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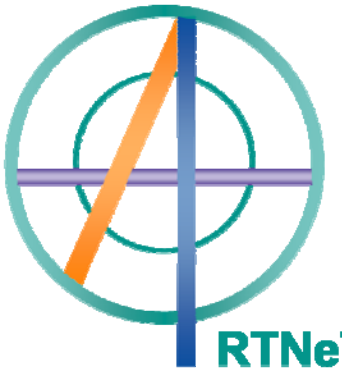

Asia-Pacific Research and Training Network on Trade

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By Kornkarun Cheewatrakoolpong, PhD and*
*Somprawin Manprasert, PhD***

Abstract

The threat of the subprime crisis in the United States began to make itself felt in early 2008, with its effects subsequently become global. It is evident that trade linkages have been the most important channel for transmitting the subprime crisis to East Asian countries, including Thailand. The international trade literature points out that trade concentration is considered to be an important factor in the amplification of the effects of the crisis. Thailand was still greatly affected by the recent crisis even though its direct exports to the G3 markets, i.e., the United States, the European Union and Japan, has been declining during the past 40 years. In fact, international trade linkages could be both directly and indirectly linked through international supply chain production. In this paper, the authors attempt to measure the importance of total trade concentration, which includes the effects through indirect linkages, and its connection to the transmission of external shocks experienced by the Thai economy. By constructing an algorithm that calculates total trade linkages, the authors find that Thailand still has high exposure to the G3 markets. Simulation using the CGE model has also confirmed that the country was, in fact, seriously affected through indirect channels. The results also show that the high concentration of domestic forward linkages in certain areas leads to those industries accumulating the effects of external shocks from financial crisis.

Keywords: trade concentration, crisis transmission, export diversification, backward linkages, and financial crisis
JEL Codes: F14, F41, F42

Introduction

The subprime crisis in the United States started at the beginning of 2008 when more than 100 mortgage-lending companies went bankrupt. The crisis is considered to be the worst financial catastrophe since the Great Depression. It has led to a sharp contraction in global trade and caused a worldwide recession. Due to strong financial and economic linkages between the United States and many countries around the world as well as the massive size of the United States' economy, the subprime crisis has been transmitted worldwide. Trade linkages are presumed to have been the most important channel for the transmission of the crisis to East Asian countries, including Thailand.

Apart from direct trade channels, the crisis has also caused a severe drop in indirect intraregional trade in parts and components, especially in the East Asian region. Most of the industrial production in East Asia – i.e., automobile and parts, computers and parts, and electronic and electrical appliances – is done through international production networks (IPNs), where production is fragmented into several stages and carried out in various countries, depending on the comparative advantages. Therefore, a decrease in the demand for final goods in the G3 countries – the United States, the European Union and Japan – has resulted in a drop in exports of parts and components in the region via IPNs.

Thailand depends heavily on exports, which accounted for 64 per cent of its GDP in 2007. About 33 per cent of Thailand's total exports in 2007 were to G3 destinations. Thailand has played a vital role as a major production base in ASEAN's IPNs with regard to the assembly of parts and components. Because 28 per cent of its total exports are parts and components serving these types of networks, Thailand has high exposure to G3 economies, via both direct and indirect trade. As a result, the country has experienced severe effects from the subprime crisis. Thailand's total exports dropped by 14 per cent in 2009, with exports to G3 destinations declining by 20.7 per cent. Consequently, industrial production, particularly in the major exporting industries, and private consumption decreased by 5.2 per cent and 2.5 per cent, respectively. The Thai economy moved into recession in the fourth quarter of 2008. These statistics led to the hypothesis that the subprime crisis had affected the Thai economy, with international trade being the most important channel of transmission.

In fact, the international trade literature points out that both geographical and commodity trade concentration are considered to be among the important factors leading to the amplification of the crisis transmission effects via international trade channels. Using the gravity model, Da Costa Neto and Romeu (2011) considered the impact of exports, destination and intra-industry concentration on export performance in Latin American countries during the subprime crisis; they found that export concentration significantly amplified trade collapse during the crisis while destination concentration played an insignificant role in helping to relieve the impact of the crisis spillover on trade.

Regarding export concentration in Thailand, Hesse (2008) showed that the country had experienced a decline in export concentration during the past 40 years. During that period, the country moved from an agricultural and resource-based economy to become a manufacturing exporter. However, the export data for Thailand still shows that export concentration is in the country's major manufacturing sectors such as

computers and parts, automobiles and parts, and electrical parts and appliances. These products may also share similar export destinations as well as backward and forward linkages. In addition, many Thai manufacturing exports comprise intermediate goods that may be re-exported to G3 destinations, i.e., the so-called indirect trade effect. Therefore, when the indirect effect is taken into account, Thailand's destination concentration may be high, especially in terms of exposure in the G3 economies. Hence, trade concentration could be one reason why the subprime crisis had a serious impact on Thailand, despite the fact that the country has very weak financial linkages with the United States.

To consider whether trade concentration, with the presence of the indirect trade effect, played a vital role in the spillover to Thailand of the 2008-2009 global financial crisis, the authors first computed the Herfindahl index in order to find the product and destination concentration of Thai exports using the Harmonized System (HS) classification of trade data at the 2-digit level. Next, the trade matrix was computed to identify Thailand's total trade dependence on, and concentration in the G3 countries, including indirect trade, i.e., trade in components and parts which will be used in the production of final goods that will also be re-exported to G3 destinations. The calculation of such a trade matrix will help to reveal the true destination concentration of Thailand's exports to the G3 economies. In addition, the authors explored the forward linkages, using the input-output matrix, in order to reveal the impact of export concentration on related industries. Finally, information was extracted from the Global Trade Analysis Project (GTAP) model and used to reconstruct a model that could decompose the total effect of external shocks on the Thai economy into direct and indirect effects. The results illustrate the importance of trade concentration in the crisis transmission to the Thai economy when the indirect trade effect is taken into account.

Section 1 of this paper reviews related literature. Section 2 explains the conceptual framework and methodology. Section 3 provides the results of the study while the conclusion is given in section 4.

1. Literature review

This section considers the previous literature regarding trade diversification and transmission of financial crises. The related literature is divided into three groups: (a) the importance of trade diversification in international trade theories; (b) the possible transmission channels of financial crises; and (c) the linkages between trade diversification and transmission of financial crises.

(a) Importance of trade diversification

Even though there is no room for product diversification in traditional trade models such as Ricardo's comparative advantage and the Heckscher-Ohlin model, the new trade theories such as Krugman (1979a) and Helpman (1981) applied the "love of variety" approach with monopolistic competition and a representative consumer, with preference given to differentiated products. Therefore, such diversification results in the higher welfare of economies. Krugman (1979a) also showed that trade liberalization induced higher diversification, which promoted welfare gains.

Furthermore, endogenous growth models such as those used by Grossman and Helpman (1991) and Matsuyama (1992) show the importance of diversification in economic development via innovation stimulation and a learning-by-doing process. Amin Guitierrez de Pineres and Ferrantino (2000) suggested that export diversification could create knowledge spillovers, leading to diversification-led growth. Krugman (1979b) and Agosin (2007) also developed models to support the fact that export diversification brings about higher growth from the process of technological transfer and imitation of existing products from the more developed countries. Coe and Helpman (1993), Van Meijl (1997) and Das (2002) showed that technological spillovers were induced by export diversification through a study of new products or techniques.

Considering the empirical literature on the relationship between export diversification and growth, the debate is continuing on whether diversification promotes economic growth. Al-Marhubi (2000), and Maloney (2003), and Herzer and Nowak-Lehmann (2006) found evidence that supported diversification-led growth.

In contrast, Imbs and Wacziarg (2003), Cabellero and Cowan (2006), and Klinger and Lederman (2006) showed that countries benefitted from diversification when their incomes were low and that they graduated towards a more specialized economy at the higher income level. Nevertheless, the empirical evidence and theoretical literature support the theory that export diversification yields higher growth in developing countries. Hesse (2008) employed the Generalized Method of Moments (GMM) estimation to find the link between export diversification and growth; he found that diversification supported economic growth in the case of developing countries while the richer countries performed better under specialization.

(b) Transmission channels of financial crises

The literature indicates that there are three possible transmission channels of financial crises, i.e., trade linkages, financial linkages and the contagion effect.

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 since that country will experience a drop in domestic demand. The depreciation makes exports cheaper. As a result, competitors encounter a drop in export demand due to the substitution effect and thus experience a currency crisis.

Calvo, Leiderman, and Reinhart (1996) and Frankel and Rose (1996) found that international interest rates influenced the movement of capital flows. A rise in international rates leads to higher funding costs and capital outflows, causing a currency crisis. Glick and Hutchison (2000), Tornell and Westerman (2002) and Kaminsky and Reinhart (1999) found that financial liberalization increased linkages among countries' money markets and capital markets as well as international lending, bringing about a rise in foreign exposure and vulnerability to currency and financial crises.

The contagion effect is another important transmission channel. Perry and Lederman (1998) and Calvo and Mendoza (1998) found that the expectations of investors changed with regard to economic conditions in countries with similar fundamental factors to a country experiencing a crisis. The main reason for such a change comes from asymmetric information concerning countries' actual exposure to the crisis. As a result, "herding behaviour" occurs in asset fire sales in those countries, leading them into the crisis as well.

Empirical studies have shown that trade linkages and the contagion effect are two important transmission channels. Eichengreen, Rose and Wyplosz (1997) and Glick and Rose (1999) found that international trade was an important source of the crisis transmission during 1971-1997. This is the reason why the financial crises during the above-mentioned periods tended to be a regional phenomenon. Kali and Reyes (2005) also found that countries which were the centre of a trade network experienced more severe effects from the crisis.

With regard to transmission channels among developing countries during the 2008-2009 financial crisis, Nissanke (2009) found that the main important channels among the low-income developing countries included a sharp drop in commodity prices, a rise in the cost of finance, and a reduction in foreign direct investment (FDI) and portfolio inflows. In the case of emerging market countries, financial and capital market linkages are the most important transmission mechanisms in terms of a collapse of stock markets, currency depreciation as well as the higher cost of bond and debt financing.

Cali, Massa and te Velde (2008) studied the impact of the global financial crisis in 2008 on developing countries and found that such countries suffered from contractions in FDI, international bank lending and portfolio equity flows.

In conclusion, most empirical studies of previous financial crises agree that trade linkages are important explanatory factors for crisis spillover, especially among developing countries.

(c) Trade diversification and transmission of financial crises

As explained in the previous section, trade linkages are one of the most important transmission channels during financial crises. One reason for this is the high share of exports to countries hit by crisis. Second reason is the high concentration on sectors whose export was affected the worst. However, only limited literature exists that tests the hypothesis empirically. Rose and Spiegel (2011) used the level of concentration of exports to the United States as one explanatory variable of the financial crisis in 2008. However, the results showed that the countries with high dependence on exports to the United States experienced a significantly less severe crisis. Therefore, it appears that destination concentration plays no role in crisis transmission.

Da Costa Neto and Romeu (2011) explored whether destination, export and intra-industry product concentrations explained the impact of the global financial crisis on trade, using the Latin American countries as their sample. The study shows that export concentration significantly increases the degree of trade collapse during a crisis while destination concentration only has an insignificant impact on trade.

The present study differs from the previous literature in that it considers not only destination and export concentration in Thailand but also the concentration of the export sectors on their forward linkages. Furthermore, with regard to destination concentration, the study also considers the effect of indirect trade. Moreover, the simulation model used to identify the effect of the global financial crisis on the Thai economy is based on the GTAP database.

2. Methodology

The analysis in this study is divided into four parts: (a) measuring trade concentration in Thailand; (b) computation of the trade matrix for measuring exposure of Thailand through exports to the G3 economies, including both direct and indirect trade effects; (c) the measurement of forward linkages in the production sector in Thailand; and (d) an estimation of the crisis impact on the Thai economy, using the simulation model. The first three parts show the level and characteristics of concentration in Thailand, whether the concentration is on destination, export sectors or production activity. Also, the complementarity of the indirect trade effect with the destination concentration is considered in order to reveal the total exposure of Thai exports to G3 economies. The last part considers the impact of the global financial crisis on the Thai economy and how concentration plays a role in crisis transmission.

(a) Trade concentration

This study follows the previous literature by employing the standard Herfindahl index in order to identify the level of trade concentration. Two types of concentration are considered: (a) destination concentration; and (b) export concentration. Destination concentration measures the exposure of Thailand's exports to particular countries, especially those experiencing financial crisis. A total of 239 destinations for Thai exports are included in the calculation. The destination Herfindahl index at time *t* (H_t^{des}) can be presented as follows:

$$HI_t^{des} = \sum_{i=1}^{239} s_i^2 \quad (1)$$

where s_i is the share of Thai exports to the country *i*.

Next, the export Herfindahl index is calculated to show the concentration in export sectors of Thailand. A total of 99 export sectors are included in the calculation. The export Herfindahl index at time *t* (H_t^{ex}) can be presented as follows:

$$H_t^{ex} = \sum_{j=1}^{99} s_j^2 \quad (2)$$

where s_j is the share of Thai exports in the sector *j*.

The trade data used in this calculation are categorized by the two-digit Harmonized System (HS) of Thai exports from 2005 to 2009 provided in the World Trade Atlas database, developed by Global Trade Information Services (GTI).

(b) Total trade exposure by trade matrix

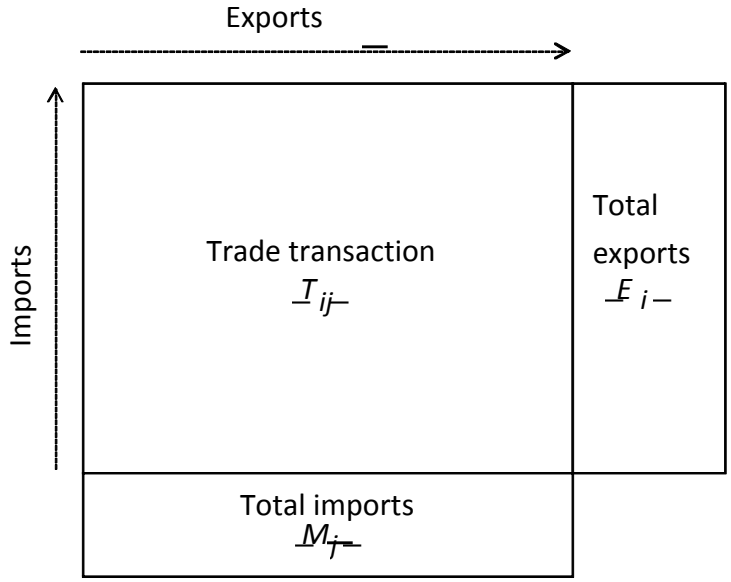
A low Herfindahl index may imply that Thailand has a low concentration of export destinations and that the exposure to particular markets is limited. However, such conclusions are based on measuring only "direct" trade linkages through reported export statistics. In fact, trade linkages involve transactions that are not just direct linkages (e.g., from the producer to the consumer market, without intermediate involvement of other markets). The study by the Bank for International Settlements (2008) suggested that "a significant proportion of China's imports were accounted for by production inputs, particularly for the export sector. About 70 per cent of Chinese imports consist of intermediate goods, and 57 per cent of these goods come from emerging Asia and Japan. At the same time, consumption and capital goods make up 72 per cent of Chinese exports to the United States and 68 per cent of those to the European Union." Therefore, examining only at the level of direct trade linkages is invalid as an indicator for international trade integration, as it may undermine the "total" trade linkages through re-exported products.

The Bank for International Settlements (2008) tried to measure the total trade linkages through both direct and indirect channels; however, the methodology used appears to be biased because the calculation of indirect exposure was simply calculated as a multiple of export shares of each segment of the direct exposure. For example, the indirect export share of Thai exports to the United States through China equals the export share of Thai's exports to China multiplied by the export share of China to the United States. For one thing, the United States may actually re-export some products to Thailand, directly and indirectly. Moreover, these trade linkages do not usually have only two segments.

Manufacturing production these days involves international supply chains, as each part of the finished goods may be assembled in different countries. Many of the supply chains involve more than two international trade linkages; for example, Thailand imports parts for computer hard disks from Japan, then assembles the hard disks and exports them to China for assembly in computers. China then exports the finished

product to the United States. Therefore, the analysis requires a more systematic approach that covers all global trade transactions in order to evaluate in a global context. A simple algorithm was therefore constructed for this study that allowed examination of the "total" trade linkages of selected Asian countries to the United States, the European Union and Japan.

In order to arrive at the solution, an "international trade matrix" was constructed that included international trade transactions. Each element of the matrix represents aggregate bilateral trade transactions of each trading partner. All data were obtained from United Nations Comtrade for 2007 global trade transactions. Unlike the input/output tables produced by the Institute of Developing Economies-Japan External Trade Organization, the international trade matrix used in this study contained aggregate trade data but represented complete global transactions rather than focusing only on specific areas.



where T_{ij} = export of country i to country j
E_i = total export of country i and equals to row sum of T_{ij}
M_j = total import from country j and equals to column sum of T_{ij}

Let $s_{ij} = T_{ij}/E_i$, which refers to the export share from country i to j, while the matrix S consists of element s_{ij}. In world equilibrium, total world exports must equal total world imports, or:

$$\sum M_j = \sum E_i \quad (3)$$

For each country, produced goods are used by domestic final consumption and by export demands. Let the matrix A contain the ratio of domestic final use to the total products available in the country:

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

where a_{ij} is the proportion of domestic final use to total demands (final use plus export demands) of the country; data are sourced from GTAP. Therefore, each country imports goods to consume and re-export according to proportions a_{ij} and $(1 - a_{ij})$, respectively. If defining the total trade linkages (l_j) equals direct linkages (d_j) plus indirect linkages (i_j), i.e.:

$$l_j = d_j + i_j \quad (4)$$

By definition, total indirect imports of country *j* must be equal to the sum of all re-exports from other countries to *j*. Therefore:

$$i_j = \sum_i l_j (1 - a_{ii}) s_{ij} \quad (5)$$

where the term $(1 - a_{ii})s_{ij}$ on the right-hand side of the above equation 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, the equation can be rewritten as:

$$l_j - d_j = \sum_i l_j (1 - a_{ii}) s_{ij} \quad (6)$$

In matrix terms:

$$L - D = L(\mathrm{I} - A)S \quad (7)$$

where L is a vector of l_j, D is a vector of d_j, A and S are matrices of domestic final consumption share and export share as defined earlier, respectively. For simplicity, it can be defined as:

$$Q = (\mathrm{I} - A)S \quad (8)$$

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

$$L = D(I - Q)^{-1}$$
$$\text{or } L = D + DQ + DQ^2 + DQ^3 + \ldots \quad (9)$$

where D is direct linkages

DQ is the linkages from first round re-export

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

(c) Forward linkages

To evaluate the concentration impact within a country, data are used from the input-output table to calculate forward linkages of production activity. The input-output data for Thailand were obtained from the National Economic and Social Development Board, and then regrouped in a way that represents 100 sectors of all producing activities in the economy. The main objective is to examine is the extent of the concentration impact from the negative shock in Thai production sectors. This study calculates the Forward Linkage Index (FLI) from the input-output analysis and explores its concentration level.

A sector that is frequently used as a factor of production (i.e., main sellers to other industries in intermediate transactions) has, as defined by the input-output analysis term, a high level of forward linkages. This sector will, in turn, be hugely affected by the aggregate shock to the economy. Moreover, if the majority of production has a high level of forward linkages (i.e., the huge impact is highly concentrated), the aggregate shock may have a large impact on the overall economy.

A calculation of FLI follows the standard approach suggested by Rasmussen (1956), in which the index also captures the indirect effect from changes in final demands. The input-output analysis starts with the identity that shows that gross output (total economic activities) equals the summation of intermediate transactions and final demand:

$$X = AX + F \quad (10)$$

where X = vector (n x 1) of gross output, F = vector (n x 1) of final demand and A = matrix (n x n) of input-output coefficients a_{ij}, in which $a_{ij} = X_{ij} / X_j$ or a ratio of intermediate use of i by sector j to the amount of total output in sector j.

Rearranging terms, the effects can be calculated from changing final demands to total activity of the economy. The above equation can thus be rewritten as:

$$X = (I - A)^{-1}.F \quad (11)$$

where $(I - A)^{-1}$ is called the "Leontief Inverse Matrix", which its element in row i and column j represents the total amount of products i used in order to satisfy a unit of demand from sector j. The FLI suggested by Rasmussen (1956) is calculated by a row sum of the Leontief Inverse Matrix. A large FLI implies a high level of a sector's forward linkage to overall activity.

(d) Model simulation

In the model simulation section, data from the GTAP model are used extensively. The model contains comprehensive details of data at the global and country levels as well as behavioural elasticities that allow an exercise to be conducted that evaluates the impacts from the subprime crisis on the Thai economy. The model was modified so that it could

clearly portray the transmission behaviour of external shocks to domestic economy through international trade linkages, given that the economy's production activity is part of the global supply chain. In this exercise, a case study of Thailand was carried out and the impacts from the external shocks in G3 countries were measured.

Two modifications were made to GTAP for this study:

(a) The direct effects were separated from the indirect effects stemming from an economic slowdown in external economies. In this case, "direct effect" refers to an outcome stemming from a decrease in G3 demand for finished goods produced in Thailand, while "indirect effect" refers to an outcome resulting from indirect trade linkages and from income-multiplier effects in other economies; and

(b) The present study focused only on the results from income effects of the external shocks.

Figure 1 shows the structure of the model. All of the behavioural coefficients were obtained from GTAP version 7.0. In the authors' modified version of the model, there are 11 economic relationships:

(a) Total private demand, where *qp*(*i*, *s*) is the private household demand for commodity *i* in region *s*, has a value determined by *EY*(*i*, *s*), which is income elasticity of private household demand for *i* in region *s*. The change in private household demand for goods will affect both domestic markets and foreign markets, as goods can be produced domestically and imported from abroad;

(b) With regard to the domestic markets, the variable *SHRDPM*(*i*, *s*) is the share of domestic product *i* used by private households in *s*, which determines household demand for the domestic product. Denote *qpd*(*i*, *s*) is the private household demand for domestic product *i* in region *s*;

(c) Changes in demand for domestic final products will then determine domestic sales *qds*(*i*, *s*), the domestic sales of commodity *i* in region *s*. The share of domestic sales *SHRDM*(*i*, *s*) will, in turn, affect local production activity *qo*(*i*, *s*);

(d) On the other hand, the change in total private demand also induces demand for imported goods, where *qpm*(*i*, *s*) is private household demand for imports of *i* in region *s*;

(e) Using coefficients of the private share of import *SHRIPM*(*i*, *s*), the share of import *i* used by private households in *s*, the model can calculate total import changes induced by private households. The total import is represented by variable *qim*(*i*, *s*), which refers to the aggregate imports of *i* in region *s*;

(f) The change in import demand from the above relationship translates directly into changes in exports by trading partners. The variable *qxs*(*i*, *r*, *s*) is the export sales of commodity *i* from region *r* to region *s,* and *SHRXMD*(*i*, *r*, *s*) represents the share of export sales of commodity *i* to region *s* from *r*;

(g) Changes in export demand induces changes in production activities in region *r*, where *qo*(*i*, *r*) is the industry output of commodity *i* in region *r*;

(h) Adjustments in production activity then determine aggregate intermediate input requirements, i.e., *qf*(*i*, *j*, *r*), the demand for commodity *i* for use by

industry *j* in region *r*. Using shares of domestic requirements, the model finds the changes in domestic intermediate input. The variable *qfd*(*i*, *j*, *r*) is the domestic good *i* demanded by industry *j* in region *r*. This then affects domestic sales *qds*(*i*, *r*) through the share of domestic product *i* used by sector *j* in region *r* at market prices, i.e., *SHRDFM*(*i*, *j*, *r*);

(i) Adjustment in production activity also determines changes in imported intermediate input from other countries. The variable *qfm*(*i*, *j*, *r*) is the demand for *i* by industry *j* in region *r*, calculated by reference to the variable *SHRIFM*(*i*, *j*, *r*), which represents the share of import *i* used by sector *j* in region *r*;

(j) Not only intermediate goods, but also adjustments in production activity affect primary inputs. The variable *qva*(*j*, *r*) captures the value-added in industry *j* of region *r*. Effects then translate into changes in capital and labour requirements. The coefficients of *SHREM*(*i*, *j*, *r*), the share of mobile endowment *i* used by sector *j* at market prices, determine the demand for endowment *i* for use in industry *j* in region *r*, namely variable *qfe*(*i*, *j*, *r*);

(k) Changes in production activity will also depress aggregate income of the country through the value of commodity *i* output in region *r* at market prices, i.e., *VOM*(*i*, *r*). The variable *y*(*r*) captures the regional household income in region *r*.

In this study, countries listed in the GTAP database have been regrouped into 16 regions (see table 2). GTAP's 57 producing sectors have been regrouped into five aggregate sectors – agriculture, natural resources, food, manufacturing and services.

Figure 1. Structure of the model

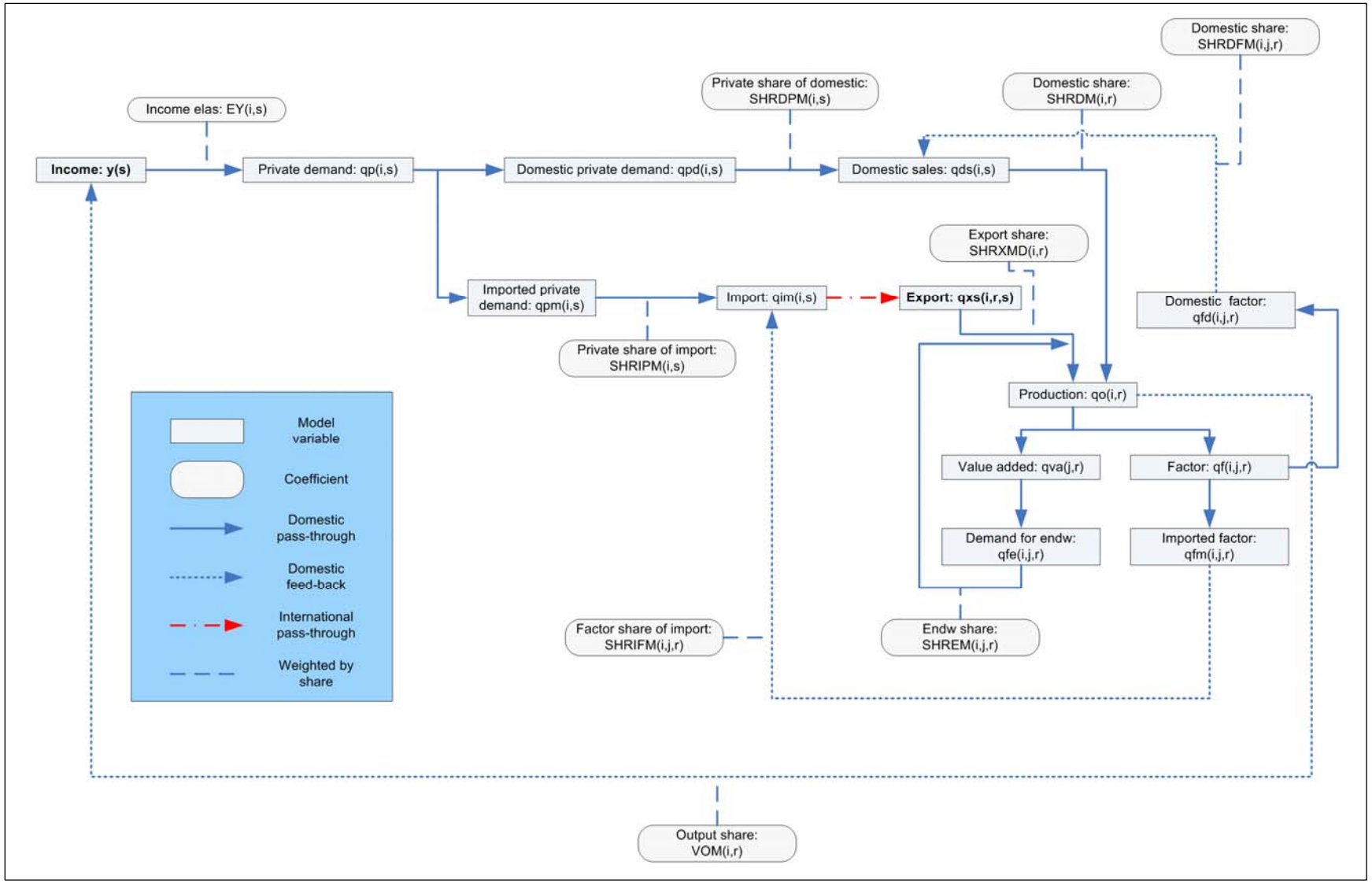


Table 1. Producing sectors in the GTAP model

I. Agriculture	1	Paddy rice	IV. Manufacturing	30	Wood products
	2	Wheat		31	Paper products, publishing
	3	Cereal grains		32	Petroleum, coal products
	4	Vegetables, fruit, nuts		33	Chemical, rubber, plastic products
	5	Oil seeds		34	Mineral products
	6	Sugar cane, sugar beets		35	Ferrous metals
	7	Plant-based fibres		36	Metals
	8	Crops		37	Metal products
	9	Cattle, sheep, goats, horses		38	Motor vehicles and parts
	10	Animal products		39	Transport equipment
	11	Raw milk		40	Electronic equipment
	12	Wool, silkworm cocoons		41	Machinery and equipment
II. Nat resources	13	Forestry		42	Other manufacturing
	14	Fishing	V. Services	43	Electricity
	15	Coal		44	Gas manufactures, distribution
	16	Oil		45	Water
	17	Gas		46	Construction
	18	Minerals		47	Trade
III. Food	19	Cattle, sheep, goat, horse meat		48	Transport
	20	Meat products		49	Sea transport
	21	Vegetable oils and fats		50	Air transport
	22	Dairy products		51	Communications
	23	Processed rice		52	Financial services
	24	Sugar		53	Insurance
	25	Food products		54	Business services
IV. Manuf.	26	Beverages and tobacco		55	Recreation and other services
					Public
	27	Textiles		56	Admin/defence/health/educ.
	28	Apparel		57	Dwellings
	29	Leather products			

The model setup can reveal the effects of a specific region's external shocks on the Thai economy. In this study, particular focus was on the shocks coming from the G3 economies. Key economic variables that are of interest include aggregate income, exports, imports, private consumption, production activities and factor incomes. For benchmark simulation, the current study used economic projections based on a study from the International Monetary Fund (2009). Because GTAP was built on a static general equilibrium setup, the base of the model portrays a long-term equilibrium of the world economy in the absence of shocks. Therefore, economic shocks in the model should also be measured in terms of "deviation" from the long-term growth rate. Table 2 displays assumptions about each region's economic activity, with the right-hand column specifically displaying the deviations from long-term growth.

Table 2. Assumptions about world economic activities

(Unit: Per cent)

Country/region	Projection for 2009	Average long-term growth	Standard deviation	Deviation from the long term
Australia and New Zealand	-1.5	3.1	0.9	-4.6
China	6.5	10.2	1.5	-3.7
Japan	-6.2	1.3	1.2	-7.5
Other East Asia	-5.1	4.1	1.8	-9.2
Thailand	-3.0	4.8	1.7	-7.8
Other South-East Asia	-0.3	5.4	1.4	-5.7
South Asia countries	4.3	7.0	2.1	-2.8
United States	-2.8	2.2	1.0	-5.0
Other North America	-3.2	2.4	1.3	-5.5
Latin America	-1.0	4.1	3.0	-5.1
Euro-currency countries	-4.2	1.8	0.8	-6.0
United Kingdom	-4.1	2.4	0.7	-6.5
Other European countries	-2.6	3.4	1.3	-6.0
Middle East and North Africa	2.5	5.4	1.4	-2.9
Sub-Saharan Africa	2.0	5.9	0.6	-3.9
Other countries	-5.1	5.6	1.1	-10.7

Source: International Monetary Fund, 2009.

Because the crisis transmission through real economic activity involves three types of effects in total, the results have been separated into direct effects, indirect effects and multiplier effects in order to examine clearly the patterns accompanying the transmission of an economic crisis to the Thai economy. Specifically, the direct effects refer to consequences from changes in G3 demand (through direct trade linkages) for Thai final products when a shock occurs. The indirect effects refer to the consequences of a G3 shock that translate into declines in demand for intermediate goods produced by Thailand. Multiplier effects refer to the income effect that, by propagating itself in other countries, further depresses Thailand's exports.

3. Results

This section describes the results from the calculation and estimation in the current study. First, Thai trade concentration levels calculated by using Herfindahl indices. Next, the level of backward and forward linkages employing the input-output table is presented. Finally, the section depicts the impact of the financial crisis on the Thai economy, using the simulation model.

(a) The level of Thai export concentration

Table 3 illustrates the export concentration of Thailand. The calculation of the Herfindahl indices shows that Thailand has a low level of concentration with regard to export destinations and sectors. Also, Thailand has a decreasing trend in the level of concentration. The findings support Hesse (2008), as they shows that Thailand has a

sharp decline in export concentration due to the change in production activities from agricultural to manufacturing exports and the development of resource-based sectors into higher value-added ones.

Table 3. Export destination and export sector concentration of Thailand during 2005-2009

Year	Export destination HHI	Export sector HHI
2005	0.0852	0.0666
2006	0.0860	0.0636
2007	0.0854	0.0568
2008	0.0781	0.0522
2009	0.0752	0.0523
Average	0.0820	0.0583

Source: Authors' calculations based on Global Trade Atlas data.

In comparison, Thailand has a higher Herfindahl index of export destination than of an export sector. This result indicates that Thailand has more diversification in export sectors than market destinations. The trade matrix shows in detail the exposure of Thailand in particular markets when the indirect effect is taken into consideration. Together with the trade matrix, the level of destination concentration is clarified. All in all, the findings in this section confirm the presence of high trade diversification in Thailand.

(b) Total export exposure

Figure 2 compares the export exposures of Thailand, the Republic of Korea, Malaysia and Singapore to the G3 countries. Each subfigure plots the direct bilateral export share in 2007 and the right-hand column represents "total" export exposure in 2007 calculated by the trade matrix algorithm.

What the study found was striking. For Thailand, for example, when the total linkages were examined, the exposure to the G3 countries increased from 38.4 per cent to 45.7 per cent (+7.3 per cent), while total exposure to Japan increased from 11.8 per cent to 12.9 per cent (+1.1 per cent). In the case of the European Union and the United States, total exposure increased from 14 per cent to 14.8 per cent (+0.8 per cent), and from 12.6 per cent to 18 per cent (+5.4 per cent), respectively. Similar results were found in case of the Republic of Korea (an increase from 34.6 per cent to 42.3 per cent, i.e., +7.7 per cent), Singapore (an increase from 24.5 per cent to 36.8 per cent, i.e., +12.3 per cent) and Malaysia (an increase from 37.6 per cent to 45 per cent, i.e., +7.4 per cent).

Figure 2. Total export exposure to the G3 economies (per cent)
Figure 2(a). Thailand

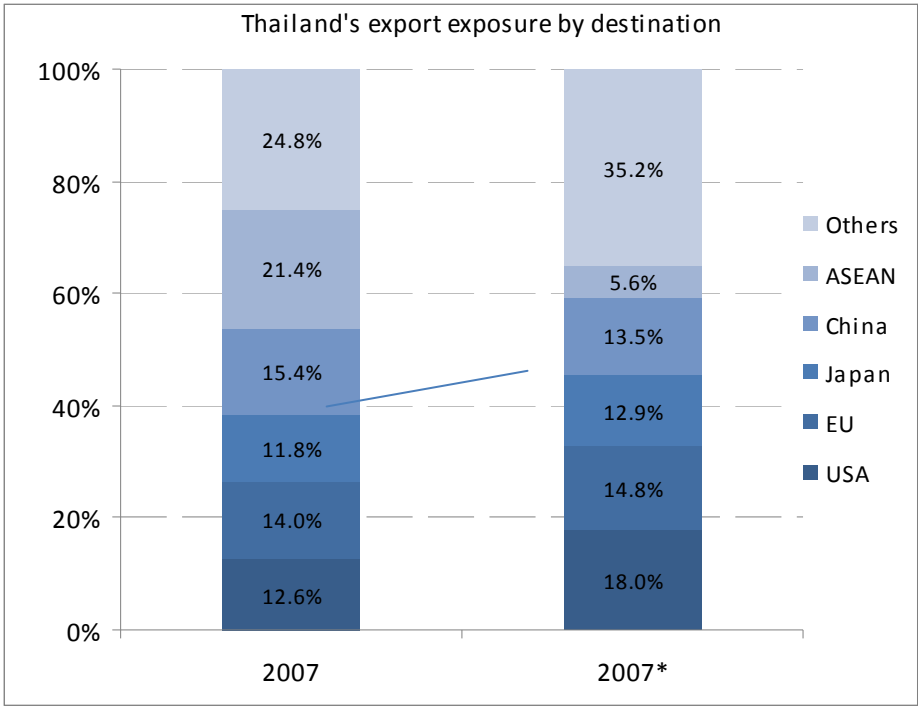


Figure 2(b). Republic of Korea

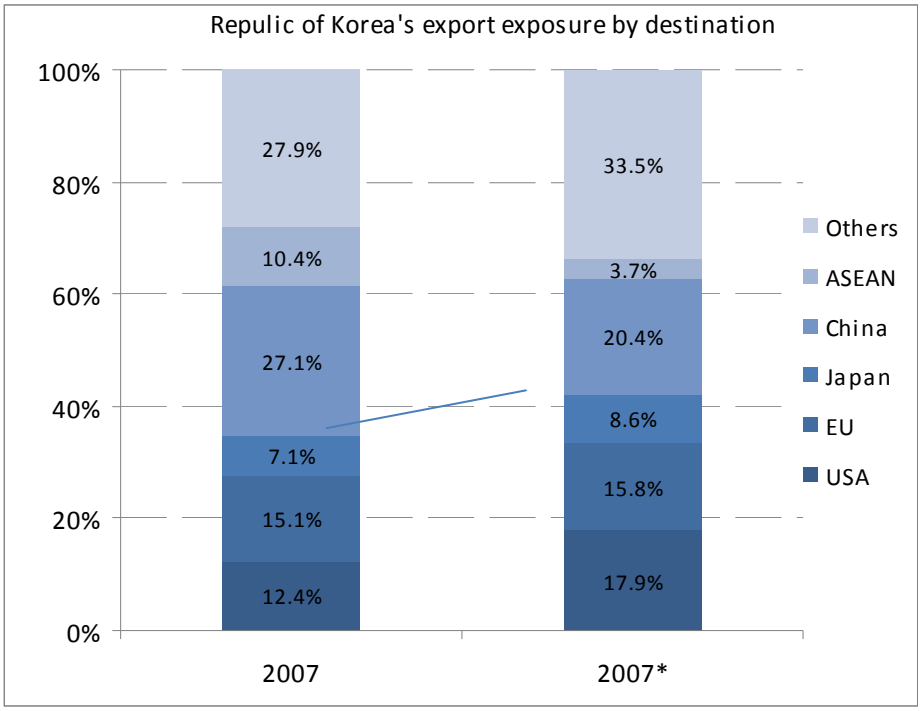


Figure 2(c). Singapore

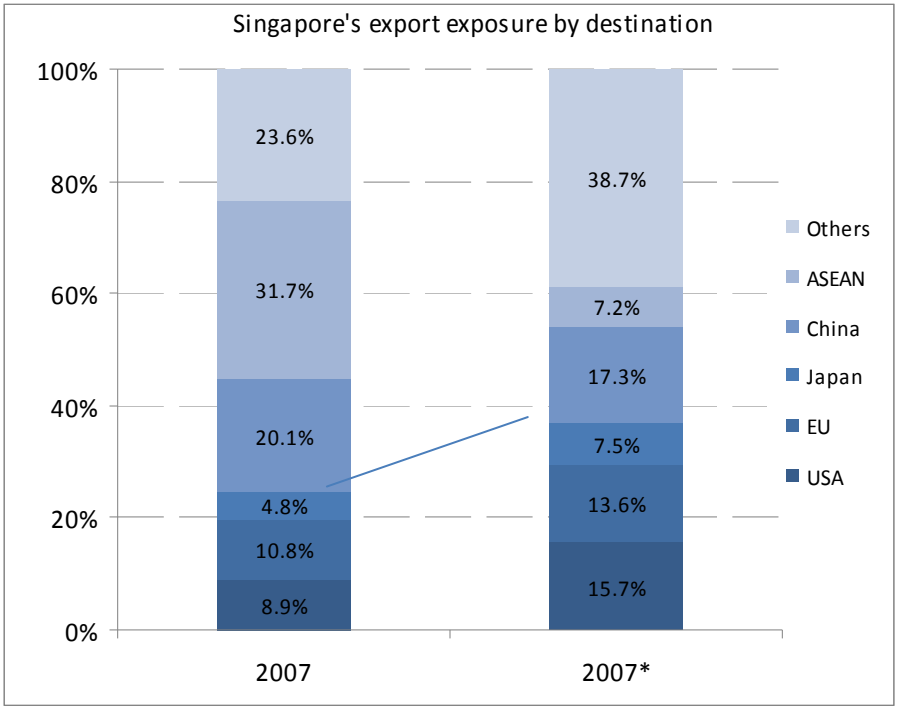
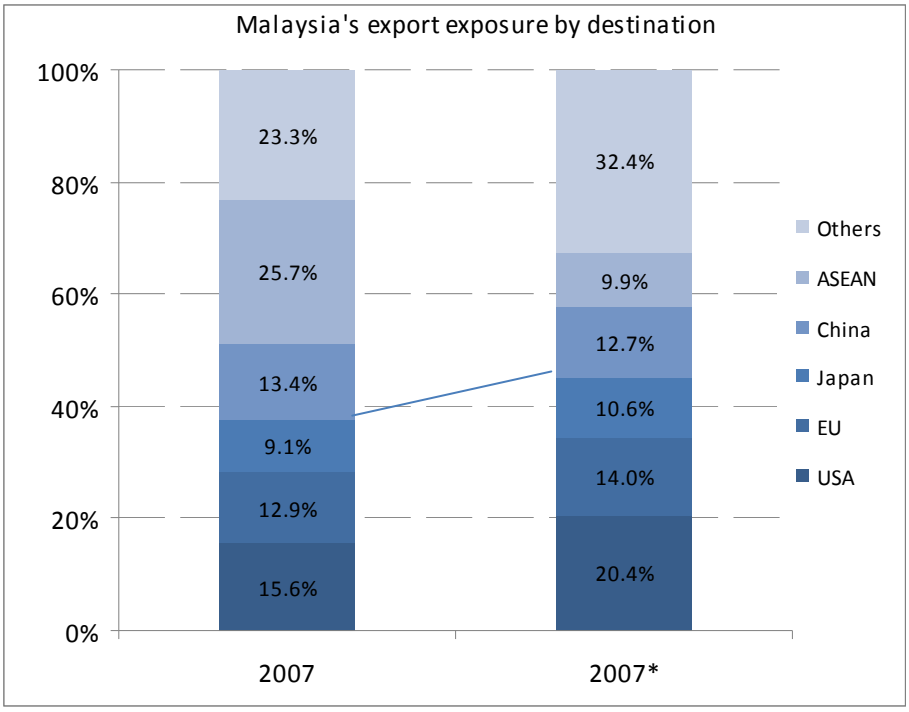


Figure 2(d). Malaysia



It should be noted that by looking only at direct export exposure, export exposure to the United States is underestimated the most; this is consistently true for all East Asian countries. On the other hand, after considering total exposure, trade linkages to China have declined. Moreover, export exposure among East Asian countries drop significantly when indirect linkages are taken into account. For example, Thailand's direct exports to Malaysia equal 5.1 per cent; however, the total export exposure of Thailand to Malaysia is only 1 per cent, since as much as 4.1 per cent was re-exported from Malaysia to other countries. Similarly, in the case of Thailand's exports to Singapore, direct export equal 6.2 per cent, but drops to 2.8 per cent when looking at total exposure. These findings also hold for other East Asian countries

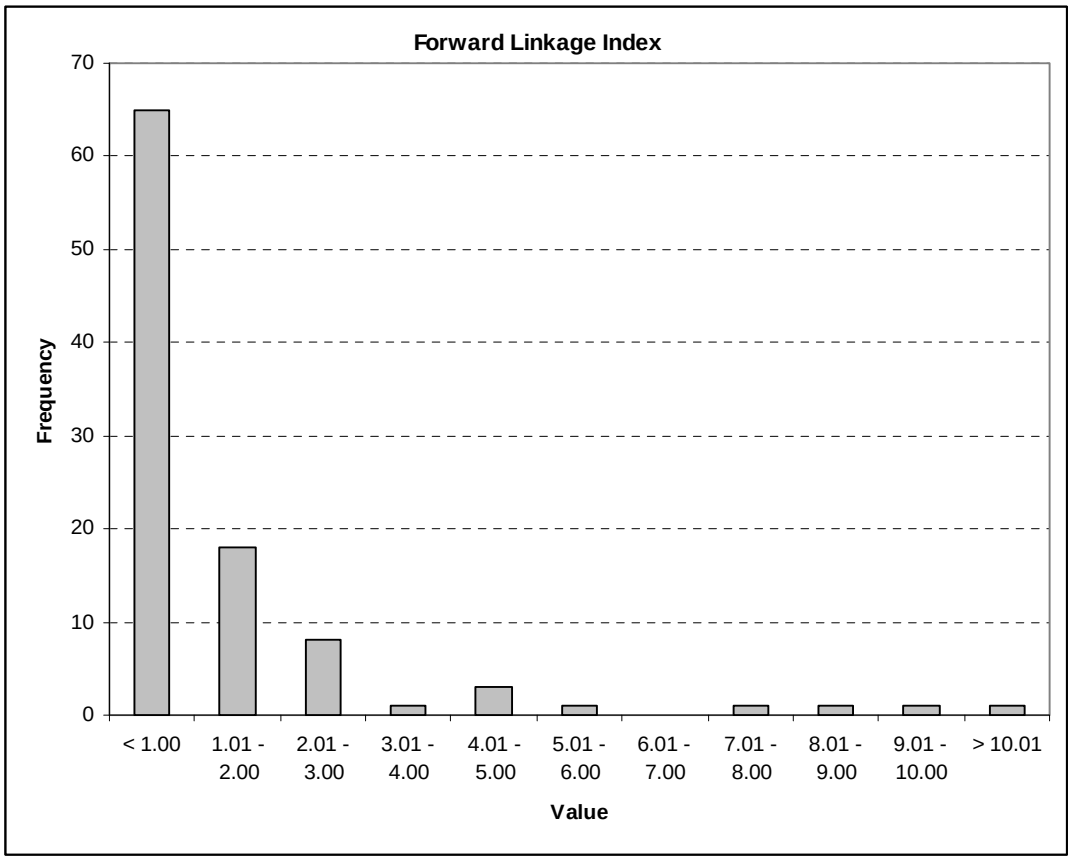
The results show that many East Asian countries are still highly exposed to the G3 countries when looking at net exposure, which counts both direct and indirect trade linkages. Trade exposure among East Asian countries drops significantly when looking at total trade linkages. What are seen are purely changes in the pattern of trade relationship; however, the level of trade linkages between East Asian countries and the G3 countries remains robust.

In contrast to the low level of destination concentration ratio, findings from this method suggest that Thailand still has high exposure to the G3 markets. As a result, Thailand has high destination concentration when indirect trade linkages are taken into account. This may explain why Thailand suffered a strong impact from the subprime crisis.

(c) Concentration of forward linkages

Figure 3 shows the FLI histogram plot for all Thailand's production sectors. The overall result clearly shows that the majority of FLI is below a value of unity, meaning that a relatively larger fraction of production sectors will experience a low impact (from being sellers of intermediate inputs) from aggregate shock. Of 100 sectors, 35 sectors have forward linkages greater than 1, which implies that those sectors will be affected proportionally more than the shock itself. However, it is also worth mentioning that only a small number of production sectors have a very high FLI value – for example, commerce (11.29), the chemical industry (9.41), petroleum and natural gas (8.32), petroleum refineries (7.86), and television and communications (5.95). These sectors could be considered as basic requirements for production activities in Thailand and are used as intermediate inputs in the production process by other sectors. Many of them are related to natural resource industries. Therefore, the aggregate shock to the economy will result in relatively more damage to such sectors.

Figure 3. Concentration of forward linkage index



The present study found evidence that Thailand's macroeconomic variables, particularly those related to international trade transactions, would be affected to a larger degree than the variables pertaining to private consumption and domestic investment. Negative growth in imports appears to be more severe than export growth. This contrast reflects the production structure of the Thai economy, wherein a large proportion of raw materials and capital goods are imported for the production process in export-oriented industries. When combining the effects from the slowdown in intermediate input requirements with domestic income effects, which pull down imports for consumption goods, negative import growth appears to be substantial.

The study's analysis of the pattern of external crisis transmission revealed that Thailand's international trade would be affected mainly through indirect linkages rather than a direct relationship. More important, however, was the finding that a larger part of the indirect effect rests on a decrease in demand for intermediate goods (e.g., not from the income effect in other countries). Therefore, indirect trade linkages play a significant role in explaining changes in the Thai economy's international trade transactions.

Table 4. Simulation results for macroeconomic variables

(Unit: Per cent)

Variables	Total effects	Direct effects	Indirect effects	
			Indirect-trade linkages	Multiplier effects
GDP	-7.77	-4.33	-3.44	
Exports	-8.34	-3.66	-4.24	-0.44
Imports	-11.21	-4.46	-6.38	-0.37
Gross output (inc. intermediate)	-6.42	-1.16	-5.26	
Private consumption	-7.77	-4.33	-3.44	
Unskilled workers	-5.82	-0.83	-4.99	
Skilled workers	-6.27	-0.55	-5.72	
Capital	-6.73	-0.93	-5.80	

Note: Results indicate percentage growth subtracted from the long-term growth rate.

The simulation results also show that a decline in gross output will be induced by indirect effects through indirect international linkages. This induced decline implies that Thailand produces a significant amount of intermediate goods for export. On the other hand, private consumption expenditures will likely be dragged down directly in a global slowdown. Given this incidence, it is reasonable to postulate that the effects of an external crisis on domestic consumption could be immediate. The factor of production that will likely bear the brunt of these effects is capital goods, whereas private investment will likely post a larger decline than that of skilled and unskilled labour employment.

The findings of the present study show that (a) most skilled labourers are employed in manufacturing industries, whereas unskilled labourers work in agriculture, and (b) that agricultural and food-related products are less sensitive to income changes. Therefore, the latter segment of the workforce will likely be less affected by external demand shocks than the former segment.

Industry-wise, export activities that will be mostly affected are those that are both pro-cyclical relative to global business cycles and highly income-sensitive such as service sectors. Natural resources sectors are hugely affected by an economic crisis because of further slowdowns in the demand of intermediate markets. When considering the pattern of crisis transmission, the study found that effects through indirect channels would likely be ample in sectors used mainly for intermediate production activities. These sectors are agriculture and natural resources. In contrast, the effect on the food industry will be transmitted through direct linkages because the products are imported by the G3 countries for final consumption.

Table 5. Effects on export growth by major sectors

(Unit: Per cent)

Sectors	Total effects	Direct effects	Indirect effects	
			Indirect trade linkages	Multiplier effects
Agriculture	-4.60	-0.89	-3.38	-0.33
Natural resources	-9.04	-2.14	-6.55	-0.35
Food	-6.20	-3.14	-2.23	-0.83
Manufacturing	-8.54	-3.70	-4.48	-0.36
Services	-9.14	-4.23	-4.33	-0.58
Total	**-8.34**	**-3.66**	**-4.24**	**-0.44**

Note: Results indicate percentage growth subtracted from the long-term growth rate.

Import growth will slow down significantly in the sectors where Thai producers need inputs from abroad. These inputs are raw materials, machinery and technology. In contrast, small changes in import growth are found in production sectors that are inelastic to income and less affected by declining export production activities, including the agricultural and food-processing industries. Apart from the service sectors, the cause of a decrease in Thailand's import demands comes mainly from the indirect effects of the G3 economies. This particular relationship means that Thailand has also imported numbers of intermediate goods for use in production that is exported to the G3 markets.

Table 6. Effects on import growth by major sectors

(Unit: Per cent)

Sectors	Total effects	Direct effects	Indirect effects	
			Indirect trade linkages	Multiplier effects
Agriculture	-8.71	-2.76	-5.51	-0.44
Natural resources	-13.50	-4.05	-9.45	0.00
Food	-8.79	-3.24	-4.66	-0.89
Manufacturing	-11.21	-4.52	-6.43	-0.26
Services	-9.66	-5.01	-3.39	-1.26
Total	**-11.21**	**-4.46**	**-6.38**	**-0.37**

Note: Results indicate percentage growth subtracted from the long-term growth rate.

Production activities will drop precipitously in the manufacturing and service sectors while the effects will be less pronounced in the food, natural-resource, and agricultural sectors. It should be noted that a reduction in all activities derives chiefly from indirect linkages between Thailand and the countries in crisis. This finding confirms that most of the production activities in Thailand are hindered by the economic stances taken in the G3 economies through indirect trade linkages. Results from the simulation scenario suggest that the agricultural sector is relatively less sensitive to external shocks than are the manufacturing and service sectors. Particularly in manufacturing, economic activities appear to strongly respond to the economic stances taken in the global business cycle. In terms of employment, unskilled labour is less sensitive than is skilled labour.

This finding further supports the assertion that agriculture-related sectors could absorb economic shocks from foreign economies relatively well.

Table 7. Effects on production activities by major sectors

(Unit: Per cent)

Sectors	Total effects	Direct effects	Indirect effects
Agriculture	-2.86	-0.10	-2.76
Natural resources	-4.58	-0.16	-4.42
Food	-5.50	-1.51	-3.99
Manufacturing	-6.97	-1.82	-5.15
Services	-6.42	-0.46	-5.96
Total	**-6.42**	**-1.16**	**-5.26**

Note: Results indicate percentage growth subtracted from the long-term growth rate.

To confirm that these results are reasonable, the simulation outcomes were compared with the actual figures during the period of the subprime crisis. Percentage changes in macroeconomic variables and changes in sectoral production activities during 2008-2009 were examined. Because the simulation was based on a general equilibrium type model, the simulated results represent relative change in two steady state equilibria. There is also no time dimension in the model; consequently, actual change in economic activities during two calendar years does not necessarily match up with those from two equilibria. Therefore, the validity of results from the model does not require simulated values to be as exact as figures shown in actual events. However, focus should be on the direction of impact and relative ranking of the affected variables. Actual figures and simulated outcomes should be consistent in these dimensions.

Figures 4 and 5 show the comparisons of actual figures and simulated results in various macroeconomic variables and sectoral production activities. Overall, it appears that the simulated outcomes are consistent with the realized figures. Thailand's imports and exports contracted the most as a result of the external shocks. Meanwhile, unskilled and skilled workers are also affected the least. Private consumption expenditure and GDP appear to be affected to the same degree. Yet, the impact on investment exhibits more severity in real figures than the simulated figures.

Figure 4. Comparison of actual macroeconomic variables and simulated outcomes

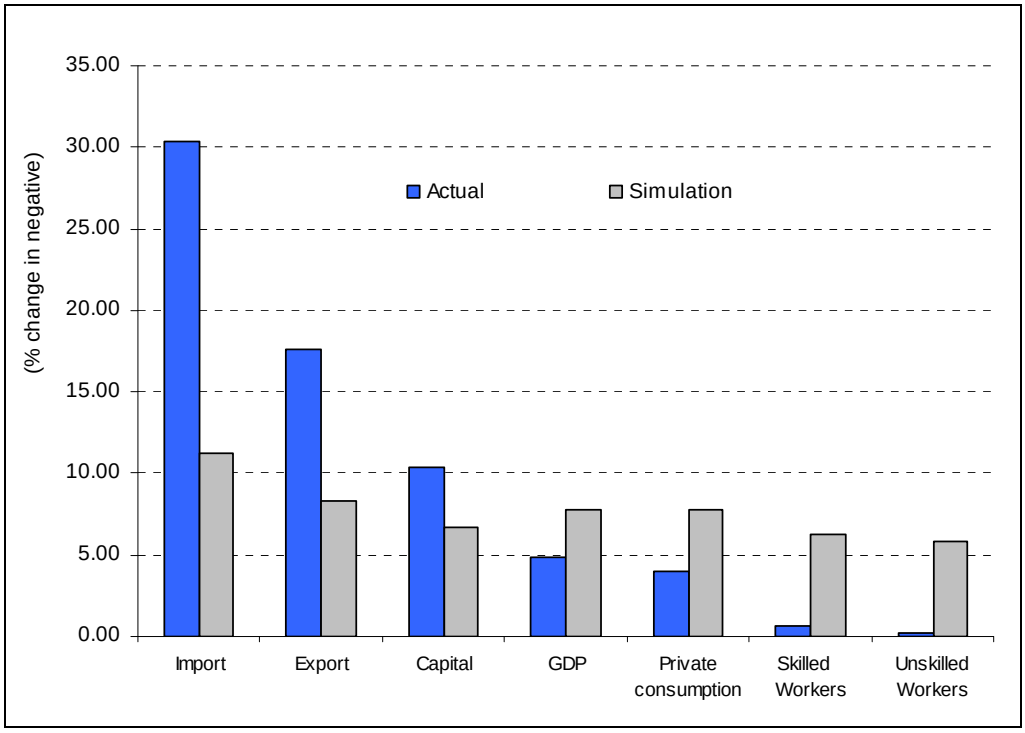
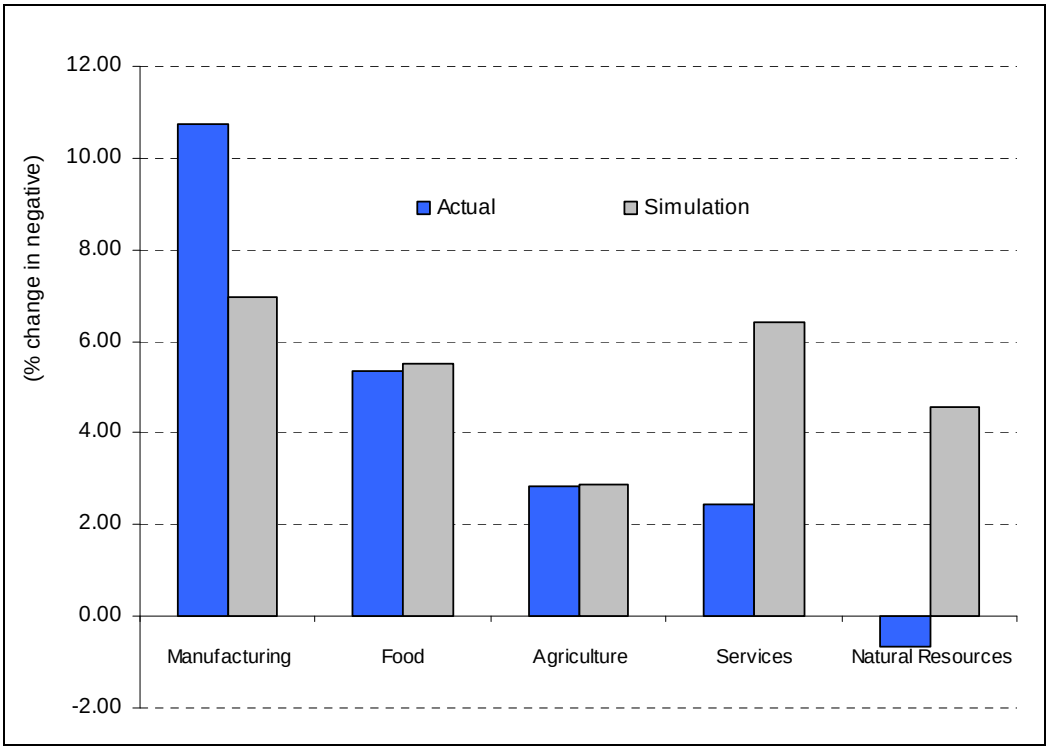


Figure 5. Comparison of actual and simulated figures for sectoral production activities



Overall, the present study shows that external shocks from decreasing international trade transactions will have unequal effects on macroeconomic variables in the Thai economy. An important finding of this study is that although trade concentration implies well-diversified markets for Thai exports, the simulation confirms that indirect linkages between Thailand and other countries are crucial to understanding the crisis transmission patterns as they emerge through international trade channels. Damage to the economy can still be concentrated in some crucial sectors through forward linkages within domestic activities. The indirect trade relationship significantly defines a pattern of export, import and production activities characteristic of the present Thai economy.

4. Conclusion

In both the theoretical and the empirical literature, it is argued that diversification is one of the most important factors determining how international trade linkages play the role of a transmission channel during an economic crisis. Previous research has suggested that the concentration of both export sectors and destinations amplifies the effect of such a crisis.

However, during the past few years, the trade exposure of East Asian economies to G3 markets has declined from an increase in intraregional dependency via the formation of regional trade agreements. The evidence from international statistics confirms that this regional cooperation in East Asia promotes intraregional trade. Many experts believe that this fact reflects diversification in exports from East Asian countries possessing relatively high levels of independence from G3 countries and higher destination diversification.

The Asian Development Bank (2007) found that an increase in intra-Asian trade resulted from the vertical integration of production networks among countries. A trade structure analysis shows that more than 70 per cent of intra-Asian trade is in intermediate goods while G3 countries remain important markets for final goods. The Monetary Authority of Singapore (2003) also estimated that only 22 per cent of total Asian exports were consumed in the region. As a result, Asian economies have remained vulnerable to recessions in the G3 economies.

The results of the present study support those findings. The calculation of the Herfindahl concentration index yields a low level of both export and destination concentration in Thailand, meaning that the country has trade diversification. However, when indirect trade linkages are taken into consideration via the estimation of the trade matrix, it is seen that Thailand still has high exposure to the G3 economies. As a result, the destination concentration of Thailand is still high when indirect trade is included.

With regard to forward linkages, Thailand has concentration in the sectors experiencing high impact from aggregate shock. This evidence implies that even though Thailand has high trade diversification in export sectors, the accumulated effect of some sectors with high forward linkages is still substantial.

Using the simulation model based on the GTAP database to study the total effect of the subprime crisis on the Thai economy via the two above-mentioned trade channels, the results indicate that the indirect effect is greater than the direct one. This inequality implies that indirect trade linkages have greater influence on changes in Thai exports and imports. Also, the overall effect of the subprime crisis on imports has been greater than on exports because the structure of Thai production depends on the use of imported intermediate goods and raw materials. The only economic variable heavily influenced by the direct effect is final product consumption. As for production factors, investment has experienced the highest levels of crisis-derived effects, followed by the production factors of skilled and non-skilled workers.

In the case of sectoral levels, the crisis has had the greatest effects on exports by the service and the natural resources sectors. This is due to the fact that trade in services is pro-cyclical and that natural resources respond to the multiplier effects from other industries. The food industry is the only sector to have experienced a direct effect that is higher than the indirect effect. Finally, the crisis has had a severe effect on production in the manufacturing and service sectors, especially via indirect effects.

Although the study shows that Thailand has trade diversification when considering direct trade data, the country still has high exposure in G3 destinations when indirect trade linkages are included. Moreover, the high concentration of forward linkages in certain industries has resulted in those industries accumulating the external shocks from he economic crisis. As a result, the transmission of the United States subprime crisis to the Thai economy occurred mainly through the indirect trade. Imports have been the most affected because Thai production has relied on raw materials and intermediate goods from abroad. The sectors experiencing the greatest effect from the crisis have been in services, natural resources and manufacturing. The factor affected the least by the crisis has been unskilled labour because such workers have been able to relocate to the agricultural-related sectors, which are relatively insensitive to economic fluctuation.

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