to currency depreciation in a country where the crisis originates, because that country will experience a drop in domestic demand. In turn, as the crisis country's depreciation makes its exports cheaper, competitors in other countries encounter export demand as substitution effects shift purchases towards the crisis country's products. As a result, the crisis country's competitors may face transmission of crisis via the mentioned demand contraction.

The major puzzle in this paper is to explain why trade linkages, whether measured by trade dependency with a crisis originator or export destination concentration, seem to have been much less important in helping to transmit the recent sub-prime crisis. Due to recent changes in composition of trade, it is possible that the change in influence may stem from the changing nature of trade linkages. Thanks to the emergence and growth of international production networks in many regions, including East Asia, many crisis effects transmitted by trade will be transmitted indirectly. For example, a substantial share of industrial production in East Asia, in products such as automobiles and parts, computers and parts, and electronic and electrical appliances, are in form of the international production networks (IPN), where production is fragmented into several stages, each of which is located in different countries, according to the countries' comparative advantages. As a result, a fall in demand for final goods in the crisis originator also results in a drop in the export of parts and components (or indirect trade) via the IPN channel.

As indirect trade linkages increase in importance, analyses that are based solely on direct trade statistics will provide an increasingly incomplete view of international trade linkages. Countries that have a low level of direct trade dependency with the United States may actually have high trade exposure if indirect trade linkages are included. As a result, our study tries to bridge this gap by recalculating trade dependency and export destination concentration using trade measures that include indirect trade linkages.

A few other studies including Sato and Shrestha (2012) have sought to measure the transmission of the financial crisis to other countries and the dispersion when indirect trade linkages are added to the analysis. In this work the authors build a com-

prehensive Global Input–Output (GIO) system that tracks the transmission of shocks via international supply chain linkages. Due to the input–output setup, results from the GIO represent "pure" effects stemming from production linkages. Similarly, Cheewatrakoolpong and Manprasert (2012) also use the GTAP framework to capture both direct and indirect trade linkages and their roles in crisis transmission in case of Thailand. Their study shows that Thailand still has high trade exposure with the G3 economies when indirect trade is included. Their results show that indirect trade channels were more important than direct trade channels in the transmission of the sub-prime crisis from the G3 economies to Thailand.

To our knowledge, however, there are no studies that consider whether trade dependency and export destination concentration are explanatory factors of crisis spillovers when indirect trade linkages are included. This is due to the fact that previous studies used trade statistics that capture only direct trade linkages to measure the level of trade dependency and export destination concentration.

As a result, our study will consider whether trade dependency with a crisis originator (namely, the United States) and export destination concentration play a role as important crisis transmission channels when indirect trade linkages are taken into account. To do so, we will first calculate total trade exposure that accounts for both direct and indirect trade linkages. The indirect trade linkages will be measured by the construction of an "international trade matrix" using data from the GTAP and UN COMTRADE to measure indirect trade linkages. Then we will utilize cross-country regressions to see whether trade dependency with a crisis originator and export destination concentration help explain crisis transmission.

The paper will proceed as follows. Section 2 explains the conceptual framework and methodology. Section 3 provides the pattern of trade linkages when indirect trade is included. Section 4 portrays the results of the study, and Section 5 concludes.

2. Methodology

The analysis in this study is divided into three parts: i) the computation of the trade matrix to measure indirect trade linkages; ii) the measurement of trade concentration; and iii) the use of cross-country regression to examine how the sub-prime crisis was transmitted.

2.1 Calculation of the total trade linkages

International trade linkages may go beyond those that are reported in bilateral statistics, because international trade transactions among trading countries may be

both directly and indirectly linked. For example, indirect trade linkages arise when ASEAN exports computer parts to China, which are used as intermediate inputs for computer notebooks and are assembled in China and re-exported to the United States. In such a case, ASEAN computer parts are "indirectly linked" to the United States (through China). To overcome the distortion arising from reported statistics, the Bank for International Settlements (BIS) (2007) tried to measure total trade linkages through both direct and indirect channels. To do so, indirect exposure was calculated by multiplying export shares for each segment of the bilateral trades. For example, an estimate of the indirect exposure of ASEAN exports to the United States through China can be calculated by multiplying the export share of ASEAN exports to China by the export share of China to the United States. The BIS results reveal that "a significant proportion of China's imports were accounted for by production inputs, particularly for the export sector. About 70 percent of Chinese imports consist of intermediate goods, and 57 percent of these goods come from emerging Asia and Japan. At the same time, consumption and capital goods make up 72 percent of Chinese exports to the United States and 68 percent of those to the European Union" (BIS 2007, 53). Although the BIS calculation highlights the importance of international trade linkage measurements, the study examined only two legs of the linkages.

Another attempt to measure real connection between trading partners was done by Koopman, Wang, and Wei (2008), who proposed a general framework for the assessment of "value-added exports." Because imports of intermediate goods are usually exempt from taxation when used in export-oriented production processing trade, processing trade data can be combined with international trade data to impute value-added export figures for a given country. It is worth noting that this method can only be applied in cases where the operation of tariff-favored production networks provides additional insight into the production process. When the method was applied to Chinese data the results showed that the share of domestic content for exported manufacturing products increased continuously during the first five years of China's WTO membership. The analysis also showed that high-tech industries were more likely to have high shares of imported content than was the case for labor intensive production activities such as textiles and clothing.

Work by Johnson and Noguera (2009) derives a "VAX ratio"—which refers to the ratio of value-added exports to gross exports—that attempts to measure the size of trade connections through infinite legs of relationships. The generation of this measure uses the GTAP 6.0 Data Base along with input–output techniques, which account for the infinite segment of indirect linkages. The ratio can be interpreted as a level of vertical specialization. More important, this work shows that the real value-added of an export may differ significantly from reported gross export due to the

activities of international production networks. On average, value-added exports were 27 percent lower than gross exports. The larger values of value-added to export ratio were found in the agricultural, natural resources, and services sectors. In contrast, manufacturing has lower VAX ratios. Finally, high-income countries often have lower ratios of value-added to gross export than do lower-income countries.

Recently Sato and Shrestha (2012) constructed a comprehensive GIO system and used it to measure the effects caused by external shocks to domestic country and the dispersion through global supply chain network. The GIO has details on 35 producing sectors, where 27 countries are endogenous to the system and the remaining 65 countries are exogenous. The table was applied to examine effects of negative import demand shock from the United States to Japan. They found that a high level of domestic content for export-oriented activities could lead Japan to be severely affected by a decline in external shocks.

In this paper, we proposed a simple algorithm that allows us to compute the "total" trade linkages for 129 countries and regions that are based on the complete set of global trade transactions for a given year. In contrast with the input–output tables produced by the Institute of Developing Economies-Japan External Trade Organization and the GIO from Sato and Shrestha (2012), the trade matrix used in this study is based on aggregate trade data that encompass all global transactions rather than a subset limited to certain countries or regions. Because we use data from the GTAP 8.0 Data Base, all 129 countries in our analysis are treated as endogenous actors in global trade transactions. By adopting the input–output technique, our results deliver measures that are based on the infinite sum of indirect trade relationship between countries.

Let matrix T consists of international trade transactions among countries in the world. Each element of T_{ij} refers to bilateral export from country i to country j. Thus the row sum of T_{ij} captures the total export of country II, which we define as E_i. On the other hand, the column sum of T_{ij}'s yields the total import by country j, which we denote by the matrix S, consisting of elements s_{ij}. In world equilibrium, total world exports equals total world imports.

$$\Sigma M_j = \Sigma E_i \tag{1}$$

For each country, produced goods are used to meet domestic final consumption and by export demands. Let A be a diagonal matrix containing ratios of domestic final good demand relative to total production available in a country.

$$A = \begin{bmatrix} a_{11} & 0 & 0 & 0 \\ 0 & a_{ii} & 0 & 0 \\ 0 & 0 & \ddots & 0 \\ 0 & 0 & 0 & a_{mm} \end{bmatrix}$$

In this matrix, the elements a_{ii} represent the proportion of domestic final use to total demands of the country i. Therefore, each country imports goods for consumption and re-exports according to proportions of a_{ii} and $(1 - a_{ii})$, respectively. We define the total trade linkages (l_j) to be equal to direct linkages (d_j) plus indirect linkages (i_j),

$$l_j = d_j + i_j \tag{2}$$

Now, let $s_{ij} = T_{ij}/E_i$, which refers to the export share of country i to j. By design, total indirect imports of country j must be equal to the sum of all re-exports from other countries to j. Therefore,

$$i_j = \sum_i l_i(1 - a_{ii})s_{ij} \tag{3}$$

In this formula the term $(1 - a_{ii})s_{ij}$ on the right-hand side of equation (3) refers to the re-export share of i to j. Thus, $l_j(1 - a_{ii})s_{ij}$ is the total re-export value from i to j, and the summation adds up to all other countries' re-exports to j. Therefore, equation (3) can be rewritten as:

$$l_j - d_j = \sum_n l_i(1 - a_{ii})s_{ij} \tag{4}$$

The left-hand side of equation (4) refers to indirect imports of country j and the right-hand side represents the sum of all re-exports from all other countries to j. While the creation of this trade measure implies that re-export value is proportional to indirect trade linkages, the absence of data on inputs used for export, outside of cases such documentation of processing trade activities as in Koopman, Wang, and Wei (2008), requires us to make this proportionality assumption. For simplicity, consider a world economy consisting of three countries trading to each other. Equation (4) could be written in matrix terms as:

$$\begin{bmatrix} l_1 \\ l_2 \\ l_3 \end{bmatrix}^T - \begin{bmatrix} d_1 \\ d_2 \\ d_3 \end{bmatrix}^T = \begin{bmatrix} l_1 \\ l_2 \\ l_3 \end{bmatrix}^T \begin{bmatrix} 1 - a_{11} & 0 & 0 \\ 0 & 1 - a_{22} & 0 \\ 0 & 0 & 1 - a_{33} \end{bmatrix} \begin{bmatrix} s_{11} & s_{12} & s_{13} \\ s_{21} & s_{22} & s_{23} \\ s_{31} & s_{32} & s_{33} \end{bmatrix} \tag{5}$$

Therefore, we can write:

$$L - D = L(I - A)S \tag{6}$$

where L is a row vector of l_j, D is a row vector of d_j, A and S are the domestic final consumption share and export share matrices defined earlier. For simplicity, define:

$$Q = (I - A)S \tag{7}$$

Total linkages, in terms of direct linkages and the re-export share, can be given as the following equation:

$$L = D(I - Q)^{-1}$$

$$\text{or } L = D + DQ + DQ^2 + DQ^3 + \ldots \tag{8}$$

where D is direct linkages

DQ are the linkages from first round re-export

DQ^2 are the linkages from second round re-exports, and so on.

From equation (8), the calculation of trade linkages follows the input–output model convention that total linkages between two countries are equal to direct transactions plus infinite indirect activities.[1]

To calculate total linkages according to above method, we used data from two different sources. Bilateral trade transactions between each pair of 129 countries were obtained from the United Nations Comtrade. These trade transactions are used to form the vector D and matrix S. Elements in matrix A were obtained from GTAP Version 8.0 coefficients. Table 1 summarizes the list of GTAP variables used in the calculation.

2.2 Measurement of trade concentration

This study follows the previous literature such as Hesse (2008) and Da Costa Neto and Romeu (2011) in utilizing the standard Herfindahl index to identify the level of trade concentration. Meilak (2011) and Samen (2010) review several concentration ratios used to measure export concentration and find that the Hirschman

1 Miller and Blair (1985) provide further background on input–output analysis.

Table 1. GTAP coefficients used in the calculation of matrix *A*

VDPA(*n*, *i*)	private consumption expenditure on domestic sector *n* in country *i*
VIPA(*n*, *i*)	private consumption expenditure on imported sector *n* in country *i*
VDGA(*n*, *i*)	government consumption expenditure on domestic sector *n* in country *i*
VIGA(*n*, *i*)	government consumption expenditure on imported sector *i*
VXWD(*n*, *i*, *j*)	exports of sector *n* from country *i* to country *j* valued FOB

$$a_{ii} = \frac{\sum_n VDPA(n,i) + \sum_n VIPA(n,i) + \sum_n VDGA(n,i) + \sum_n VIGA(n,i)}{\sum_n VDPA(n,i) + \sum_n VIPA(n,i) + \sum_n VDGA(n,i) + \sum_n VIGA(n,i) + \sum_{n,j} VXWD(n,i,j)}$$

index[2] and the Herfindahl index are the most widely used measurements of destination concentration and export (or commodity) concentration. Meilak (2008) explains that the Herfindahl index is the simplest and is friendly with data availability. Also, it also captures relative size variation among sectors. Meilak (2011) portrays three desirable features one would like to find in concentration measures, and shows that only the Herfindahl index and the Hannah and Key index possess these properties. As a result, we use the Herfindahl index for the measurement of export destination concentration and export sector concentration.

A total of 129 destinations are included in the calculations. The destination Herfindahl index for country j at time t is given by:

$$H_t^j = \sum_{i=1}^{129} s_i^2 \tag{9}$$

where s_i^2 is the share of the exports from the country j to the country i.

2.3 Causes of crisis

To identify the channels for crisis spillovers, we follow the approach of Rose and Spiegel (2011), Berkmen et al. (2012), and Blanchard et al. (2010), which means using cross-country regressions to investigate the causes of differences in country crisis severity (or output impact) from the GFC.

Some studies such as Rose and Spiegel (2009) use real GDP growth over 2008–09 to measure crisis severity. Rose and Spiegel (2011), however, argue that such a measure does not capture underlying growth trends. Therefore, our study follows Blanchard, Das, and Faruqee (2010) and Lane and Milesi-Ferretti (2011) in using the real GDP growth difference between 2008–09 and 2005–07 instead.

2 The Hirschman index is similar to the Herfindahl index. It is the square root of the Herfindahl index.

Berkmen et al. (2012) suggest that crisis transmission may follow four groups, namely, i) trade linkages, ii) financial linkages, iii) vulnerabilities, and iv) policy frameworks. The important measures for trade linkages according to Rose and Spiegel (2011), Da Costa Neto and Romeu (2011), and Blanchard et al. (2010) are the degree of openness, the share of export to GDP, the share of export to the U.S. market, commodity composition, export sector concentration, and export destination concentration. All of the mentioned studies find that trade linkages were not a significant spillover channel for the sub-prime crisis. According to Da Costa Neto and Romeu (2011) and Berkmen et al. (2012), only export composition matters; export sector concentration could significantly lessen crisis severity.

For financial linkages or financial measures, the previously mentioned studies use short-term external debt, total foreign debt, short-term foreign debt, and lending from advanced economies as important indicators. Blanchard et al. (2010) notes that short-term external debt significantly explains the incidence of crisis.

The measures of economic vulnerabilities are measured by growth in bank credit, credit-to-deposit ratio, house price appreciation, the ratio of current account to GDP, and public debt as a share of GDP. Claessens et al. (2010) find that house price appreciation, bank credit growth, and the magnitude of current account significantly explain the crisis spillovers. Similarly, Rose and Spiegel (2011) and Lane and Milesi-Ferrertti (2011) uncover a connection between of the current account and the severity of crisis transmission.

On the policy dimension, Berkmen et al. (2012) suggest that exchange-rate policy regime can affect the severity of crisis. More flexible exchange rates may help to buffer the external shocks. In addition, credit market regulation is another important policy factor that explains the incidence of crisis. Giannone Lenza, and Reichlin (2010) and Rose and Spiegel (2011) find that the countries with more liberal credit market regulation suffered more from the financial crisis.

In our study, we model the channels of transmission as follows. To measure crisis severity, we focused on the difference between 2008–09 and 2005–07 real GDP growth. In choosing explanatory variables, we follow Berkmen et al. (2012) and divide transmission channels into their four previously mentioned categories, namely, trade linkages, financial linkages, vulnerabilities, and policy framework. Since Rose and Spiegel (2011) note that the 2007 values of variables might already be contaminated by the subprime crisis, we follow their decision to use 2006 values for all explanatory variables in the regressions. Our explanatory variables are as follows.

i) Trade linkages

To measure trade linkages, we follow Spiegel (2011) and Da Costa Neto and Romeu (2011) using trade dependency on the U.S. market, measured by a fraction of exports to the United States to the total exports, and export destination concentration as explanatory variables. Export concentration is included to enable us to test whether trade diversification lessens crisis severity. In contrast with the previous literature, when we generate our measures of trade dependency and export destination concentration our study includes indirect trade linkages using in addition to the commonly included direct trade statistics. Our calculation of total trade linkages follows the method described in Section 2.1. Due to the importance of this measure, we portray patterns of trade linkages in the next section.

ii) Financial linkages

Following Blanchard et al. (2010), we use a fraction of short-term external debt to GDP as our explanatory variable for financial linkages, since short-term debt is more sensitive to crisis than long-term debt.

iii) Vulnerabilities

To measure economic vulnerabilities we follow Claessens et al. (2010) and Rose and Spiegel (2011) using house price appreciation, the ratio of current account, and bank credit growth.

iv) Policy framework

Because many countries adopted a flexible exchange rate regime after the 1997–98 Asian financial crisis, we only credit market regulation as our measure of policy.

3. Pattern of trade linkages

To examine the pattern of trade linkages obtained from our calculation, we used the L_1 norm, namely, the Manhattan norm, to calculate distance between vectors of reported bilateral trade figures and the calculated total linkages. For each exporting country i, the L_1 distance between a vector of bilateral and a vector of total linkages, $||x_i||_1$, could be written as:

$$||x_i||_1 = \sum_j |total_{ij} - direct_{ij}| \tag{10}$$

Table 2. Proportion (%) of indirect trade transactions in international trade

	2000	2004	2008	2009	2010	2011	2000–11
World	**11.8**	**12.2**	**12.6**	**12.6**	**12.8**	**13.0**	**1.1**
Albania	19.7	20.9	22.5	20.2	18.4	18.4	−1.3
Argentina	11.7	13.0	12.4	12.3	12.2	12.1	0.4
Armenia	23.3	18.8	18.0	17.2	18.6	19.2	−4.1
Australia	12.6	12.1	13.1	14.0	14.6	14.8	2.2
Austria	13.6	13.1	12.4	12.9	13.0	13.0	−0.6
Azerbaijan	18.3	21.3	15.3	17.2	18.1	17.6	−0.8
Bahrain	22.4	22.7	22.8	23.0	23.9	27.0	4.6
Bangladesh	7.2	7.3	6.5	6.6	6.7	7.2	0.1
Belarus	19.4	16.9	18.2	18.6	17.7	18.6	−0.8
Belgium	9.3	10.0	10.1	9.9	9.7	9.7	0.4
Bolivia, Plurinational Republic of	13.7	13.2	15.0	15.2	14.5	13.9	0.2
Botswana	22.6	20.9	20.5	20.7	21.2	20.8	−1.8
Brazil	7.8	9.3	10.3	11.2	11.7	11.7	3.9
Bulgaria	11.1	10.6	10.3	10.6	10.0	10.4	−0.7
Cambodia	11.7	12.8	13.5	21.5	18.1	14.7	3.0
Cameroon	18.1	15.1	16.9	18.1	18.3	18.8	0.8
Canada	8.8	8.4	7.7	7.3	7.6	7.6	−1.2
Caribbean	7.4	8.8	9.6	9.3	9.3	9.7	2.3
Central Africa	10.7	13.3	13.7	14.4	20.2	23.1	12.5
Chile	9.1	10.1	11.7	12.9	13.3	12.5	3.4
China	12.4	12.4	11.7	11.8	11.2	11.4	−1.0
Colombia	7.4	8.2	9.7	10.3	8.9	9.0	1.6
Costa Rica	8.1	8.1	9.4	10.5	10.0	10.1	2.0
Cote d'Ivoire	13.2	14.6	13.7	14.1	14.6	15.1	1.9
Croatia	15.2	15.2	14.2	14.0	15.0	14.7	−0.5
Cyprus	16.4	13.9	13.6	14.2	14.1	14.1	−2.3
Czech Republic	15.8	14.5	13.2	13.4	13.3	13.4	−2.4
Denmark	12.0	11.3	11.1	11.1	11.2	11.1	−0.8
Ecuador	10.1	10.0	11.0	11.5	10.8	11.2	1.2
Egypt	14.3	14.3	14.1	14.5	14.0	13.7	−0.6
El Salvador	20.5	20.7	9.6	9.6	9.3	9.8	−10.7
Estonia	18.1	17.6	16.3	16.8	16.8	16.2	−1.9
Ethiopia	17.2	15.7	15.9	17.0	18.1	16.7	−0.5
Finland	8.8	10.3	9.7	9.2	10.0	10.2	1.4
France	9.4	9.8	9.6	9.9	10.2	10.3	0.9
Georgia	18.5	19.2	19.9	20.2	18.3	20.7	2.1
Germany	9.7	9.6	9.8	10.2	10.3	10.4	0.7
Ghana	17.1	18.4	19.5	21.4	21.2	16.9	−0.2
0Greece	10.0	9.5	9.5	9.9	9.8	11.1	1.1
Guatemala	10.1	12.4	9.9	9.4	9.4	8.8	−1.3
Honduras	9.5	9.3	8.1	9.1	7.7	7.9	−1.6
Hong Kong	14.6	16.9	18.6	18.8	19.3	20.0	5.4
Hungary	14.1	12.7	12.1	11.4	11.7	12.6	−1.4
India	11.0	12.6	13.5	12.5	13.0	12.7	1.7
Indonesia	12.3	12.5	12.8	13.1	12.9	13.0	0.7
Iran, Islamic Republic of	21.0	19.9	16.5	16.6	27.9	29.0	8.0
Ireland	7.8	9.6	9.7	10.1	9.9	9.5	1.7
Israel	8.3	8.5	20.8	9.2	8.9	9.2	0.9
Italy	7.7	7.8	8.1	8.0	8.1	8.2	0.5
Japan	12.4	12.9	13.3	14.1	13.9	13.4	1.1
Kazakhstan	18.2	19.7	18.3	17.1	17.1	18.5	0.2
Kenya	14.1	15.2	15.5	15.6	15.6	14.1	0.0
Korea Republic of	10.9	12.3	13.9	14.2	13.6	13.3	2.3
Kuwait	25.2	24.7	24.1	24.0	15.3	15.5	−9.7
Kyrgyzstan	24.0	27.0	26.7	30.1	27.3	30.8	6.8
Lao People's Democratic Republic	24.9	23.2	29.5	29.2	30.9	31.0	6.1
Latvia	14.8	14.0	14.9	15.4	15.2	15.1	0.3
Lithuania	12.5	12.5	12.7	13.0	13.5	13.5	1.0
Luxembourg	11.3	11.7	12.2	12.4	12.8	12.8	1.5
Madagascar	14.2	11.8	12.6	11.6	13.7	15.3	1.1
Malawi	12.3	12.0	15.8	18.3	16.5	15.0	2.6
Malaysia	15.7	14.5	13.8	14.1	13.4	12.7	−3.0
Malta	15.1	15.9	16.1	16.6	17.5	15.6	0.4
Mauritius	10.4	11.8	13.9	12.8	12.2	13.0	2.6
Mexico	9.0	9.4	8.5	8.3	8.3	8.3	−0.7
Mongolia	23.4	20.3	28.5	30.6	30.8	31.1	7.7

Table 2. ***(Continued)***

	2000	2004	2008	2009	2010	2011	2000–11
Morocco	10.8	11.1	11.7	11.6	11.3	11.4	0.6
Mozambique	20.1	26.6	24.9	22.3	25.6	22.5	2.3
Namibia	18.1	17.5	18.5	14.4	14.0	17.6	−0.5
Nepal	13.5	12.7	15.2	15.3	15.9	15.9	2.4
Netherlands	11.0	10.6	10.9	10.9	11.1	11.4	0.4
New Zealand	9.4	9.1	10.9	10.3	10.4	10.6	1.1
Nicaragua	9.7	9.2	10.1	11.3	11.2	11.9	2.2
Nigeria	10.6	10.5	10.1	11.1	10.7	10.7	0.1
Norway	11.1	11.1	11.3	11.2	11.6	11.4	0.3
Oman	21.8	21.8	20.6	17.1	21.8	18.4	−3.4
Pakistan	8.9	9.6	11.0	10.5	10.3	10.2	1.4
Panama	13.1	11.7	15.6	13.9	15.1	13.9	0.8
Paraguay	14.6	15.6	15.6	16.3	16.8	14.5	0.0
Peru	9.8	9.3	13.4	15.1	14.2	15.3	5.5
Philippines	13.9	15.0	14.0	14.6	15.1	13.1	−0.8
Poland	13.7	12.8	11.9	11.6	11.8	12.0	−1.7
Portugal	10.0	12.3	12.8	12.0	11.8	12.2	2.2
Qatar	19.9	18.7	21.8	19.3	18.4	17.2	−2.7
Rest of Central America	12.5	12.8	25.7	25.9	12.2	17.6	5.1
Rest of East Asia	8.6	10.2	13.1	19.5	21.1	26.1	17.6
Rest of Eastern Africa	22.0	26.0	28.0	27.3	24.3	29.2	7.2
Rest of Eastern Europe	16.7	16.9	15.5	15.1	15.2	16.3	−0.4
Rest of EFTA	11.2	12.0	14.4	14.6	14.8	15.1	3.9
Rest of Europe	12.0	11.7	13.4	13.3	14.1	14.6	2.6
Rest of Former Soviet Union	21.2	18.6	17.8	17.9	19.8	22.4	1.2
Rest of North Africa	11.3	11.1	11.1	10.9	11.3	10.8	−0.5
Rest of North America	25.7	25.9	25.4	21.9	21.9	20.1	−5.6
Rest of Oceania	19.2	14.6	14.8	12.3	16.2	14.4	−4.8
Rest of S.African Customs Union	17.4	18.5	21.4	16.2	14.3	16.5	−0.9
Rest of South America	17.8	19.4	20.6	19.8	20.1	21.0	3.2
Rest of South Asia	13.9	20.7	19.2	22.4	19.6	19.4	5.4
Rest of Southeast Asia	15.6	16.7	18.9	18.5	28.5	17.0	1.4
Rest of the World	21.5	22.3	25.2	27.4	28.1	24.2	2.8
Rest of Western Africa	14.6	15.4	17.2	18.2	20.3	21.1	6.4
Rest of Western Asia	20.0	17.7	16.8	17.2	14.5	18.9	−1.1
Romania	11.1	10.2	10.9	10.8	10.5	11.1	0.0
Russian Federation	13.2	14.3	13.4	13.1	13.3	14.7	1.5
Saudi Arabia	19.6	21.3	19.7	21.4	21.0	20.1	0.5
Senegal	14.7	16.6	18.3	17.2	18.7	18.2	3.5
Singapore	18.6	16.9	17.3	17.3	17.1	17.0	−1.6
Slovakia	15.6	15.3	12.8	13.3	13.5	14.0	−1.6
Slovenia	13.6	12.5	12.0	12.1	11.9	12.3	−1.2
South Africa	13.7	12.8	10.9	11.6	11.5	12.9	−0.8
South Central Africa	16.5	18.4	15.7	17.8	19.3	18.5	2.0
Spain	8.1	8.3	8.1	8.6	8.7	8.6	0.5
Sri Lanka	7.8	8.3	8.5	9.0	9.2	10.3	2.5
Sweden	9.0	9.3	10.0	9.9	10.0	10.4	1.3
Switzerland	8.0	8.0	7.9	7.7	7.9	8.8	0.7
Taiwan	11.8	15.2	16.6	16.5	16.6	16.9	5.1
Tanzania United Republic of	12.3	14.5	18.3	18.3	19.2	19.4	7.1
Thailand	11.5	11.8	12.3	12.5	12.3	12.5	1.0
Tunisia	13.2	13.3	12.9	13.9	13.0	14.0	0.8
Turkey	10.3	10.2	12.1	12.3	12.4	12.8	2.6
Uganda	20.0	20.6	19.8	18.1	18.2	18.8	−1.2
Ukraine	15.0	13.9	15.7	15.6	15.7	16.0	1.0
United Arab Emirates	23.0	22.6	23.3	23.4	27.0	27.6	4.7
United Kingdom	9.8	9.8	10.3	9.9	9.9	9.8	0.1
United States of America	14.2	14.1	13.0	12.8	12.8	12.7	−1.5
Uruguay	11.2	9.7	12.2	12.0	13.1	13.4	2.2
Venezuela	9.3	10.4	15.0	25.2	25.3	26.7	17.4
Viet Nam	13.5	10.8	9.8	10.1	9.2	8.5	−5.0
Zambia	21.3	22.0	28.0	28.2	30.2	28.9	7.6
Zimbabwe	15.7	16.7	20.2	20.9	20.7	22.2	6.5

Source: *Authors' calculations.*

Where $total_{ij}$ is our calculated value of total linkages from i to j, and $direct_{ij}$ is the bilateral export from i to j. The right-hand side of equation (10) implies that we sum all indirect transactions between country i and other countries. The summation double-counts transactions, however, because indirect trades appear on both sides—for both exporter and importer. In other words, indirect exports from country i to j will be the indirect imports of country j from i. To arrive at a more intuitive indicator, we computed the value $||x_i||_1/2$ to represent the proportion of indirect transactions that involve in country i exports. Table 2 displays the calculated values of $||x_i||_1/2$ for all 129 countries over the period 2000–11.

On average, the world's indirect trade transactions have been increasing over time—from 11.8 percent of the total trade transactions in 2000 to 13.0 percent in 2011. This provides evidence that production-sharing activities have grown in importance over the past decade. Of the 129 countries, there are 76 countries where the proportion of indirect trade exceeds the world's average, and the other 50 countries have a lower proportion. For example, large shares of indirect trades are found in Mongolia, Lao PDR, Kyrgyzstan, Iran, and Zambia. For these countries, the indirect transactions involve as much as 30 percent of their international trade activities. On the other hand, countries like Bangladesh, Canada, Honduras, Italy, and Mexico have only small indirect transactions with the proportions well below 10 percent. The largest growth in indirect activities during 2000–11 were recorded in Venezuela, Iran, Mongolia, and Zambia.

4. Results

In this section we use regression analysis to search for insights into the international transmission crisis.

4.1 Data description and descriptive statistics

Our study uses country-level data on 108 countries:[3] 33 developed countries and 75 developing countries.[4] The limitation comes from the data of house price appreciation that we could collect only for 35 countries. Our dependent variable, data on country GDP growth, is obtained from the World Bank. To give information on our

3 We use data from the World Bank's database, composed of 214 countries. Some countries, however, have missing data in some categories such as the short-term external debt. Also, only 127 countries have public debt data. As a result, 108 countries is the largest panel data set we can use in our regression.

4 This list of countries follows the World Bank's World Development Indicators database with deduction of the countries with missing data. Our developed countries here are listed following the definition of IMF's advanced economies.

Table 3. Descriptive statistics of variables in the model

Variable	No. of observations	Mean	Std. Dev.	Min	Max
Growth difference (%)	108	−4.33022	4.260868	−22.0365	3.318626
Trade dependency, direct (%)	108	0.131501	0.165912	0	0.848658
Trade dependency, total (%)	108	0.153346	0.149439	0.012439	0.766414
Export concentration, direct (%)	108	0.157809	0.149672	0.045986	0.901686
Export concentration, total (%)	108	0.118635	0.10003	0.041025	0.589822
Public debt/GDP (%)	108	0.4206	0.015576	−3.924	7.5335
Credit market regulation (%)	104	8.567202	1.005234	5.0982	10
Current account/GDP (%)	109	0.438073	10.02169	−22.6817	44.61526
ST external debt / GDP (%)	109	5.347162	4.634809	0	11.23899
Bank credit growth (%)	109	12.97766	14.33622	−36.5489	64.02757
House price appreciation (%)	35	10.3904	14.20482	−19.0998	65.18899

Source: *Authors' calculations.*

Table 4. Correlations of variables in the model

Explanatory variables	Correlations with growth difference
Trade dependency, direct	0.0323
Trade dependency, total	0.0451
Export concentration, direct	0.0668
Export concentration, total	0.0612
Public debt/GDP	−0.0492
Credit market regulation	−0.3148
Current account/GDP	0.0921
ST external debt / GDP	0.0314
Bank credit growth	−0.4438
House price appreciation	−0.6621

Source: *Authors' calculations.*

data set, Table 3 shows the average, standard deviation, minimum and maximum of each variable. Variable correlations with our dependent variable—growth difference—are shown in Table 4. The highest correlation comes from house price appreciation at –0.66, implying that bubble prices in housing sector may aggravate crisis severity. Other notably explanatory variables with high correlations are the growth of bank credit to private sector and credit market regulation.

4.2 Regression results

This section reports the results from our estimation. To provide a comparison with the earlier literature on this topic, Table 5 displays the regression results for our project when we limit our measure of trade linkages to the common variable that is calculated using direct trade statistics alone. The results in Table 5 are in line with the previous literature, because we find that trade linkages, both as a fraction of export to the U.S. market and export destination concentration, play no role in explaining the severity of spillovers from the subprime crisis. In comparison, export destination concentration has more impact on crisis incidence than dependency on the U.S. market.

Table 5. Regression results when using direct trade linkages

Variables	1	2	3
Export dependency on U.S., direct linkages	0.908 (0.499)	−0.68 (3.116)	1.075 (0.219)
Export concentration, direct linkages	2.589 (0.327)	−0.558 (0.319)	2.388* (0.111)
Export dependency × dummy DC			−2.837 (0.252)
Export concentration × dummy DC			3.986 (0.656)
Credit market regulation	−1.187* (0.067)	−0.766 (1.082)	−1.196* (0.0534)
Dummy of being developed countries	−2.457* (0.112)	0.94 (0.342)	−2.619** (0.0177)
Current account/GDP	−0.00181 (0.00944)	0.0383 (0.00628)	−0.000723 (0.0112)
Short-term external debt/GDP	−0.211 (0.0226)	0.264* (0.0166)	−0.216* (0.0131)
Bank credit growth	−0.132 (0.0124)	−0.0835 (0.0284)	−0.133 (0.0133)
Public debt/GDP	−0.160* (0.0078)	−0.648 (0.0853)	−15.51 (1.518)
House price appreciation		−0.142 (0.035)	
Constant	8.942* (0.566)	2.978 (9.308)	9.070* (0.331)
Observations R-squared	102 0.321	35 0.632	102 0.321

Source: *Authors' calculations.*

Note: *Robust standard errors in parentheses.*

***Statistically significant at the 1% level; *statistically significant at the 5% level.*

After running our initial specification, we augment our regression with a developed country dummy variable, which is interacted with the trade exposure measures. Such a modification is relevant if the transmission of crisis differed for developed and developing countries. The new regression result is shown in model 3 of Table 5. We find that trade concentration may have a role in crisis severity when we separate trade linkages between developed countries and developing countries. In contrast with previous literature such as Grossman and Helpman (1991) and Matsuyama (1992), which illustrate that trade diversification stimulates economic growth, our findings are similar to Da Costa Neto and Romeu (2011) in finding that export destination concentration lessens crisis severity.

Similar to Giannone et al. (2010) and Rose and Spiegel (2011), we find that the countries with more liberal credit market regulation suffered more severely from crisis spillovers. Also, we find that the countries with a high fraction of public debt and short-term external debt, which represent reliance on foreign credit and financial linkages, experienced worse crisis outcomes than other countries that had better financial conditions. This result is similar to Claessens et al. (2010), Lane and Milesi-Ferrertti (2011), and Rose and Spiegel (2011).

In addition, the regression results indicate that developed countries were affected by the sub-prime crisis more heavily than developing countries.

Finally, we observe that even though house price appreciation has high negative correlation with crisis severity, the regression estimates do not reveal evidence that house price appreciation explained the incidence of crisis. It is important to point out, however, that we have limited observations in non-house price appreciation (35 countries). As a result, the regression result on this issue may be weak due to the small sample size.

In sum, the results in Table 5 point out that financial vulnerability plays the most important role as a crisis transmission channel.

In Table 6 we replace the trade measures that are based solely on direct trade with our new measures of total trade linkages, and repeat the analysis of Table 5. As before we find that a share of public debt to GDP and credit market regulation are still the most important explanatory variables for crisis severity.

Although the full sample results in Table 6 suggest that trade linkages are insufficient to explain the transmission of crisis for our full sample countries, trade linkages are found to be relevant when we allow for differential transmission to developing versus developed countries. In particular, the results in Table 6 show that developed countries with a higher share of exports to the U.S. market suffer from financial crisis during 2008–09 more severely than the developed countries that were less closely tied by trade. Thus, in contrast with Rose and Spiegel (2011), we find that trade dependency to the U.S. market could explain crisis severity of developed countries when total trade linkages are used instead of direct trade statistics. The regression results confirm our hypothesis that direct trade statistics may fail to accurately capture trade pattern for countries that are deeply connected via international production networks.

As for trade diversification, Table 6 shows that developed countries with higher export concentration experienced less severe crises that did countries whose exports were more diversified.

It is also important to point out that trade linkages could not explain the crisis severity of developing countries. One possible explanation for the lack of regression evidence for a connection is that the GFC was a global phenomenon, unlike the more regional crises during 1971–97. As a result, trade linkages may play a less important transmission role than they did in the regional crises. The developing countries hit

Table 6. Regression results when using total trade linkages

Variables	1	2	3
Export dependency on U.S., total linkages	0.355 (1.204)	−5.29 (1.358)	0.696 (0.567)
Export concentration, total linkages	4.757 (1.581)	6.008 (4.558)	4.522 (1.153)
Export dependency × dummy DC			−3.074* (0.157)
Export concentration × dummy DC			3.656* (0.125)
Credit market regulation	−1.198* (0.0691)	−0.843 (1.024)	−1.212* (0.0472)
Dummy of being developed countries	−2.453 (0.223)	1.185 (0.384)	−2.551* (0.180)
Current account/GDP	−0.00141 (0.00731)	0.0388 (0.0145)	−0.000693 (0.00830)
Short-term external debt/GDP	−0.212 (0.0343)	0.293 (0.0322)	−0.219 (0.0225)
Bank credit growth	−0.133 (0.014)	−0.0985 (0.0387)	−0.133 (0.0145)
Public debt/GDP	−0.153** (0.00234)	−0.623 (0.102)	−14.82* (1.148)
House price appreciation		−0.14 (0.0257)	
Constant	8.958* (0.675)	3.624 (8.9)	9.094* (0.445)
Observations R-squared	102 0.323	35 0.634	102 0.324

Source: *Authors' calculations.*

Note: *Robust standard errors in parentheses.*

***Statistically significant at the 1% level; *statistically significant at the 5% level.*

more severely by the GFC are the countries with more vulnerability such as higher public debt ratio, weak credit market regulation, or a larger fraction of short-term external debt.

5. Conclusion

Previous studies such as Berkmen et al. (2012), Rose and Spiegel (2011), Da Costa Neto and Romeu (2011), and Blanchard et al. (2010) point out that trade linkages do not explain cross-country crisis severity stemming from the GFC. We suggest that direct trade linkages may play a less important role in a crisis transmission following the GFC than they did in the earlier crises during 1971–97, since the composition of trade has changed. Notably, due to the growth of international production networks, direct trade statistics fail to capture trade exposure. Therefore, to improve the measures of total trade linkages, we use a trade matrix to construct trade dependence measures that include both direct and indirect trade connections. When we include indirect trade linkages, our findings show that export dependency on the

U.S. market significantly crisis severity in case of developed countries. As a result, trade linkages are still one of the important causes of crisis when indirect trade linkages are taken into account. Thus, while our findings confirm that trade statistics alone cannot fully explain trade exposure and trade pattern nowadays, our analysis shows that it is important to include indirect trade linkages to analyze trade-related issues. Finally, similar to previous work we find that vulnerabilities such as a high public debt ratio, high fraction of short-term foreign debt, and weak credit market regulation remain important in explaining the international transmission of the crisis.

References

Berkmen, Pelin S., Gaston Gelos, Robert Rennhack, and James P. Walsh. 2012. The Global Financial Crisis: Explaining Cross-country Differences in the Output Impact. *Journal of International Money and Finance* 31(1):42–59.

BIS. 2007. *77th Annual Report 2006/07.* Basel: Bank for International Settlements.

Blanchard, Olivier, Mitali Das, and Hamid Faruqee. 2010. The Initial Impact of the Crisis on Emerging Market Countries. *Brookings Papers on Economic Activity* 41(1):263–323.

Cheewatrakoolpong, K., and S. Manprasert. 2012. Trade Concentration and Crisis Spillover: Case Study of Transmission of the Subprime Crisis to Thailand. ARTNeT Working Paper Series No. 112. Bangkok: UNESCAP.

Claessens, S., G. Dell'Ariccia, D. Igan, and L. Laeven. 2010. Cross-Country Experience and Policy Implications from the Global Financial Crisis. *Economic Policy* 62:269–293.

Da Costa Neto, Nelson, and Rafael Romeu. 2011. Did Export Diversification Soften the Impact of the Global Financial Crisis? IMF Working Paper No. WP/11/99. Washington, DC: International Monetary Fund.

Eichengreen, Barry, Andrew Rose, and Charles Wyplosz. 1997. Contagious Currency Crises. NBER Working Paper Series No. 5681. Cambridge, MA: National Bureau of Economic Research.

Giannone, D., M. Lenza, and L. Reichlin. 2010. Market Freedom and the Global Recession. CEPR Discussion Paper No. 7884. Washington, DC: Center for Economic and Policy Research.

Glick, Reuven, and Andrew Rose. 1999. Why Are Currency Crises Contagious? *Review of World Economics* 134(4):664–691.

Grossman, Gene, and Elhanan Helpman. 1991. Trade, Knowledge Spillovers, and Growth. *European Economic Review* 35(2–3):517–526.

Hesse, Heiko. 2008. Export Diversification and Economic Growth. Commission on Growth and Development. Working Paper No. 21. Washington, DC: The World Bank.

Johnson, R. C., and Guillermo Noguera. 2009. Accounting for Intermediates: Production Sharing and Trade in Value-Added. Working Paper. Dartmouth, NH: Dartmouth College.

Kali, Raja, and Reyes, Javier A. 2005. Financial Contagion on the International Trade Network. Working Paper, Department of Economics. Fayetteville: University of Arkansas, Sam M. Walton College of Business.

Koopman, R., Z. Wang, and S. Wei. 2008. How Much of Chinese Exports is Really Made In China? Assessing Domestic Value-Added When Processing Trade is Pervasive. NBER Working Paper No. 14109. Cambridge, MA: National Bureau of Economic Research.

Lane, Philip R., and Gian M. Milesi-Ferretti. 2011. The Cross-country Incidence of the Global Crisis. *IMF Economic Review* 59(1):77–110.

Matsuyama, Kiminori. 1992. Innovation and Growth in the Global Economy: Gene M. Grossman and Elhanan Helpman. *Journal of International Economics* 33(3–4):383–386.

Meilak, Chris. 2011. Measuring Export Concentration: The Implications for Small States. *Bank of Valletta Review* 37(Spring 2008):35–48.

Miller, R. E., and P. D. Blair. 1985. *Input-Output Analysis: Foundations and Extensions.* Englewood Cliffs, NJ: Prentice Hall.

Perry, Guillermo, and Daniel Lederman. 1998. *Financial Vulnerability, Spillover Effects, and Contagion: Lessons from the Asian Crises for Latin America.* World Bank Latin American and Caribbean Studies.

Rose, Andrew, and Mark Spiegel. 2009. Cross-country Causes and Consequences of the 2008 Crisis: Early Warning. NBER Working Paper No. 15357. Cambridge, MA: National Bureau of Economic Research.

Rose, Andrew, and Mark Spiegel. 2011. Cross-country Causes and Consequences of the Crisis: An Update. *European Economic Review* 55(3):309–324.

Samen, Salomon. 2010. A Primer on Export Diversification: Key Concepts, Theoretical Underpinnings and Empirical Evidence. Growth and Crisis Unit, World Bank Institute, May.

Sato, Kiyotaka, and Nagendra Shrestha. 2012. Global and Regional Shock Transmission—New Evidence from Globally Integrated Input–Output Table. Paper presented at the 13th International Convention of the East Asian Economic Association, October 2012, Singapore.