Deepening of International Interdependence and the East Asian Economy: Empirical Evidence based on Global VAR

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1. Introduction

In today’s world economy in which international interdependence is deepening, the question of the impacts of East Asian economy has been a concern among policymakers in various countries, as the so-called “de-coupling theory.” However, it is not easy to quantitatively validate such a question, and it is difficult to say that there is abundant accumulation of research. In this paper, several quantitative analyses that pertain to the question above are conducted using time-series analysis. The time-series model used in this paper is known as Global VAR, which captures the interdependence of many countries in the form of trade links. This model uses data of various countries to enable for a variety of simulation analyses regarding the various problems that the current world economy is faced with. In particular, it is successful in obtaining several pieces of meaningful knowledge regarding the kinds of impacts that the recent financial shock in Europe and the US have on the real economy of East Asian countries.

The contents of this paper are as follows. In Section 2, there is a slight introduction regarding the kinds of methods that exist to quantitatively analyze international interdependence. In Section 3, the Global VAR structure that serves as the basis of this paper is explained, and analysis examples that utilize this model are clarified. The construction of Global VAR is carried out in Section 4. In Section 5 and 6, the impacts of the financial shock that originated in the US and Europe on the East Asian economy are examined in detail. When doing so, the relationship of economic fluctuations in East Asia come to possess an important meaning, and some discussions are conducted in Section 7. The findings that are obtained through the analyses are summarized in Section 8.

2. Quantitative Analysis of International Interdependence

In association with the development of mutual dependence of the world economy, there have been various attempts at quantitative analyses regarding the extent to which economic fluctuations in a country impact other countries, and regarding how and in what form a political shock in one’s
own country affects other countries. As representative types of quantitative analyses, the “macro-econometric model,” “DSGE model,” and “time-series model” are given below. The characteristics of each model are summarized and their orientation in the analysis methods in this paper will be confirmed.

The macro-econometric model is an important analytical framework in quantitatively comprehending interdependence of the world economy (hereinafter referred to as the “world economy model”). From the 1970s to the 1980s, various world economy models were developed in advanced countries. In Japan, the Economic Planning Agency developed the EPA world economy model, and various quantitative analyses regarding the characteristics of the Japanese economy under an open system were conducted.

The macro-econometric model, which serves as the basis for the world economy model, estimates the various functions comprising the macro general equilibrium system, and then carries out various simulation analyses. The characteristic when constructing such a type of quantitative model can be summarized into the following three points. First, although the various functions (such as the consumption function, investment function, etc.) are based on theory, when conducting estimations, there are times when difficult variables that cannot be considered as being theoretically clear are attached as explanatory variables. Second, the parameters of various coefficients are all estimated using data, and thus, it is possible to revise the model using the data up to the most recent point in time. Third, it is not always easy to update the model using the latest data. In particular, before and after a large change in the macro economy, it is highly possible that parameter values differ and as a result, it is possible that the predicted values and various policy simulation values change between the old and new models.

Next, let’s look at the characteristics of the “DSGE model”. The characteristics of this model can be summarized into the three points below. First, as the theoretical basis is clear, it is easy to trace the repercussion mechanism for various shocks. Second, since the behavior equations such as the consumption function and investment function are derived from optimized behavior of household budgets and companies, parameters that constitute these functions are formed from deep

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1 Bryant et al. (1989) compares and examines the characteristics of the world economy models of various countries and the simulation performance in detail.
2 With regard to details on the EPA world economy model, the explanation by Lawrence Klein and Ichimura (ed.) (2011) is informative.
3 Based on this kind of meaning, the “Lucas critique” was made by Lucas (1976), saying that there are limitations to policy evaluations based on structural parameters that estimate the macro-econometric model.
4 DSGE is short for “dynamic stochastic general equilibrium.” Examples of DSGE models that assume global economies include the Global Economy Model (GEM) developed by the IMF (an overview is introduced in Bayomi et al. (2004)), McKibbin and Stoeckel (2009), and Faruquee, Laxton, Muir and Pesenti (2007).
parameters such as the preferences of household budgets and technological structure of companies. As such deep parameters are not thought to change significantly due to various policy shocks, the possibility of being directly faced with the “Lucas critique” pointed out in the “macro-econometric model” is low. Third, in the case of the DSGE model, there are many cases where parameter values are virtually established and adjusted (calibrated), and thus, it is difficult to say that information from data is sufficiently incorporated into the model.

Lastly, let’s look at the characteristics of the “time-series model.” When specifying interdependence among macro variables using the time-series model, the vector autoregressive model (hereinafter referred to as “VAR model”) is widely used. Compared to the macro-econometric model and the DSGE model, the VAR model has the three characteristics below. The first is that compared to the macro-econometric model and the DSGE model, the theoretical basis of the VAR model is not always clear. In other words, with the VAR model, the information in data is used to the maximum extent. Second, in the VAR model, since the theoretical structure is not clear, it is not always easy to interpret the repercussion mechanism in relation to various shocks based on theory. Third, although the above kinds of issues exist, the mobility of model development can be considered high as compared with other models. Based on updated data, interdependence of variables can be comprehended based on information in data as of the latest point in time.

As described above, we have organized the characteristics of the three types of models. Since the macro-econometric model and DSGE model are based on theory to some extent, they are attractive with regard to the point that there is some persuasive power in explanations, etc. of simulation results. However, under today’s world economy in which changes are dynamic, it can be said that there is no small meaning in the development of the VAR model that uses information found in up-to-date data to the maximum extent. In particular, when the world economy systems comprised of many countries is developed and updated arbitrarily in the macro-econometric model and DSGE model, enormous labor is necessary. Accordingly, even if the theoretical background is not necessarily clear, sketching the world economy based on the VAR model and trying to

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5 Recently, however, due to the expansion of Bayesian econometrics, there is an increasing number of cases where parameters that form the DSGE model are estimated using data (this kind of system is called the “Bayesian DSGE model”).

6 However, there have also been attempts to incorporate some kind of theoretical structure to the VAR model, and this is called “structural VAR.”

7 For example, in the EPA world economy model developed by the Economic Planning Agency, the constituent countries are limited to nine countries. The constituent regions in the DSGE model developed in Faraquee, Laxton, Muir and Pesenti (2007) also consist of four regions.
quantitatively comprehend the magnitude of global repercussions of various shocks, can be considered as a sufficiently significant endeavor. Thus, in this paper, the Global VAR model that was developed based on this kind of problem-awareness is introduced, and validations will be conducted on the dynamism of the world economy based on this model.

3. Structure and Applications of Global VAR

In this section, an overview of the structure of Global VAR (hereinafter referred to as “GVAR”), which serves as the basis for validations, will be given. If we summarize the characteristics of GVAR in one phrase, it would be “the value of one’s own country in this term is affected by the past values of one's own country and the past and current values of other countries.” This characteristic will be expressed as a mathematical formula below. When doing so, the system will first be explained based on the three countries of Japan (J), US (U), and China (C), and a general system explanation will be made afterwards.

3-1 Structure of GVAR (1): System based on three countries

For the purpose of simplification, it is hypothesized that the economy of each country is comprised of the three variables of income (y), commodity prices (p), and interest rates (r). The values for variables for this term for Japan (J), US (U), and China (C) can be depicted as follows.

\[
\begin{align*}
  x_J &= \begin{pmatrix} y_{Jt} \\ p_{Jt} \\ r_{Jt} \end{pmatrix}, \\
  x_U &= \begin{pmatrix} y_{Ut} \\ p_{Ut} \\ r_{Ut} \end{pmatrix}, \\
  x_C &= \begin{pmatrix} y_{Ct} \\ p_{Ct} \\ r_{Ct} \end{pmatrix}
\end{align*}
\]

(1)

As mentioned above, the first characteristic of GVAR is that “the value of one’s own country in the current term is dependent on the past values of one's own country.” Focusing on Japan, if hypothesizing that the values for this term are dependent only on the values in the previous term, it is possible to particularize as in the equations (2) below.

\[
\begin{align*}
  y_{Jt} &= \phi_1 y_{Jt-1} + \phi_2 p_{Jt-1} + \phi_3 r_{Jt-1} \\
  p_{Jt} &= \phi_4 y_{Jt-1} + \phi_5 p_{Jt-1} + \phi_6 r_{Jt-1} \\
  r_{Jt} &= \phi_7 y_{Jt-1} + \phi_8 p_{Jt-1} + \phi_9 r_{Jt-1}
\end{align*}
\]

(2)

When (2) is shown as a matrix, it is represented as in the following equations (3).

\[
x_J = \Phi x_{Jt-1}
\]
Next, let’s assume that the value of one’s own country is affected by the values of foreign countries in this term and in the past, which is the second characteristic of GVAR. If assuming that the magnitude of the impact from the US on Japan is $w_{JU}$, and the magnitude of the impact from China on Japan is $w_{JC}$, the impacts from both China and the US on Japan can be expressed as shown below in Equation (4).

$$x_{Jt, t}^* = \begin{pmatrix} y_{Jt}^* \\ p_{Jt}^* \\ r_{Jt}^* \end{pmatrix} = w_{JU} \begin{pmatrix} y_{Ut} \\ p_{Ut} \\ r_{Ut} \end{pmatrix} + w_{JC} \begin{pmatrix} y_{Ct} \\ p_{Ct} \\ r_{Ct} \end{pmatrix}$$

(4)

Now, let’s confirm the method for calculating the extent of impacts from other countries on one’s own country in GVAR. In summarizing the characteristics of the calculation method, “the calculation method is determined depending on linkage with total trade transactions with each country.” Hypothetically, the total amount of trade (exports + imports) between Japan and China is 60, the total amount of trade between Japan and the US is 40, and the total amount of trade between the US and China is 160. Among the total amount of trade transactions for Japan (100), transactions with the US amount to 40 and $w_{JU} = 0.4$, and transactions with China amount to 60 and $w_{JC} = 0.6$. Upon calculating the extent of impacts in such a manner, and particularizing the characteristic of “the foreign variables of the past and of this term have an impact on the variables of one’s own country for this term,” Equation (5) is obtained.

$$x_{Jt} = \Lambda_0 x_{Jt}^* + \Lambda_1 x_{Jt-1}$$

(5)

$$\Lambda_0 = \begin{pmatrix} \lambda_{01} & \lambda_{02} & \lambda_{03} \\ \lambda_{04} & \lambda_{05} & \lambda_{06} \\ \lambda_{07} & \lambda_{08} & \lambda_{09} \end{pmatrix} \quad \Lambda_1 = \begin{pmatrix} \lambda_{11} & \lambda_{12} & \lambda_{13} \\ \lambda_{14} & \lambda_{15} & \lambda_{16} \\ \lambda_{17} & \lambda_{18} & \lambda_{19} \end{pmatrix}$$

By integrating Equations (3) and (5), it is possible to create the system for Japan’s GVAR in the
form of Equation (6).

\[ x_{it} = \Phi x_{it-1} + \Lambda_{10} x^*_{it} + \Lambda_{11} x^*_{it-1} + u_{it} \]  

(6)

### 3-2 Structure of GVAR (2): System based on N countries

Based on the 3-country, 3-variable case above, a more general \( N \)-country, \( k \)-variable GVAR structure is constructed. This system can be expressed as in Equation (7) below.

\[ x_{it} = a_{i0} + \Phi x_{it-1} + \Lambda_{i0} x^*_{it} + \Lambda_{i1} x^*_{it-1} + u_{it} \]  

(7)

\[ \begin{align*}
  x_{it} & : k \times 1 \\
  x^*_{it} & : k^* \times 1 
\end{align*} \]

Foreign variables have an impact on one’s own country as influential variables from foreign countries in the form of Equation (8), through the influence rate that corresponds to the amount of trade transactions (hereinafter referred to as “weighting matrix”), as introduced above.

\[ x^*_it = \sum_{j=0}^{N} w_{ij} x_{jt} \]  

(8)

\[ \sum_{j=0}^{N} w_{ij} = 1 \]  

(9)

### 3-3 Application examples of GVAR

Pesaran et al. (2004) is a pioneering work in the development of GVAR. In their paper, the Global VAR model was developed for the purpose of expanding the VECM (vector error correction model) into a system that takes into consideration interdependence among many countries. Thus, a system comprised of the US, Germany, France, Italy, UK, Japan, China, and other countries (20 countries) was constructed and various simulations are attempted. Afterwards, several expansions and revisions were carried out by Pesaran (Pesaran et al. (2006) (2009a) (2009b), Dees et al. (2007a) (2007b) (2011)). With regard to the global repercussions of credit risks, which is a pressing issue at the moment, investigations are carried out in Pesaran et al. (2006) and Chen et al. (2010). In addition, predictions of economic variables of ASEAN5 are made in Han and Ng (2001) using GVAR.
4. Construction of GVAR

4-1 Systems of various countries

The construction method for GVAR in this analysis is explained below. As explained above, GVAR has a structure where the system of one’s own country is linked to the systems of foreign countries based on the influence rate from trade transactions. First, let’s establish the system of one’s own country (hereinafter referred to as “VARX”). Target countries consist of a total of 8 regions (34 countries), including the East Asian region (8 countries), other Asian regions (3 countries), Euro region (8 countries), other European regions (4 countries), African region (1 country), North American region (2 countries), Latin American region (6 countries), and Oceania (2 countries). A list of the constituent countries in each region is summarized in Table 1.

Table 1  GVAR regions and constituent countries

<table>
<thead>
<tr>
<th>East Asia</th>
<th>Other Asia</th>
<th>Euro</th>
<th>Other Europe</th>
<th>Africa</th>
<th>North America</th>
<th>Middle South America</th>
<th>Oceania</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHINA</td>
<td>INDIA</td>
<td>AUSTRIA</td>
<td>NORWAY</td>
<td>SOUTH AFRICA</td>
<td>CANADA</td>
<td>ARGENTINA</td>
<td>AUSTRALIA</td>
</tr>
<tr>
<td>INDONESIA</td>
<td>SINGAPORE</td>
<td>BELGIUM</td>
<td>SWEDEN</td>
<td>USA</td>
<td>BRAZIL</td>
<td>NEW ZEALAND</td>
<td></td>
</tr>
<tr>
<td>JAPAN</td>
<td>TURKEY</td>
<td>FINLAND</td>
<td>SWITZERLAND</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KOREA</td>
<td>FRANCE</td>
<td>UNITED KINGDOM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MALAYSIA</td>
<td>ITALY</td>
<td></td>
<td></td>
<td></td>
<td>MEXICO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHILIPPINES</td>
<td>NETHERLANDS</td>
<td></td>
<td></td>
<td></td>
<td>PERU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SINGAPORE</td>
<td>SPAIN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>THAILAND</td>
<td>Germany</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 7 | 3 | 8 | 4 | 1 | 2 | 6 | 2 |

There are six variables that comprise VARX: real GDP, inflation rate, real stock prices, real effective exchange rate, nominal short-term interest rate, and nominal long-term interest rate. The estimation period is the period from 1979 2Q to 2009 4Q. The lag order for VARX is determined

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8 The GVAR that is used as a basis for this analysis is based on Smith and Galesi (2011) Demo version. The definition, collection, and processing methods for each variable are the same as this analysis.

9 For the Euro zone the variable values of eight countries (weighted average using GDP of each country) is tabulated and set as the variable for the Euro zone.
from AIC (Akaike Information Criterion), and the order is different for each country.

4.2 Calculation of the weighting matrix

The weighting matrix that indicates the influence rate of foreign variables on one's own country is as shown above, and depends on the amount of trade transactions of each country with other countries. In this analysis, the weighting matrix is changed diachronically, and impacts from foreign countries are regarded flexibly. Concretely, the weighting matrix is calculated upon averaging the three-year transition in trade amounts of each country between 1980Q1 to 2009Q4. Figures 1-1 to 1-4 depict the shifts in the weighting matrix in the US, Europe, China, and Japan.
In the case of the US, it is clear that the influence rate from the Euro zone, Japan, and East Asian countries starting in the 1990s is decreasing. In contrast, a prominent raise in the influence rate from China can be observed. Similarly, there is a significant increase in the influence rate from China on the Euro zone and Japan. However, when China is the target country (Figure 1-3), the areas in which the influence rate is increasing is the Euro zone and East Asia. Although its relationship with the US rises from the 1980s to 2000, it slows down somewhat afterwards. Influence from Japan gradually decreases starting in the latter half of the 1980s.

5. Validations Based on GVAR (1)

5-1 Impacts of the financial shock that originated in the US

Based on the GVAR that was constructed above, several simulations will be attempted below. Examining in a detailed manner the kinds of impacts that financial crises such as the subprime crisis and European crisis have on the macroeconomy of various countries under the current world economy is extremely important when looking from the policy viewpoint. Thus, in this analysis, we examine in detail the kinds of impacts that the financial shock that originated in the US and the
financial shock that originated in Europe (Euro zone) have on the real economy of Asia. In this analysis, with regard to the financial shock that originated in the US, a case where the US stock prices are affected by a negative shock of one standard deviation’s worth of residual error is assumed, and validations of the impacts on the real GDP of the Asian region (Japan, China, East Asian region) are conducted based on impulse reactions. The results of impulse responses for various Asian countries are summarized in Table 2\textsuperscript{10}.

<table>
<thead>
<tr>
<th></th>
<th>8Q later (2 years later)</th>
<th>12Q later (3 years later)</th>
<th>16Q later (4 years later)</th>
<th>20Q later (5 years later)</th>
<th>40Q later (10 years later)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>-0.002</td>
<td>-0.002</td>
<td>-0.002</td>
<td>-0.002</td>
<td>-0.002</td>
</tr>
<tr>
<td>Indonesia</td>
<td>-0.002</td>
<td>-0.003</td>
<td>-0.003</td>
<td>-0.003</td>
<td>-0.002</td>
</tr>
<tr>
<td>Japan</td>
<td>-0.003</td>
<td>-0.003</td>
<td>-0.002</td>
<td>-0.001</td>
<td>-0.002</td>
</tr>
<tr>
<td>Korea</td>
<td>-0.006</td>
<td>-0.006</td>
<td>-0.006</td>
<td>-0.006</td>
<td>-0.005</td>
</tr>
<tr>
<td>Malaysia</td>
<td>-0.007</td>
<td>-0.008</td>
<td>-0.008</td>
<td>-0.008</td>
<td>-0.007</td>
</tr>
<tr>
<td>Philippines</td>
<td>-0.002</td>
<td>-0.002</td>
<td>-0.001</td>
<td>-0.001</td>
<td>-0.001</td>
</tr>
<tr>
<td>Singapore</td>
<td>-0.01</td>
<td>-0.013</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
</tr>
<tr>
<td>Thailand</td>
<td>-0.003</td>
<td>-0.003</td>
<td>-0.003</td>
<td>-0.003</td>
<td>-0.002</td>
</tr>
</tbody>
</table>

As shown in Table 2, when looking at the impulse response for 16Q later (four years later) for example, all countries show a negative reaction and values do not change much afterwards. Compared to China and Japan, the degree of shock in Korea, Malaysia, and Singapore is somewhat higher. This is thought to be resulting from the fact that with regard to the aspect of trade, the level of dependency of Korea on the US (or in other words, weighting matrix) is relatively high.

As a reference, let’s also take a look at responses in regions other than the Asian region.

<table>
<thead>
<tr>
<th></th>
<th>8Q later (2 years later)</th>
<th>12Q later (3 years later)</th>
<th>16Q later (4 years later)</th>
<th>20Q later (5 years later)</th>
<th>40Q later (10 years later)</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Asia</td>
<td>-0.004</td>
<td>-0.005</td>
<td>-0.005</td>
<td>-0.005</td>
<td>-0.004</td>
</tr>
<tr>
<td>Europe</td>
<td>-0.006</td>
<td>-0.007</td>
<td>-0.007</td>
<td>-0.007</td>
<td>-0.007</td>
</tr>
<tr>
<td>Latin America</td>
<td>-0.007</td>
<td>-0.008</td>
<td>-0.008</td>
<td>-0.008</td>
<td>-0.008</td>
</tr>
<tr>
<td>Pacific Rim</td>
<td>-0.005</td>
<td>-0.005</td>
<td>-0.005</td>
<td>-0.005</td>
<td>-0.005</td>
</tr>
<tr>
<td>Middle East/Africa</td>
<td>-0.0006</td>
<td>-0.001</td>
<td>-0.002</td>
<td>-0.003</td>
<td>-0.003</td>
</tr>
</tbody>
</table>

As shown in the summary of Table 3, the financial shock that originated in the US also has a

\textsuperscript{10}Each value indicates the accumulated impulse response.
negative impact on other regions. In the Latin American region, active trade transactions with the US are reflected, and the reaction is somewhat high as compared to other regions; in other regions, however, the impacts do not differ greatly, and the common characteristic of the worsening of real economy can be observed. To rephrase, it can be summarized that “the financial shock that originated in the US is impacting nearly the entire world economy.”

5-2 Impacts of the financial shock that originated in Europe

Next, let's validate the impacts of the financial shock that originated in the Euro zone. Similar to the case of the US, Euro zone stock prices are affected by a negative shock one standard deviation’s worth of the residual error. The impacts on the real GDP in the Asian region are observed in impulse reactions.

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Shifts in impulse reactions (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8Q later (2 years later)</td>
</tr>
<tr>
<td>China</td>
<td>-0.002</td>
</tr>
<tr>
<td>Indonesia</td>
<td>0.001</td>
</tr>
<tr>
<td>Japan</td>
<td>0.0004</td>
</tr>
<tr>
<td>Korea</td>
<td>0.0008</td>
</tr>
<tr>
<td>Malaysia</td>
<td>0.0007</td>
</tr>
<tr>
<td>Philippines</td>
<td>0.0004</td>
</tr>
<tr>
<td>Singapore</td>
<td>0.0008</td>
</tr>
<tr>
<td>Thailand</td>
<td>0.002</td>
</tr>
</tbody>
</table>

As shown in Table 4, with regard to the GDPs in the Asian region, only China is affected negatively by the European financial shock; the impacts on other countries are minor. The background to such kinds of results is one where, as confirmed in Figure 1-3, the impact of the Euro zone on China in the aspect of trade has been increasing significantly in recent years. Table 5 organizes the impacts on other regions as well.

<table>
<thead>
<tr>
<th>Table 5</th>
<th>Shifts in impulse reactions (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8Q later (2 years later)</td>
</tr>
<tr>
<td>East Asia</td>
<td>0.0005</td>
</tr>
<tr>
<td>Europe</td>
<td>-0.003</td>
</tr>
<tr>
<td>Latin America</td>
<td>-0.004</td>
</tr>
<tr>
<td>Pacific Rim</td>
<td>-0.0006</td>
</tr>
<tr>
<td>Middle East/Africa</td>
<td>-0.004</td>
</tr>
</tbody>
</table>
China is affected negatively, but for East Asia as a whole, the impacts of the financial crisis originating in Europe remain unobserved for the most part. The region other than the Euro zone in which negative impacts can be significantly seen is the various Latin American countries. It is highly possible that in this region, the strength of transactions with the Euro zone in the aspect of trade is reflected.

In order to further clearly compare the differences in the impacts of the shock that originated in the US and the shock that originated in Europe, the reactions that were calculated above are organized into the forms of Figure 2-1 and Figure 2-2.

Figure 2-1  Impacts of the US shock and European shock on GDP: China

Figure 2-2  Impacts of the US shock and European shock on GDP: Japan and Korea
As clearly shown in Figure 2-1, the impacts of the shock that originated in the US and the shock that originated in Europe can be observed as being approximately the same level in China. However, there is a clear difference in other countries, where the shock that originated in the US has a significantly larger impact. Such kinds of results can also be confirmed to some extent based on real data as well.

Figure 3-1 Shifts in exports from East Asia to the EU after the Lehman shock

Figure 3-2 Shits in exports from East Asia to the EU after the European shock
Figure 3-1 shows the shifts in exports from various East Asian countries to the EU on a monthly basis after September 2008, when the Lehman shock occurred. As clearly indicated in this figure, the exports of all countries fell at once at the end of 2008, taking on the so-called “great trade collapse.” In other words, exports fell all together even in countries that did not have very many trade transactions with Europe, suggesting that the real economy was worsening.

Figure 3-2 shows exports from East Asian countries to the EU on a monthly basis after September 2011, when the European crisis became serious. Contrary to the Lehman shock, the impacts of the great trade collapse are not observed, and only China appears to have a significant decline in exports. It can be inferred from Figure 3-2 that China in particular among the East Asian countries experienced serious worsening of the real economy in the European crisis.

Based on the above validation results, it cannot be said that the financial shocks that originated in the US and Europe had no impact at all on the real economy of East Asia. In particular, it is highly possible that the financial shock that originated in the US yielded a worsening of the real economies of all countries in East Asia. Can it thus be said that these kinds of financial shocks that originated in the US and Europe that affected East Asia are changing diachronically? In other words, are there changes in the interdependence in the aspect of economy among the US, European countries, and East Asian countries arising from structural changes in the world economy? The next section examines this point in further detail.

6. Validations Based on GVAR (2)

6-1 Changes in trade transactions and impacts on the East Asian economies

As observed in Figures 1-1 to 1-4, the trading partners for trade transactions for each country change largely depending on the timing, and these changes also cause changes to the extent of impact with the economies of other countries. When observing Figures 1-1 to 1-4 in further detail, around 1995 as the border, it is suggested that there were changes in trade transactions in all countries. For example, in the case of the US (Figure 1-1), trade transactions with China start increasing significantly around 1995, while those with the Euro zone and Japan start to decrease. In the cases of the Euro zone (Figure 1-2) and Japan (Figure 1-4), trade with China starts increasing around 1995. In the case of China (Figure 1-3), transactions with the Euro zone start increasing around 199511.

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11 Behind such a background, firstly, the growing force behind the gaining power of the Chinese economy that started becoming full-fledged from the mid-1990s can be given. The encouragement of world trade as a whole that started in 1995 by the
Based on the recognition of the abovementioned facts, validations were carried out by setting the period from 1979 2Q to 1994 4Q as Estimation Period (1), and the period from 1979 2Q to 2009 4Q as Estimation Period (2)\(^\text{12}\). Figures 4-1 to 4-3 show comparisons of impulse reactions of China, Korea, and Japan.

**Figure 4-1** Comparison of impulse reactions: China

US stock price shock

![Graph](image1)

Euro zone stock price shock

![Graph](image2)

**Figure 4-2** Comparison of impulse reactions: Korea

US stock price shock

![Graph](image3)

WTO (World Trade Organization) and the increase in exports to regions other than the US (increase in imports from the US perspective) due to the dollar appreciation (currency depreciation of other countries) starting in autumn of 1995 can also be considered as yielding structural change in world trade.

\(^{12}\)Since stable parameter values could not be obtained upon estimating by setting the estimation period as (2) 1995Q1 to 2009 Q4, the initial point for Estimation Period (2) was set as 1979Q2.
The characteristic that is common to the three countries is that the extent to which the shock that originated in the US worsened the real economy is larger during Estimation Period (2) as compared to Estimation Period (1).

In the case of the European shock, the effects on the Korean and Japanese real economics were unclear, and the impacts of changes in estimation periods were also unclear. However, in the case of China, up until approximately 12Q later (three years later), it is clear that Estimation Period (2) worsens the real economy to a greater extent.
Here, the changes in the extent to which the shock that originated in the US worsened real economies is examined in further detail. As seen in Figure 1-3, in China’s case, trade transactions with the US started increasing after the mid-1990s. Accordingly, it is highly possible that such a change in the trade structure makes the impulse reactions (extent of worsening of the real economy) larger when the estimation period is prolonged to 2009. In Japan, on the other hand, as seen in Figure 1-4, trade transactions with the US start to decrease after the mid-1990s. Regardless of this, the extent to which the shock that originated in the US worsened the real economy is larger when the estimation period is prolonged to 2009. These kinds of results are not considered as being necessarily consistent with changes in the trade structure. In order to clarify this point, further detailed consideration of the relationship between economic fluctuations in the East Asian region is essential. This point will be examined in the next section.

7. Relationship of Economic Fluctuations in East Asia and the Causes and Effects

In this section, several complementary validations will be attempted regarding the relationship of economic fluctuations in the East Asian region. By carrying out such a kind of analysis, it should become possible to deeply interpret some of the simulation results obtained in the previous section.

There are various methods to quantitatively comprehend how economic fluctuations mutually relate to each other, as well as their causes and effects. As a representative method, there is the “Granger causality test.” This analysis is a simple method that is carried out based on the VAR method, but it has some limitations. The biggest limitation is that it is only possible to comprehend two-way causal relationships (for example, the US and China). Accordingly, it is not possible to validate the causality among multiple entities at once, such as validate the kind of path (causal relationship) through which the shock that originated in the US propagated to Japan.

Shiotani and Matsubayashi (2013) used a new method known as Bayesian network analysis to attempt to overcome the above problem. Concretely, analysis is carried out regarding the kinds of repercussion mechanisms that propagated the stock price shock that originated in the US to stock prices in the East Asian region (Japan, Korea, Taiwan, China and Thailand)13. The results that were found to be most interesting are those from 2002 to 2003 (Figure 5).

As can be seen from Figure 5, the stock price shock that originated in the US propagated first to China and Korea (and Taiwan). Then, it is clear that it propagated to Japan and there were repercussions in Japan. At the beginning of the 2000s, the stock shock that originated in the US did not have direct repercussions on Japan. The background to such a mechanism being embossed is that there were changes in the trade structure in East Asia during the same period. In the first half of the 2000s, the growing force behind the Chinese economy started gaining power in earnest in East Asia, and the trade structure in East Asia changed greatly. To clarify this image, let’s think about production and consumption of computers. Semiconductors, which make up computers (intermediate goods), are produced in Korea. Based on these semiconductors, several parts for computers as well as machinery to assemble computers (capital goods) are produced in Japan and exported to China. In China, the main computer units (final goods) are finally produced, and then exported to the US, which is a major consumer market. This kind of trade structure is generally referred to as “vertical trading,” and it is this vertical trade structure that generates a new repercussion mechanism for economic fluctuations in East Asia. For example, let’s say that consumption of computers in the US starts to fall suddenly due to the financial shock that originated in the US. This impact first causes direct damage to the Chinese economy, which is the producer of computers. The decrease in computer production in China then indirectly impacts
Japan and Korea, where capital goods and intermediate goods for computers are produced. In other words the conventional economic fluctuations as represented by the saying, “when the US sneezes, Japan catches a cold,” is transforming into a more multifaceted one centering around China due to the progression of vertical trading in East Asia\textsuperscript{14}.

As observed in Figure 4-3, the extent to which the financial shock that originated in the US aggravates Japan’s real economy is larger when the estimation period is prolonged to 2009. This suggests that in association with the progression of vertical trading in East Asia nowadays, the shock that originated in the US is amplifying due to the mechanism of this shock propagating to the Japan through China as an intermediary\textsuperscript{15}.

Here, let’s reconfirm the possibility of occurrence of the mechanism that was explained above using a simple VAR model. Concretely, a VAR where the US (stock prices), Japan (GDP), Korea (GDP), and China (GDP) are the four variables is set. When doing so, a case where the Chinese GDP is the endogenous variable and another where the Chinese GDP is the exogenous variable are assumed, and the impacts on the Japanese and Korean GDPs when a positive shock is applied to US stock prices are viewed. If the mechanism where China serves as an intermediary with regard to economic fluctuations in Japan and Korea is deemed as not being important, there should be no large differences in simulation results between the case where the Chinese GDP is the endogenous variable and the case where it is the exogenous variable. On the other hand, if the role of China cannot be ignored, the results of both cases should differ greatly.

\textsuperscript{14}In Iwasaki, Kawai and Hirakata (2012), a three-country DSGE model based on Japan, China, and the US is constructed. In this model, a vertical trade structure between Japan and China is assumed, and upon analyzing the effects that the increase in productivity in China has on commodity prices in Japan, the point that the role of vertical trading is important is quantitatively confirmed.

When discussing the deepening of interdependence of the economies of various countries, it is extremely important to consider not only transactions in the aspect of trade, but transactions in the aspect of finance as well. With regard to financial transactions and interdependence of the economies of various countries, there are analyses by Bacus et al. (1992), Kose et al. (2003), Imbs (2004)(2006), Bui and Bayoumi (2010), Gracia-Herrero and Ruiz (2008), Dees and Zorell (2011), Kalemli-Ozcecan et al.(2009), etc.

As a method for analyzing linkage among the economies of various countries, "network work analysis" that was developed in the field of sociology is starting to be used.

\textsuperscript{15}However, in Shiotani and Matsubayashi (2013), when the sampling period was 2008 to 2009, it was confirmed that there are direct causes and effects from the US to Japan, in addition to the causal relationship in Figure 5. This indicates that due to the rapid decline in automobile exports to the US due to the Lehman shock during this same period, the existence of trade transactions of automobile trading between the US and Japan were reconfirmed more than transactions of vertical trading in East Asia.
As can be seen from Figures 6-1 and 6-2, the economic boost in Japan and Korea is relatively larger when the Chinese GDP is endogenized. Based on the results obtained from the above supplemental validation, it is suggested that economic fluctuations in the East Asian region increase the extent of interdependence where China is the core. It is necessary to recognize these kinds of changes as a new economic fluctuation mechanism, particularly in the case of Japan.

8. Conclusion

In this paper, quantitative examinations were carried out using time-series analysis regarding the point of how the East Asian economies are affected in a state where global interdependence is deepening. The time-series model used in this analysis is a system known as Global VAR, which captures the interdependence of multiple countries based on trading links; with this system, it is possible to conduct various types of simulations regarding the various problems that the current world economy is faced with. In particular, we were successful in obtaining several interesting findings regarding the kinds of impacts that the financial shock in the US and European countries have on the real economies of East Asian countries. The following is a summarization of the results that were obtained.

1. The financial shock that originated in the US (negative stock prices shock) is aggravating the
real economies of nearly the entire world. This characteristic is unexceptional in the various East Asian countries.

2. There is uneven distribution in the impacts of the financial shock that originated in Europe (Euro zone) on the real economy of each country. Although there are negative effects on the real economies of the Euro zone and Latin America, its impacts on the rest of the world are subtle. Among the East Asian countries, there was aggravation in the real economy of only China.

3. It is possible that the impacts on the East Asian economy, and on the Chinese economy in particular, of economic fluctuations of the US and various European countries are becoming higher starting after the mid-1990s. The background behind this lies in a large structural change in the world economy where “links are becoming more cohesive through trade transactions with China and the US/European economics.”

4. Within East Asia, it is highly possible that China lies at the core of propagation of economic climates. The factor behind this is that trade structures in this region are expanding “vertical trading.”

Summing up the four results above, the economic shocks that are attributable to Europe and the US, which are advanced countries, impact the East Asian economies in no small part; the state is one where it is difficult to say that the economies of the various advanced countries in Europe and the US and the economies of East Asian countries are de-coupling. In other words, it is necessary to supervise the occurrence of financial crises that originated in advanced countries carefully from a global viewpoint, and to carry out policy prescriptions when a crisis occurs, also from a global viewpoint.

When focusing within the East Asian region, “China” is at the core of propagation, and the structural transformation of the world economy, as represented by an expansion in global linkage through the aspect of trade is further being embossed through the existence of China.
References


Han, F and T.H.Ng, (2011), “ASEAN-5 Macroeconomic Forecasting Using a GVAR Model.”


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