**Economic Contagion under Uncertainly:**

**CGE with a Monte Carlo Experiment**

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**Abstract**

Economic contagion is increasingly felt as economic interdependence deepens in today’s economy. This study quantitatively investigates how economic shocks of a certain country influence a different country. Usually, a positive shock has a positive influence, and a negative shock has a negative influence. For instance, the monetary crisis of Europe affected the Asian economy as well as the economy of Europe itself. The Chinese economy, which recently accomplished the most remarkable economic growth in the Asian region, has also declined in rates of growth, and has become a risk factor for the global economy. The downturn of the economy in regions with economic power may have a negative influence on the economy of other countries.

Under such circumstances, this study quantitatively analyzes the economic shock influence of a certain country to other countries, at the same time there is a possibility of influence to the opposite direction supposing the economic shock occurs under uncertainty. The model employed in the study uses the general algebraic modeling system (GAMS), it uses the global trade analysis project (GTAP) database, which is compiled as a computable general equilibrium (CGE) model using multiple countries’ data. Moreover, this database is constantly updated to a recent year to feature more realistic knowledge.

Furthermore, this study uses the Monte Carlo experiment to model uncertainty. This is realizable by adding the random number of a normal distribution to the exogenous variables of the model.

JEL classification: C15, C68, D58, O53, R13

Keywords: Economic Contagion, Multi-country Computable General Equilibrium Model, Monte Carlo Experiment

**1. Introduction**

The global economy has thrived remarkably because of globalization. However, the development of the global economy has recently met a crossroads. The holdup is the considerable influence of economic growth from one economy to other countries. If one representative country’s economic growth is high, it will not be a problem. However, if its economic growth stops, growth of the other countries may start to decrease. The global economy has experienced big crises in the past, but all crises after 1990 met the global economy without causing havoc to the global economy. For example, the 1997 Asian financial crisis, the subprime mortgage crisis, the Greek bond crisis, and the European sovereign debt crisis, and so on. The word “contagion” started to be used to refer to these phenomena around the 1990s.

Contagion is defined as “the spread of market changes or disturbances from one regional market to others. Contagion can refer to the diffusion of either economic booms or economic crises throughout a geographic region” (*Investopedia*, sited on 16th Aug, 2016). Economic contagion is increasingly watched as economic interdependence deepens. In its definition, a positive shock has a positive influence, and a negative shock has a negative influence. For instance, the monetary crisis of Europe affected the Asian economy as well as the economy of Europe itself. The Chinese economy, which accomplished the most remarkable economic growth in the Asian region, has also recently waned in rates of growth. Interdependence is also one of the reasons of the downturn of the economy in Europe. Likewise, the downturn of China’s domestic economy may also be considered. Moreover, the downturn of the economy of a region with economic power may have a negative influence on the economy of other countries. Lately, the United Kingdom decided to leave the EU in a plebiscite. The flounder of the Chinese economy is thought to be more severe than the official statistical publications, and while the world is confused, the politicians’ introverted-oriented remarks are valued by some countries. The current state of affairs may be a trial for keeping up globalization. It can also be said, that the global economy’s uncertainty of the future is rising by these phenomena.

Obviously, it may not become a contagion. Even if a country suffers a negative shock, others may not be affected. Such situations are known as a decoupling.[[1]](#footnote-1) This study quantitatively investigates to what magnitude the economic shock of a certain country should affect a different country, and mentions the possibility of whether it will be a contagion or a decoupling. Concerning the methodology, this study adopts a multi-country computable general equilibrium (CGE) model instead of using an econometric model. The empirical literature on testing for contagion (especially financial contagion) has focused on increases in the correlation of returns between markets during periods of crisis. In this case, the vector autoregression (VAR) model is predominantly used to measure contagion. However, to estimate a VAR model, a sufficient time series sample is required. Moreover, the estimated result cannot necessarily judge whether it is a contagion or not.[[2]](#footnote-2) Then, it is the purpose of this research to propose another method.

Several studies of contagion focus mainly on the financial market (therefore it will be called “financial contagion”). On the other hand, the CGE model estimates economic contagion through international trade by adding the number of handled goods (this model does not deal with the financial market). It is almost entirely different from former studies on this subject. The global trade analysis project (GTAP) model is widely used all over the world as a multi-country CGE model.[[3]](#footnote-3) The CGE model is built on the data of a specific year, and the GTAP model is not an exception. However, the base year is updated every so often. Additionally, the GTAP model can also compute various countries (regions) and custom industries. Therefore, if this model would be used, the influence of contagion can be investigated in many countries at the same time.

As another feature of this study, the uncertain situation of an economy is assumed. When seeing the world’s situation nowadays, you can find out that uncertainty to the future is high. Hence, if an economic forecast is also considered uncertain, it is desirable. This study adopts the Monte Carlo experiment to consider the uncertainty about an economic fluctuation.[[4]](#footnote-4) Because distribution of changes occur with other variables subject to uncertainty, the possibility of a wider economic fluctuation can be considered. Furthermore, when judging whether it shows economic propagation, the direction of change of other variables (here positive or negative rates) is important. Therefore, it is possible to explore the robustness of the direction of change by simulating uncertainty of the variables.

**2. Evidence**

Figure 1 to Figure 3 show graphs of the economic growth rate of the selected economies, which include several Asian countries.[[5]](#footnote-5) Furthermore, in 1990 and afterwards, there have been two spells of economic crises. The first time was the Asian financial crisis in 1997, and the second time was the subprime mortgage crisis in 2009. Moreover, the European Union with the Greece crisis, continued a downturn until 2011, their hope of economic convergence is not possible at the present time. It can be said that Greece and the European Union, is one example of economic contagion in a negative direction. Obviously, all countries in the contagions above did suffer from a reduction of growth, which can be regarded as a decoupling.

Table 1 and Table 2 show the percentage in two standards of growth, one exceeding a positive growth rate, and the other a global average of these countries. First on Table 1, for each year you can appreciate the countries’ results, and the contraction of the economy in 1998 and on 2009, portraying an economic crisis. Additionally in 1998, in comparison with the global average, because the economic crisis was mainly in Asia, their growth rates were below average, the Asian continent contracted more than half its economy. Second, there was a continued growth rate in many countries, as you can see in Table 1, in the first years of the 2000s, the majority of the countries exceeded the global average, and their performance was also stable. Third, Table 2 shows the economic growth rate of each region in 1990 and afterwards, China, India, Laos, and Vietnam had positive growth rates during these periods. On the other hand, in Brunei, Japan, and Russia, about 1/4 of the period had a reduction of the economy. It turns out that the economic growth of Japan was very low. Fourth, in comparison with the global average, China and Laos are the only ones that have fulfilled economic growth every year. On the other hand, Brunei, Canada, the European Union, Japan, and the United States recorded less than the global average in many years. This analysis is simple, however, a possibility of both a contagion and a decoupling could be discerned.

**3. Model and Simulation**

Under such a context, this study quantitatively analyzes the economic shock influence from some countries to other countries, at the same time the possibility of a reduction in the rate of growth is presumed when an economic shock occurs under uncertainty. The model employed is the general algebraic modeling system (GAMS) code which Rutherford (2010) advocates, this study also uses the trade data from the GTAP.[[6]](#footnote-6)

Data from the GTAP can be taken out independently, when these variables indicate a structure of the input-output table, shown in Table 3. To use the GTAP database, it is necessary to first aggregate the production factor, the production sector, and the regions.[[7]](#footnote-7) In this study, the production factor was not aggregated. However, Table 4 aggregates 18 commodities (production sectors) and 20 regions (countries). These are specific to the typical Asian country’s economic sectors, these industries are added to the GTAP calculation, the selection of industries has been made independently by the author

However, when making 2007 the base year, a problem surges of not using the most recent data. That is because the Chinese gross domestic product (GDP) was smaller than the Japanese GDP in that year. The Chinese GDP passed Japan’s in 2010. Therefore, it is more desirable to use a recent database. The GTAP has already published the GTAP 9 database, which includes the reference year of 2011, but it is not efficient to wait for new data to be published. Therefore, to renew the GTAP data, this study considered updating the report to 2014.

We worked the estimation of 2014 data based on the 2007 data.

1. Multiply the items using the growth rate of Table 5 for “vom”, “vfm”, “vdfm”, “vifm”, “vxmd” and “vtwr” of Table 3.

2. Estimating the adjustment parameter from the condition of vom = vdfm + rtfd + vifm + rtfi + vfm + rtf + rto of Table 3.

3. Recalculate the “vfm”, “vdfm”, “vifm”.

4. Estimating the adjustment parameters from conditions of vifm = vxmd + vtwr + rtxs + rtms of Table 3.

5. Recalculate the “vxmd”, “vtwr”, “vst” (aggregate of “vtwr”).

6. Estimating the adjustment parameters from condition of vom = vdfm + vxmd + vst.

7. Recalculate the “vom”.

8. Repeat (2 to 7).

This study reports six simulations by using estimated data. The Monte Carlo experiment is applied because it can model uncertainty. It is realizable by adding the random number of a normal distribution to the exogenous variables of the model. The normal random number which has an average of 1, and the calculated standard deviation is multiplied to one or two variables. Table 6 shows the variable, target country, and the standard deviation that performs the simulation.[[8]](#footnote-8) Simulation 1 is a case where Chinese consumption demand has uncertainty. Simulation 2 is a case where the European Union’s consumption demand has uncertainty. Simulation 3 is a case where Chinese labor supply has uncertainty. Simulation 4 is a case where consumption demand in China and the European Union have uncertainty. Simulation 5 is a case where Chinese consumption demand and labor supply have uncertainty. Simulation 6 is a case where India’s consumption demand has uncertainty. The uncertainty characteristics are taken up as a reference for the selection of a country in this study. Regarding the uncertainty of consumption demand and labor supply, the intention of people’s behavior is likely to change dramatically due to changes in the economic situation. The standard deviation differs in each simulation, in order that it may assemble the influence of a simulation result to some extent. For example, consumption in United States and the European Union is much larger than China’s (Table 7), so we set the degree of uncertainty at 5% in China, and 1% in the European Union, respectively. On the other hand, although the share of labor in China is high, the influence of uncertainty of Chinese labor has on a foreign country is not great, we set the degree of uncertainty to 10%.[[9]](#footnote-9)

**4. Result**

The result of each simulation is introduced below. First, Table 7 shows the calibration result for use by all simulations. The GDP of China exceeds Japan’s, but it does not reach that of the United States and the European Union. In addition, value added (unskilled) labor in China is relatively high. Table 8 to Table 13 show the change of the GDP of each country by using 200 experiments for every simulation. The table reports the maximum, the minimum, the average, and the standard deviation. For example, in the Simulation 1 (Table 8), when consumption demand of China has 5% of uncertainty, the GDP of China receives more than a 5% change in the standard deviation, and there is more than 30% difference between the maximum and the minimum. Moreover, the change of about 4% is set to other countries, and the influence to the global economy by the fluctuation of the Chinese economy can be seen.[[10]](#footnote-10) However, it can be said that this is about the same rate of change of the European Union’s economy. Simulation 2 (Table 9) has grown the GDP to 1% of uncertainty from the consumption demand of the European Union. The European Union has also more than 3% change in the standard deviation, and about a 3% change in foreign countries. This is because the level of consumption of the 27 countries of the European Union is very large as shown in Table 7. Therefore, it can be said that the influence of 1% of uncertainty to the global economy is considerable.

Next, when the (unskilled) labor supply of China has 10% of uncertainty (Simulation 3), and about a 4% change in standard deviation, there is hardly any effect to other countries. Because the uncertainty of supply of labor is affected by domestic production, is not affected directly by foreign trade, it is considered not to cause change to other countries (Table 10).

Since Simulation 4 (Table 11) and Simulation 5 (Table 12) are a combination of the above-mentioned simulations, the result depends on two uncertainties that reshape the positive or negative change of the GDP.

Finally, we will introduce the case of India where future growth can be expected (Table 13). When the consumption demand of India has 5% of uncertainty, the GDP of India takes more than a 6% change in the standard deviation. However, influence to the global economy stops at about 2% of change in the standard deviation. It turns out that influence from a country to another country by uncertainty of consumption demand is largest in the European Union, second in China, and last in India. The uncertainty of consumption demand is related to the initial value of the consumption demand.[[11]](#footnote-11)

However, the direction of change is not known, taking from the above result, and it is not yet validated whether it is a contagion or a decoupling. Below we will discuss positive or negative outcomes from the results. We totaled the entries and the positive or negative values of the 200 experiments. Table 14 shows how many of the 200 experiments differed in the sign in each region (country). Here, for each simulation, when signs differ even once, 1 time is counted as causing uncertainty. In other words, 200 times means that in each simulation, some region always shows a different sign. And, 0 times means that the same sign is shown in all regions.

As far as Table 14 is concerned, it shows the change of quantity of production of many industries, and the amount of consumption, so we can see that the signs may differ in each region. Yet, the GDP shows some differences on all simulations. For example, in Simulation 1 and in Simulation 2, the influence uncertainty brings remains only in the change of quantity, and all regions can be referred to as having the same sign. This can be interpreted as a highly probable likeliness that the economy will be affected by contagion in each region. On the other hand, in the case of Simulation 3, it is the contrary, and it serves as a decoupling event. Nevertheless, from Table 10, we can see the likeliness of a decoupling, since the changes that affect other countries are very small.

When the uncertainty of consumption demand exists in China and the European Union randomly, the result of Simulation 4 shows that there is a possibility of decoupling. Additionally, the possibility of decoupling exists when consumption demand and labor supply are uncertain.

**5. Concluding Remarks**

This study explains the possibility of economic contagion or a decoupling between many countries by the framework of the CGE model. The methodology gave uncertainty to the (fixed) variable in a CGE model, analyzed the width and the direction of change by conducting a Monte Carlo experiment. As a result, the uncertainty of consumption demand provides change in the same direction as other countries. Therefore, if positive, the influence affects the global economy, but if it is negative, it will influence the global economy with negative outcomes. However, if uncertainty happened randomly in two or more countries, it will not necessarily become a contagion. On the other hand, the uncertainty of labor supply brings about the possibility of decoupling, although the influence to other countries is small.

The economic conditions of the present era seem to just spread negatively. Obviously, the problem will be solved if the consumption demand of China or the European Union (big economies with magnitude) is improved. Nonetheless, if not damaged by contangion, a country may become an example to follow.

All situations possible were not considered, and it will be necessary to pursue a more realistic situation of this experiment in future studies.

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Figure 1 Economic Growth Rates of the Selected Regions (1) (1990–2014)

(Source) IMF: *International Financial Statistics* (January, 2016) and http://ecodb.net/

Figure 2 Economic Growth Rates of the Selected Regions (2) (1990–2014)

(Source) IMF: *International Financial Statistics* (January, 2016) and http://ecodb.net/

Figure 3 Economic Growth Rates of the Selected Regions (3) (1990–2014)

(Source) IMF: *International Financial Statistics* (January, 2016) and http://ecodb.net/

Table 1 Percentage of the Economic Growth Rate of Selected Regions (year base, %)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Year | Positive growth rate | Higher than world growth | Year | Positive growth rate | Higher than world growth |
| 1990 | 100.00 | 59.09 |  |  |  |
| 1991 | 78.26 | 63.64 | 2003 | 100.00 | 66.67 |
| 1992 | 91.30 | 68.18 | 2004 | 100.00 | 62.50 |
| 1993 | 95.83 | 78.26 | 2005 | 100.00 | 58.33 |
| 1994 | 91.67 | 82.61 | 2006 | 100.00 | 66.67 |
| 1995 | 95.83 | 65.22 | 2007 | 100.00 | 70.83 |
| 1996 | 92.00 | 66.67 | 2008 | 84.00 | 62.50 |
| 1997 | 92.00 | 66.67 | 2009 | 48.00 | 54.17 |
| 1998 | 56.00 | 45.83 | 2010 | 100.00 | 50.00 |
| 1999 | 92.00 | 66.67 | 2011 | 96.00 | 54.17 |
| 2000 | 100.00 | 62.50 | 2012 | 96.00 | 62.50 |
| 2001 | 92.00 | 62.50 | 2013 | 92.00 | 54.17 |
| 2002 | 100.00 | 83.33 | 2014 | 88.00 | 45.83 |

(Note) Selected regions defined as Table 2. It shows percentages of the region beyond the two standards calculated from the selected regions (24 regions) in each year.

(Source) Author’s calculation

Table 2 Percentage of the Economic Growth Rate of Selected Regions (region base, %)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Region | Positive growth rate | Higher than world growth | Region | Positive growth rate | Higher than world growth |
| World | 96.00 |  |  |  |  |
| Australia | 96.00 | 44.00 | Korea | 96.00 | 76.00 |
| Brazil | 92.00 | 36.00 | Laos | 100.00 | 100.00 |
| Brunei | 76.00 | 16.00 | Malaysia | 92.00 | 88.00 |
| Cambodia | 96.00 | 88.00 | Myanmar | 96.00 | 88.00 |
| Canada | 92.00 | 24.00 | New Zealand | 92.00 | 36.00 |
| Hong Kong | 92.00 | 60.00 | Philippines | 92.00 | 68.00 |
| China | 100.00 | 100.00 | Russia | 72.73 | 54.55 |
| Macao | 80.00 | 76.00 | Singapore | 88.00 | 80.00 |
| Euro Area | 84.21 | 10.53 | Taiwan | 92.00 | 80.00 |
| India | 100.00 | 92.00 | Thailand | 88.00 | 68.00 |
| Indonesia | 96.00 | 84.00 | United States | 92.00 | 28.00 |
| Japan | 76.00 | 8.00 | Vietnam | 100.00 | 96.00 |

(Note) It shows percentages of the year beyond the two standards calculated from the selected years (1990-2014, 1996-2014 in Euro Area, 1993-2014 in Russia) in each region.

(Source) Author’s calculation

Table 3 Simple Description of GTAP Data

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | intermediate | | expenditure | | export | | transportation | output |
| Region 1 | Region 2 | Region 1 | Region 2 | Region 1 | Region 2 |  |  |
| intermediate | R 1 | vdfm | vifm | vdfm | vifm | vxmd | vxmd | vst (vtwr) | vom |
|  | R 2 | vifm | vdfm | vifm | vdfm | vxmd | vxmd | vst (vtwr) | vom |
| tax | R 1 | rtfd | rtfi | rtfd | rtfi |  |  |  |  |
|  | R 2 | rtfi | rtfd | rtfi | rtfd |  |  |  |  |
| factor | | vfm | vfm |  |  |  |  |  |  |
| tax | | rtf | rtf |  |  |  |  |  |  |
| subsidy | | rto | rto |  |  |  |  |  |  |
| output | | vom | vom | vom | vom |  |  |  |  |

(Note) All variables are defined by Rutherford (2010).

vom: Aggregate output.

vfm: Endowments, firms’ purchases at market prices.

vdfm: Intermediates, firms’ domestic purchases at market prices.

vifm: Intermediates, firms’ imports at market prices.

vxmd: Trade, bilateral exports at market prices.

vst: Trade, exports for international transportation. Aggregate of “vtwr”.

vtwr: Trade, margins for international transportation at world prices.

rtxs: Export subsidy (rate).

rtms: Import taxes (rate).

rto: Output subsidy (rate).

rtf: Primary factor and commodity taxes (rate).

rtfd: Firms domestic tax (rate).

rtfi: Firms’ import tax (rate).

vifm = vxmd + vtwr + rtxs + rtms (zero profit condition for import).

(Source) GTAP 8 Database and author

Table 4 Mapping Information

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Production Factor | | Production Sector | | Country (Region) | |
| lab | Unskilled labor | agri | Agriculture | aus | Australia and New Zealand |
| skl | Skilled labor | mine | Mining | chn | China |
| cap | Capital | food | Food | hkg | Hong Kong |
| res | Resources | text | Textiles | jpn | Japan |
| lnd | Land | wood | Wood | kor | Korea |
|  |  | peto | Petroleum Chemical | idn | Indonesia |
|  |  | meta | Metals | mys | Malaysia |
|  |  | moto | Motor vehicles | twn | Taiwan |
|  |  | elec | Electronic equipment | phl | Philippines |
|  |  | mech | Machinery and others | sgp | Singapore |
|  |  | egwp | Electricity Gas Water | tha | Thailand |
|  |  | cons | Construction | vnm | Vietnam |
|  |  | trad | Trade | asa | Other ASEAN countries |
|  |  | ntra | Transport | ind | India |
|  |  | wtra | Water transport | can | Canada |
|  |  | atra | Air transport | usa | United States |
|  |  | comm | Communication | bra | Brazil |
|  |  | serv | Other services | eeu | European Union |
|  |  |  |  | rus | Russian Federation |
|  |  |  |  | xwd | Rest of the World |

(Source) GTAP 8 Database and author

Table 5 Growth Rate for Estimation

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 2007-14 | average |  | 2007-14 | average |
| aus | 1.243 | 1.028 | tha | 1.251 | 1.028 |
| chn | 2.054 | 1.094 | vnm | 1.586 | 1.059 |
| hkg | 1.275 | 1.031 | ind | 1.758 | 1.073 |
| jpn | 1.028 | 1.003 | can | 1.134 | 1.016 |
| kor | 1.311 | 1.034 | usa | 1.092 | 1.011 |
| twn | 1.313 | 1.035 | bra | 1.286 | 1.032 |
| idn | 1.564 | 1.057 | rus | 1.210 | 1.024 |
| mys | 1.453 | 1.048 | asa | 1.836 | 1.079 |
| phl | 1.519 | 1.054 | eeu | 1.038 | 1.005 |
| sgp | 1.502 | 1.052 | xwd | 1.288 | 1.032 |

(Source) IMF: *International Financial Statistics* (January, 2016) and http://ecodb.net/

Table 6 Simulation Design

|  |  |  |  |
| --- | --- | --- | --- |
| Simulation | Sector | Country | Frequency |
| Simulation 1 | Consumption | China (chn) | 0.05 |
| Simulation 2 | Consumption | EU (eeu) | 0.01 |
| Simulation 3 | (Unskilled) Labor | China (chn) | 0.10 |
| Simulation 4 | Simulation 1 + Simulation 2 |  |  |
| Simulation 5 | Simulation 1 + Simulation 3 |  |  |
| Simulation 6 | Consumption | India (ind) | 0.05 |

(Note) We use a random number of a normal distribution whose average is 1 in the Monte Carlo experience.

(Source) Author

Table 7 Initial (Monetary) Value and Share of Consumption, (Unskilled) Labor, and GDP (billion USD, %)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Consumption |  | Labor |  | GDP |  |
| aus | 693.365 | 1.77 | 381.082 | 2.08 | 1256.390 | 1.89 |
| chn | 2686.705 | 6.85 | 2548.499 | 13.92 | 6950.825 | 10.44 |
| hkg | 158.163 | 0.40 | 56.404 | 0.31 | 274.841 | 0.41 |
| jpn | 2567.578 | 6.54 | 1229.793 | 6.72 | 4550.522 | 6.84 |
| kor | 739.889 | 1.89 | 403.625 | 2.20 | 1395.598 | 2.10 |
| twn | 280.257 | 0.71 | 154.086 | 0.84 | 548.376 | 0.82 |
| idn | 421.354 | 1.07 | 210.399 | 1.15 | 680.296 | 1.02 |
| mys | 113.274 | 0.29 | 79.419 | 0.43 | 274.678 | 0.41 |
| phl | 153.696 | 0.39 | 54.398 | 0.30 | 224.260 | 0.34 |
| sgp | 101.098 | 0.26 | 63.449 | 0.35 | 249.754 | 0.38 |
| tha | 157.861 | 0.40 | 73.767 | 0.40 | 313.505 | 0.47 |
| vnm | 72.942 | 0.19 | 28.370 | 0.15 | 106.648 | 0.16 |
| ind | 1287.651 | 3.28 | 713.328 | 3.90 | 2168.014 | 3.26 |
| can | 915.957 | 2.33 | 459.387 | 2.51 | 1596.433 | 2.40 |
| usa | 10866.294 | 27.69 | 5051.520 | 27.59 | 15427.127 | 23.18 |
| bra | 1047.983 | 2.67 | 489.378 | 2.67 | 1765.119 | 2.65 |
| rus | 808.839 | 2.06 | 294.348 | 1.61 | 1560.909 | 2.34 |
| asa | 46.255 | 0.12 | 18.614 | 0.10 | 75.523 | 0.11 |
| eeu | 10313.136 | 26.28 | 3624.866 | 19.79 | 17368.993 | 26.09 |
| xwd | 5812.897 | 14.81 | 2377.513 | 12.98 | 9779.709 | 14.69 |
|  | 39245.194 |  | 18312.245 |  | 66567.520 |  |

(Source) Calibrated by author based on GTAP 8 Database (reference years of 2007)

Table 8 Change of GDP (Simulation 1)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | aus | chn | hkg | jpn | kor |
| max | 1.135015 | 1.190151 | 1.145222 | 1.141910 | 1.139505 |
| min | 0.907114 | 0.875085 | 0.899191 | 0.901436 | 0.902436 |
| average | 1.006497 | 1.009378 | 1.006954 | 1.006792 | 1.006650 |
| std dev | 0.040292 | 0.055557 | 0.043522 | 0.042533 | 0.041945 |
|  | twn | idn | mys | phl | sgp |
| max | 1.151083 | 1.137238 | 1.144489 | 1.142552 | 1.153363 |
| min | 0.894690 | 0.905374 | 0.899253 | 0.900394 | 0.891993 |
| average | 1.007216 | 1.006597 | 1.006902 | 1.006799 | 1.007282 |
| std dev | 0.045357 | 0.041002 | 0.043395 | 0.042845 | 0.046266 |
|  | tha | vnm | ind | can | usa |
| max | 1.142400 | 1.124727 | 1.137756 | 1.136622 | 1.138509 |
| min | 0.900429 | 0.910397 | 0.904242 | 0.905193 | 0.903808 |
| average | 1.006789 | 1.005855 | 1.006590 | 1.006542 | 1.006629 |
| std dev | 0.042814 | 0.037990 | 0.041304 | 0.040932 | 0.041512 |
|  | bra | rus | asa | eeu | xwd |
| max | 1.133085 | 1.128793 | 1.127625 | 1.138382 | 1.051904 |
| min | 0.908408 | 0.911797 | 0.911580 | 0.903685 | 0.964808 |
| average | 1.006402 | 1.006214 | 1.006120 | 1.006614 | 1.002520 |
| std dev | 0.039719 | 0.038357 | 0.038221 | 0.041514 | 0.015393 |

(Source) Author’s calculation

Table 9 Change of GDP (Simulation 2)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | aus | chn | hkg | jpn | kor |
| max | 1.080046 | 1.084368 | 1.085306 | 1.083755 | 1.084305 |
| min | 0.918316 | 0.913583 | 0.912702 | 0.914188 | 0.913464 |
| average | 1.002709 | 1.002839 | 1.002875 | 1.002818 | 1.002829 |
| std dev | 0.028855 | 0.030464 | 0.030790 | 0.030246 | 0.030470 |
|  | twn | idn | mys | phl | sgp |
| max | 1.085199 | 1.080592 | 1.081309 | 1.083899 | 1.084909 |
| min | 0.912315 | 0.917808 | 0.916499 | 0.913831 | 0.912274 |
| average | 1.002848 | 1.002729 | 1.002726 | 1.002813 | 1.002822 |
| std dev | 0.030830 | 0.029045 | 0.029394 | 0.030331 | 0.030778 |
|  | tha | vnm | ind | can | usa |
| max | 1.083051 | 1.084075 | 1.082115 | 1.081485 | 1.082550 |
| min | 0.914700 | 0.914132 | 0.915976 | 0.916615 | 0.915524 |
| average | 1.002784 | 1.002841 | 1.002768 | 1.002746 | 1.002782 |
| std dev | 0.030025 | 0.030320 | 0.029637 | 0.029410 | 0.029795 |
|  | bra | rus | asa | eeu | xwd |
| max | 1.079825 | 1.079034 | 1.078630 | 1.094796 | 1.031152 |
| min | 0.918581 | 0.919581 | 0.920109 | 0.903725 | 0.968640 |
| average | 1.002703 | 1.002685 | 1.002677 | 1.003230 | 1.001075 |
| std dev | 0.028769 | 0.028454 | 0.028291 | 0.034100 | 0.011162 |

(Source) Author’s calculation

Table 10 Change of GDP (Simulation 3)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | aus | chn | hkg | jpn | kor |
| max | 1.003048 | 1.110497 | 1.003724 | 1.011001 | 1.012501 |
| min | 0.996242 | 0.893268 | 0.992010 | 0.983830 | 0.981810 |
| average | 1.000072 | 0.996474 | 0.999927 | 1.000137 | 1.000165 |
| std dev | 0.001192 | 0.038692 | 0.002017 | 0.004754 | 0.005369 |
|  | twn | idn | mys | phl | sgp |
| max | 1.011560 | 1.006062 | 1.012862 | 1.006634 | 1.023321 |
| min | 0.982401 | 0.992925 | 0.982590 | 0.988739 | 0.968666 |
| average | 1.000116 | 1.000162 | 1.000232 | 1.000011 | 1.000431 |
| std dev | 0.005096 | 0.002313 | 0.005319 | 0.003102 | 0.009605 |
|  | tha | vnm | ind | can | usa |
| max | 1.012203 | 1.022218 | 1.010335 | 1.008319 | 1.010152 |
| min | 0.983757 | 0.978818 | 0.986746 | 0.988972 | 0.986028 |
| average | 1.000232 | 1.000820 | 1.000221 | 1.000160 | 1.000172 |
| std dev | 0.004986 | 0.007724 | 0.004144 | 0.003394 | 0.004229 |
|  | bra | rus | asa | eeu | xwd |
| max | 1.004139 | 1.000828 | 1.003860 | 1.010728 | 1.003771 |
| min | 0.995148 | 0.999511 | 0.999297 | 0.985334 | 0.995555 |
| average | 1.000110 | 1.000045 | 1.000295 | 1.000186 | 1.000099 |
| std dev | 0.001585 | 0.000245 | 0.000867 | 0.004453 | 0.001450 |

(Source) Author’s calculation

Table 11 Change of GDP (Simulation 4)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | aus | chn | hkg | jpn | kor |
| max | 1.136315 | 1.172474 | 1.145965 | 1.142993 | 1.142365 |
| min | 0.887405 | 0.862698 | 0.878611 | 0.881052 | 0.881256 |
| average | 1.011143 | 1.014949 | 1.011914 | 1.011645 | 1.011476 |
| std dev | 0.053866 | 0.068402 | 0.057920 | 0.056709 | 0.056354 |
|  | twn | idn | mys | phl | sgp |
| max | 1.148648 | 1.137936 | 1.142081 | 1.143426 | 1.149625 |
| min | 0.875359 | 0.885962 | 0.881033 | 0.880104 | 0.873569 |
| average | 1.012234 | 1.011300 | 1.011708 | 1.011655 | 1.012312 |
| std dev | 0.059520 | 0.054598 | 0.056877 | 0.057026 | 0.060265 |
|  | tha | vnm | ind | can | usa |
| max | 1.142635 | 1.135517 | 1.139538 | 1.138422 | 1.140295 |
| min | 0.880688 | 0.887126 | 0.884024 | 0.885058 | 0.883467 |
| average | 1.011618 | 1.010488 | 1.011333 | 1.011247 | 1.011398 |
| std dev | 0.056795 | 0.052926 | 0.055249 | 0.054779 | 0.055534 |
|  | bra | rus | asa | eeu | xwd |
| max | 1.135184 | 1.132448 | 1.131683 | 1.151190 | 1.052981 |
| min | 0.888425 | 0.891342 | 0.891560 | 0.876005 | 0.957266 |
| average | 1.011013 | 1.010745 | 1.010632 | 1.011813 | 1.004351 |
| std dev | 0.053319 | 0.051955 | 0.051720 | 0.058547 | 0.020685 |

(Source) Author’s calculation

Table 12 Change of GDP (Simulation 5)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | aus | chn | hkg | jpn | kor |
| max | 1.141646 | 1.239613 | 1.151858 | 1.146892 | 1.144021 |
| min | 0.918769 | 0.887801 | 0.910665 | 0.909216 | 0.909280 |
| average | 1.007980 | 1.007970 | 1.008378 | 1.008372 | 1.008226 |
| std dev | 0.041669 | 0.067151 | 0.045102 | 0.044586 | 0.044117 |
|  | twn | idn | mys | phl | sgp |
| max | 1.156415 | 1.143316 | 1.149187 | 1.148528 | 1.156127 |
| min | 0.902856 | 0.915996 | 0.906909 | 0.910291 | 0.894735 |
| average | 1.008862 | 1.008188 | 1.008613 | 1.008269 | 1.009247 |
| std dev | 0.047558 | 0.042548 | 0.045571 | 0.044588 | 0.049626 |
|  | tha | vnm | ind | can | usa |
| max | 1.147354 | 1.127044 | 1.142984 | 1.142090 | 1.143667 |
| min | 0.908124 | 0.914370 | 0.912450 | 0.914329 | 0.911948 |
| average | 1.008470 | 1.007962 | 1.008217 | 1.008110 | 1.008214 |
| std dev | 0.044922 | 0.040648 | 0.043205 | 0.042668 | 0.043433 |
|  | bra | rus | asa | eeu | xwd |
| max | 1.139522 | 1.135521 | 1.134020 | 1.143366 | 1.053812 |
| min | 0.919246 | 0.924168 | 0.923654 | 0.911619 | 0.968137 |
| average | 1.007892 | 1.007621 | 1.007775 | 1.008213 | 1.003160 |
| std dev | 0.041148 | 0.039553 | 0.039453 | 0.043476 | 0.016070 |

(Source) Author’s calculation

Table 13 Change of GDP (Simulation 6)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | aus | chn | hkg | jpn | kor |
| max | 1.067289 | 1.068417 | 1.068454 | 1.066936 | 1.066162 |
| min | 0.955574 | 0.953899 | 0.953634 | 0.955226 | 0.955418 |
| average | 1.003221 | 1.003246 | 1.003241 | 1.003187 | 1.003141 |
| std dev | 0.019424 | 0.019954 | 0.020022 | 0.019455 | 0.019303 |
|  | twn | idn | mys | phl | sgp |
| max | 1.066873 | 1.069518 | 1.063551 | 1.066090 | 1.063462 |
| min | 0.954546 | 0.954474 | 0.956594 | 0.955204 | 0.956267 |
| average | 1.003160 | 1.003336 | 1.002998 | 1.003128 | 1.002981 |
| std dev | 0.019592 | 0.019977 | 0.018668 | 0.019337 | 0.018727 |
|  | tha | vnm | ind | can | usa |
| max | 1.065346 | 1.058091 | 1.257004 | 1.066217 | 1.066528 |
| min | 0.955456 | 0.956585 | 0.869950 | 0.955787 | 0.955402 |
| average | 1.003083 | 1.002616 | 1.013656 | 1.003154 | 1.003164 |
| std dev | 0.019170 | 0.017880 | 0.065877 | 0.019224 | 0.019356 |
|  | bra | rus | asa | eeu | xwd |
| max | 1.064026 | 1.066022 | 1.081176 | 1.065993 | 1.023553 |
| min | 0.957014 | 0.956740 | 0.949280 | 0.955475 | 0.983699 |
| average | 1.003040 | 1.003171 | 1.003975 | 1.003130 | 1.001105 |
| std dev | 0.018633 | 0.018986 | 0.022795 | 0.019265 | 0.006970 |

(Source) Author’s calculation

Table 14 Number of the Different Signs in 200 Experiences

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Simulation 1 | Simulation 2 | Simulation 3 | Simulation 4 | Simulation 5 | Simulation 6 |
| consumption | 200 | 200 | 200 | 200 | 200 | 200 |
| agri | 200 | 0 | 0 | 179 | 113 | 200 |
| mine | 200 | 200 | 200 | 200 | 176 | 200 |
| food | 200 | 200 | 200 | 200 | 200 | 200 |
| text | 200 | 200 | 200 | 200 | 195 | 200 |
| wood | 200 | 200 | 200 | 200 | 200 | 200 |
| peto | 200 | 200 | 200 | 200 | 200 | 200 |
| meta | 200 | 200 | 200 | 200 | 200 | 200 |
| moto | 200 | 200 | 200 | 200 | 200 | 200 |
| elec | 200 | 200 | 200 | 200 | 200 | 200 |
| mech | 200 | 200 | 200 | 200 | 200 | 200 |
| egwp | 200 | 200 | 200 | 200 | 200 | 200 |
| cons | 200 | 200 | 200 | 200 | 200 | 200 |
| trad | 200 | 200 | 200 | 200 | 200 | 200 |
| ntra | 200 | 200 | 200 | 200 | 200 | 200 |
| wtra | 200 | 200 | 200 | 200 | 200 | 200 |
| atra | 200 | 200 | 200 | 200 | 200 | 200 |
| comm | 200 | 200 | 200 | 200 | 200 | 200 |
| serv | 200 | 200 | 200 | 200 | 173 | 200 |
| gdp | 0 | 0 | 200 | 11 | 55 | 0 |

(Note) After a simulation, if the sign of all regions is the same, it will not count, but it will be counted if at least one region marks different sign. This table shows the case where the different sign is counted at the time of conducting Monte Carlo experiment 200 times.

(Source) Author’s calculation

1. Decoupling is defined as “the occurrence of returns on asset classes diverging from their expected or normal pattern of correlation. Decoupling takes place when two different asset classes that typically rise and fall together move in opposing directions, such as one increasing and the other decreasing (*Investopedia*, 2016)”. Rise of the developing countries called BRICs (Brazil, Russia, India and China) have increased the public attention to the meaning of decoupling. Nevertheless, economic growth is also recently decreasing in these countries. [↑](#footnote-ref-1)
2. These arguments are introduced by *Wikipedia* (“Financial contagion”, sited on 16th Aug, 2016). Therefore, we do not site related literatures in this study. [↑](#footnote-ref-2)
3. In detail, see Hertel, eds. (1997). [↑](#footnote-ref-3)
4. Now, literature on the CGE model is also diverse and it is very difficult to introduce them in detail. The combination of the CGE model and the Monte Carlo experiment has never been used in the field, for example, the research of Abler et al. (1999) and Harris and Robinson (2001) are relatively old. [↑](#footnote-ref-4)
5. Selection of the countries is integrated with the candidate country of the simulation which introduces next. [↑](#footnote-ref-5)
6. GTAP model has also calculation software (General Equilibrium Modelling PACKage, GEMPACK). However, the way GTAP is rewritten in the GAMS code tends to make an extension and a correction of the model. Although various improvements were considered for the Rutherford model in this study, the original model was used as it was, and the present study only added the Monte Carlo experiment code. [↑](#footnote-ref-6)
7. The GTAP 8 database, boasts dual reference years, 2004 and 2007, as well as 129 regions for all 57 GTAP commodities. We use 2007 for the reference year and estimate to the statistics of the year 2014. [↑](#footnote-ref-7)
8. In GAMS code, vom (“c”, r) is consumption demand and evom (“lab”, r) is (unskilled) labor supply (“evom” is disaggregated of “vfm”). These variables show the monetary value and they are exogenous in the model. For the endogenous variables, the model sets up change of quantity (*Y*, *FT* and so on) and change of a price (*P*, *PF* and so on) which sets the initial value to 1, respectively. [↑](#footnote-ref-8)
9. This setting was decided after doing simulation experiments many times. [↑](#footnote-ref-9)
10. In the Rutherford model, the region which is the largest initial value of the representative agent is set as the numeraire region. Because the value of the representative agent is fixed in the numeraire region, therefore there is no fluctuation in the representative agent after a simulation, and the fluctuation of the GDP is also small. When the data of this study was used, the initial value of the representative agent of the United States is the largest in the model. Because of the fluctuation of the GDP of the United States becoming small, when it is simulated, the rest of the world (xwd) is set as the numeraire region in this study. [↑](#footnote-ref-10)
11. In this model, we assume the economy of 27 Euro countries are aggregated as one region. Obviously, a different result will be expected when the European Union is taken apart in several areas or countries. [↑](#footnote-ref-11)