Changes in the global economic environment and their impacts on Korean exports

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Abstract

This paper estimates bilateral export functions of Korea to its four major trading partners (China, the Euro Zone, Japan, and the US) and examines the impacts of changes in the global economic environment on Korean exports based on the estimation results. Both income elasticity and price elasticity are estimated to have the expected signs. External demand for the products of Korea’s Asian trading partners also plays an important role in determining Korean exports to those countries. Although the recovery of the global economy is expected to contribute to an increase in Korean exports, appreciation of the Korean won will reduce its impact. Because Korea’s economy heavily depends on external demand, especially on imports by China, a negative shock to the Chinese economy would more severely damage the Korean economy than the recent financial crisis, which mainly damaged the Western economies. Twenty seven percent of the sharp increase in Korean exports to Japan in 2011 is ascribed to the 3.11 earthquake. As its impact fades away and as the Korean won appreciates against the Japanese yen, Korean exports to Japan may not increase as rapidly as they did in recent years.

JEL Classification: C2, F1, F3
Keywords: Korean export, Asian production network, Global imbalance, Cointegration, Structural break
1. Introduction

The purpose of this paper is to examine how and to what extent the changing environment of the global economy affects Korean exports. Specifically, this paper estimates Korean bilateral export functions, and discusses the impact of changes in the global economic environment on Korean exports based on the estimation results.

The most noticeable changes in the global economy which have significantly influenced the Korean economy are related to the two financial crises the world has experienced in the last few decades. The first is the 1997 East Asian crisis, and the second is the recent global economic crisis caused by sub-prime mortgage failures in the US and fiscal problems in the Euro Zone.

The 1997 Asian crisis was understood at first as a sign of the fade-off of Asia’s (especially East Asia’s) miraculous growth. East Asian countries, which had boasted surprisingly rapid economic growth until 1996, were badly hit by the 1997 crisis, and it was obvious that the crisis was rooted in the failures of East Asian economic institutions. Therefore, not many economists predicted swift recovery from the crisis.

Contrary to the expectations of many economists, however, the East Asian economies quickly recovered from 1999 and showed higher economic growth rates than most other parts of the world. In their recoveries, external demand from China and Western countries played a crucial role. Partly due to deeply depreciated currency values, they were able to have current account surpluses and to accumulate huge foreign currency reserves, leading to the so-called ‘global imbalance’ problem. At the same time, their economies became more heavily dependent on foreign demand and more vulnerable to external shocks.

Korea was not an exception. As is well known, the Korean won sharply depreciated during the 1997-1998 crisis, and it helped Korea drastically increase its export volume, leading to a positive trade balance and economic recovery. At the same time, Korea’s economy got more dependent on foreign demand. In addition, the share of China both in Korea’s imports and exports gradually increased.

After the global economy was hit by the Lehman Shock in September 2008, Korea’s GDP growth rate became negative for three quarters consecutively, from the fourth
quarter of 2008 to the second quarter of 2009, for the first time since the 1997 crisis, and it was only 1% in the third quarter of 2009. It is not surprising that Korea’s economy was heavily hit by the economic downturn of the Western economies, considering its dependence on those countries. In fact, the surprising phenomenon is that Korea recovered very quickly this time, too, as it did after the 1997-1998 crisis. On this occasion, it was again Korea’s exports which sustained its economy. The Korean won depreciated sharply after the Lehman Shock, and the Chinese economy, which was already the biggest market for Korea’s exports, quickly recovered. This environment enabled Korea to enjoy a big trade surplus and contributed to its economic recovery. Also, China’s share in Korean exports and imports became a record high in the first quarter of 2010. As of the end of 2011, China’s share in Korean exports is 24.5%, more than two times as high as that of the US, which is only 10.3%.

As we can see from a brief history of the Korean economy in the face of the two economic crises, external demand played a very important role in Korea’s economic recovery, and Korea has become more dependent on external demand. Therefore, it is very important to understand how the exports of Korea are related to the external environment to understand Korea’s current economy and also its future prospects. Against this background, this paper estimates bilateral export functions for Korea and discusses the impact of changes in the global economic environment on Korean exports based on the estimation results.

Section 2 describes the economic environment surrounding the Korean economy and its changes in more detail. Then, Section 3 presents and estimates Korea’s bilateral export functions for China, the Euro Zone, Japan, and the US, which are major trading partners of Korea. The explanatory variables in each export function are selected on the basis of the discussion in Section 2. The results of the estimations along with some econometric issues are also presented in Section 3. Section 4 discusses how and to what extent the changes in the global economic environment can affect Korea’s exports based on the estimation results in Section 3. Finally, Section 5 concludes.

2. The Korean economy and changes in the global economic environment

2.1. Importance of external demand in Korea

It is well known that international trade was an important engine of economic growth in
East Asia. A trade-oriented or export-oriented growth strategy was nothing new in East Asia. Even so, as briefly mentioned in the previous section, East Asian countries including Korea came to depend more heavily on external demand after the 1997 crisis than before.

Figure 1. Korean exports and imports (Ratio over GDP, %)

As Figure 1 illustrates, the export/GDP ratio of Korea had continuously risen until the mid-1980s, when the country had a trade surplus for the first time in its modern history. In 1987, the ratio rose up to almost 40%. However, it declined to lower than 30% in the late 1980s, and it remained at that level until 1996, when the ratio was 27.9%. In 1998 the ratio rose back up to 44.3% and has never declined below 30%. The ratio sharply increased in 2008 again, and it has been between 49 and 60% since then. These facts imply that the two financial crises (1997 and 2008) pushed Korea to further depend on external demand for its economic recovery.

Even though foreign trade is an important growth engine in China and Japan, too, the ratio of exports over GDP has been lower than 30% in China and lower than 20% in
Japan for the past five years. Moreover, according to the data from the World Development Indicator, Korea is the only country whose ratio of exports over GDP is higher than 50% as of 2011 among those countries whose GDP values (measured in current US dollar) are between one and two trillion dollars. For example, the ratio is 31.7% in Mexico and 21.3% in Australia, even though their economic size is very similar to that of Korea. Those facts also confirm the heavy dependency of the Korean economy on external demand.¹

2.2. **Rise of China and East Asian production network**

Regarding the source of external demand, there has been a substantial change since 2000. In the 20th century, the dominantly important trading partner of Korea was the US. However, the share of the US in Korean exports has declined over the last decade, and China replaced the US as the biggest market for Korean exports. As Figure 2-1 shows, the share of China in Korean exports was only 10% in 2000, but increased to almost 24% in 2011, while the share of the US decreased from 20% to 10% in the same time period. Similarly, the share of China in Korean imports is also the highest among Korea’s trading partners as of 2011.

**Figure 2-1. Korean exports**  
(Share of trading partners, %)

![Figure 2-1. Korean exports](image)

**Data Source:** Computed by the author using the data from DOTS

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¹ Ha et al. (2010) point out that the heavy dependency of the Korean economy on foreign demand makes it too vulnerable to external shocks and argue that Korea needs to seek a balance between external and domestic demand.
Figure 2-2. Korean imports
(Share of trading partners, %)

Data Source: Computed by the author using the data from DOTS

Of interest is that the share of Western countries in Korean imports has always been lower than their share in Korean exports in the period depicted in Figures 2-1 and 2-2. This phenomenon is also observed in the Chinese and the Japanese data. In Figures 3-1 and 3-2, the share of Asian countries (Japan and Korea) in Chinese imports is much higher than their share in Chinese exports, while the share of Western countries (the US and the Euro zone) in Chinese imports is much lower than their share in Chinese exports. China is selling more than 30% of its exports to Western countries but buying less than 20% of its imports from them. Overall, Asian countries import more from Asia and export more to non-Asian countries. This is related to the formation of production networks in East Asia.
East Asian countries, especially China, Japan, and Korea, have formed strong production networks through fragmentation of production processes for the last two decades.\(^2\) Therefore, Korea’s exports to China are dependent not only on Chinese domestic needs but also on external demand for Chinese products. In other words, Korea can export more to China if China exports more to the world. This dependency is further deepened by Korean companies or joint ventures producing in China and exporting to the world, since they usually import parts and intermediate goods from their parent companies in Korea.

According to recent research papers such as Yao (2006), Bonham et al. (2007), and Koopman, Wang, and Wei (2008), the drastic growth in Chinese exports over the last two decades can mainly be ascribed to the contribution of foreign multinationals. Considering the active investment from Japan and Korea to China, there should be quite a few Japanese and Korean companies behind the aggressive exports of China. From January of 2006 to July of 2012, the share of Korea in the utilized FDI inflow to China was 6.5%, higher than that of the US (5.8%) or Germany (2.6%).\(^3\) Only Japan (9.9%)

\(^2\) See, for more detailed information, Ando and Kimura (2003), Gaulier et al. (2005), Tong and Zheng (2008), Nicolas (2009) and Kimura and Obashi (2011)

\(^3\) The shares were computed from the data obtained from CEIC. In the computation, FDI from Hong Kong was not included in the total FDI inflow to China.
and Singapore (9.0%) have higher shares.

Figure 4. Economic growth rates

Because China is now the biggest trading partner of Korea, the performance of the Korean economy is strongly connected to that of China. As Figure 4 illustrates, when the economic growth rate of Korea was -4.2% in the first quarter of 2009, a record low for Korea in the 21st century, that of China in the same quarter was 6.5%, also a record low in the 21st century. The global economy was also in recession during that time period. However, the US had its lowest trough in the second quarter of 2009, and Korea had its lowest trough in the same period not with the US but with China. Moreover, as China quickly recovered from the recession, Korea followed, as Cho (2009) also points out. When the Chinese economy was at a peak in its business cycle in the first quarter of 2010, the Korean economy was, too, although the US and the European economies had not recovered yet.\(^4\)

In summary, China is now the most important trading partner to Korea, and the Korean economy is strongly connected to the Chinese economy through trade and investment. Due to production networks in East Asia, exports from Korea to China depend on not only China’s domestic needs but also external demand for Chinese products.

\(^4\) Ando (2010) attributes the rapid recovery of the East Asian trade since the sub-prime mortgage crisis to the regional production/distribution networks.
2.3. Global imbalance and Korean exchange rates

The 1997 Asian crisis was a very big shock to Asian countries. Realizing the importance of possessing enough international reserves, East Asian countries eagerly accumulated foreign currency reserves by generating current account surpluses from international trade. Since the current account surpluses of East Asia (or emerging economies in a broader scope) were accompanied by current account deficits in Western economies, this phenomenon was named the ‘global imbalance.’ See Figure 5 for the imbalance of current account between the US and Asian countries and Figure 6 for the amount of foreign currency reserves possessed by major countries.

Figure 5. Imbalance of current account (billion US$)

Data source: IFS

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East Asian countries were able to make trade surpluses partly due to the low value of their currencies following the sharp depreciations during the 1997-1998 crisis period. China was not badly damaged by the 1997 crisis but had fixed its currency value to the US dollar since 1997 to avoid exchange rate volatility. Since the value of the Chinese yuan was fixed despite a huge current account surplus and rapid economic growth, Western countries put pressure on China to revalue its currency. As a result, the Chinese government announced a movement from a fixed exchange rate regime to a floating regime in July 2005. Even so, the global imbalance was not narrowed but widened in both 2005 and 2006. Then, the global imbalance was reduced as the sub-prime mortgage crisis hit the US economy and the Euro Zone suffered from fiscal problems. However, there are still hot debates between policy makers in China and the US surrounding the equilibrium value of the Chinese yuan.

Japan also has had a current account surplus for the last few decades, and the Japanese yen was also believed to be undervalued in the mid-2000s. Even though the pressure from the Western countries was not as heavy on the Japanese monetary authorities as on the Chinese authorities, it is true that the Japanese yen was also blamed to be purposely undervalued and one of the causes of the global imbalance. However, due to a psychological change in the global financial market caused by the recent financial
turbmoil, the Japanese yen was the strongest currency from 2008 to mid 2012, and Japan even experienced trade deficits for several quarters. The Japanese yen began to depreciate from late 2012.

Although it was strongly believed by many that the Chinese yuan and the Japanese yen were undervalued in the mid-2000s, it is not certain whether they are undervalued or overvalued as of the end of 2012, because the two currencies have substantially appreciated over the last several years. By contrast, the Korean won began to depreciate after the start of the sub-prime mortgage crisis in 2007, and it further and sharply depreciated after the Lehman Shock in 2008, while the Japanese yen and the Chinese yuan were appreciating. Even though it began to appreciate from the second quarter of 2009, its value is still far lower than its value before the sub-prime mortgage crisis.

Figure 7. Exchange rates against the US dollar (index, 2005=100)

![Graph showing exchange rates against the US dollar for China, Japan, and Korea from 2000 Q1 to 2012 Q4.]

Data Source: Computed by the author using the data from IFS

According to Baak (2012), the Korean won was overvalued before the Lehman Shock and substantially undervalued after the shock. Therefore, even though the Japanese yen is currently depreciating, the Korean won is not predicted to follow the dynamics of the Japanese yen, considering the appreciation of the Chinese and the Japanese currencies since the global economic turmoil and the efforts of the global economy to reduce the global imbalance. Rather, it will maintain the current level or even appreciate if the

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6 The exchange rate against the US dollar is used here. Refer to Figure 7.
Chinese yuan further appreciates and/or the Japanese yen stops depreciating. Just as Korea benefited from the low value of its currency for at least a few years after each of the two crises, appreciation of the Korean won may have a negative impact on Korean exports in the near future.

### 2.4. Economic recession in the world economy

Because the Western countries have been more severely damaged by the recent economic turmoil than Asian countries, it has further pushed up the share of Asia in the global economy. Figures 8-1 and 8-2 illustrate that China’s shares of world exports and imports have been increasing while those of the US have been decreasing. Therefore, Korea’s dependence on Asia (especially on China) will get more severe. In this respect, an economic downturn in China, if it occurs, will have a very negative impact on Korea. In addition, because exports to Western markets are a very important factor in sustaining Asian economies, including China, if economic recession in the US and the Euro Zone prolongs, it will adversely influence the Korean economy directly and also indirectly through neighboring Asian countries.

Figure 8-1. Share in the world exports

![Figure 8-1. Share in the world exports](image)

Data Source: Computed by the author using the data from DOTS
3. Tests and Estimations

3.1. The Export Function

As pointed out above, the current Korean economy heavily depends on external demand. Therefore, understanding what variables determine Korean exports is very important in discussing the future prospects of the Korean economy.

Against this background, the bilateral export functions of Korea with its four major trading partners are estimated in this section. As shown in Figures 2-1, the four major trading partners of Korea—China, the Euro Zone, Japan, and the US—cover almost 50% of Korea’s total exports.

The discussions in the previous section imply that the incomes of foreign countries and exchange rates between Korea and its trading partners should be important factors in determining the size of Korean exports. In fact, those variables are typically included as explanatory variables in export functions, and they are included in all four export functions in this paper.

In addition, the production networks in East Asia imply that not only domestic economic conditions of Korea’s Asian trading partners but also external demand for
their products plays a role in determining the size of Korean exports to them. Therefore, a measure of external demand is included as an explanatory variable in the Korean export functions to China and Japan. Adding to those, dummies for recent economic recessions and a dummy for the 2011 earthquake in Japan are also considered as explanatory variables to capture some effects which may not be explained by typical economic variables.

In particular, an export function (or a long-run equilibrium relation between exports and other economic variables) is assumed to have the following functional form:  

$$ Y_{ijt} = \beta_0 + \beta_1 g_{jt} + \beta_2 p_{ijt} + \beta_3 \sigma_{ijt} + \beta_4 x_{jt} + \beta_5 D_{1j} + \beta_6 D_{2j} + \beta_7 \text{trend} + \varepsilon_{ijt} $$  

--- (1)

where $Y_{ijt}$ denotes real exports from country $i$ to country $j$. Therefore, $i$ is Korea, and $j$ is one of the following four economies: China, the Euro Zone, Japan, or the US. The variable $g_{jt}$ denotes the measure of economic activity of the importing country, $j$. The variables $p_{ijt}$ and $\sigma_{ijt}$ are real bilateral exchange rates and volatility of real bilateral exchange rates, respectively. Specifically $p_{ijt}$ is the exchange rate of the Korean won against the currency of an importing country $j$. Therefore, if $p_{ijt}$ rises, the products of Korea become cheaper.

The external demand for country $j$ is denoted by $x_{jt}$. Then, $D_{1j}$ is the dummy for a financial crisis period in country $j$, and $D_{2j}$ is the dummy for a natural disaster in country $j$. Finally ‘trend’ is the time trend variable, and $\varepsilon_{ijt}$ is a disturbance term. All variables except dummies are in natural logarithms, and the subscript $t$ symbolizes the time. More specific explanation of the variables is provided in the following subsection.

Because the GDP of an importing country is believed to be positively correlated with exports from Korea, the value for $\beta_1$ is expected to be positive. Since a higher $p_{ijt}$ means a lower relative price of Korean products, the value for $\beta_2$ is also expected to be positive.

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The coefficient of exchange rate volatility, $\beta_3$, would be negative, if economic agents are moderately risk averse, as De Grauwe (1988) shows. Baak et al. (2007), Baak (2008), Thorbeck (2008), and Chit, Rizov, and Willenbockel (2010) report some empirical evidence showing that exchange rate volatility negatively influences the export volumes of some East Asian countries. If not only the domestic income but also external demand for the products of country $j$ affects Korean exports to country $j$, $\beta_4$ will be positive.

3.2. The Variables

3.2.1. Real exports ($Y_{ijt}$)

The real export volume of country $i$ to country $j$ is defined as follows:

$$Y_{ijt} = \ln\left( \frac{EX_{ijt}}{EXUV_{it}} \times 100 \right), \quad (i = \text{Korea}; \quad j = \text{a trading partner of Korea})$$

where $Y_{ijt}$ denotes the log value of the real exports of country $i$ to country $j$, $EX_{ijt}$ is the quarterly nominal exports of country $i$ to country $j$, and $EXUV_{it}$ denotes the export unit value index of country $i$.

The bilateral trade data of Korea were obtained from the DOTS (Direction of Trade Statistics). Export unit value indices of Korea have been collected from the IFS (International Financial Statistics).

3.2.2. Real GDP ($g_{jkt}$)

The real GDP of an importing country (country $j$) is commonly used as a proxy measure for the economic activity of the country in much of the literature dealing with quarterly

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8 See Secru and Uppal (2000) and their references for more discussion concerning exchange rate volatility and its impacts on trade.
9 In order to ensure consistency in the data, variables which were not seasonally pre-adjusted were adjusted for seasonality prior to taking the logarithm, by applying the method Census X12 available in the software package Eviews 6.
or annual data. Accordingly, in this paper the real GDP of each importing country is used for $g_{it}$ in equation (1). The real GDP data were obtained from the IFS. Since the data for China is available only from 2000Q1, the analysis of this paper covers the period from 2000Q1 to 2011Q4.

### 3.2.3. Real bilateral exchange rates ($p_{ij}$)

The real exchange rates are computed in the conventional way as follows:

$$p_{ijt} = \ln \left( E_{ijt} \times \frac{CPI_{it}}{CPI_{jt}} \right)$$

where $p_{ijt}$ symbolizes the real quarterly exchange rate in natural logarithm scale; $E_{ijt}$ is the nominal quarterly exchange rate of country $i$’s currency against country $j$’s currency, and $CPI_{it}$ and $CPI_{jt}$ denote the quarterly consumer price index of an exporting country $i$ and an importing country $j$, respectively.

The data for nominal exchange rates of all countries involved and the data for consumer price indices (CPI) of the Euro Zone, Japan, Korea, and the US were obtained from the IFS. In the case of China, consumer price indices are not reported in the IFS. Instead, the annual growth rates of monthly indices from 1986 are reported. The monthly Chinese consumer price indices are computed using these growth rates and the consumer price indices for the year from December 2000 to November 2001.10 Quarterly data are then computed from these monthly data.

### 3.2.4. Real exchange rate volatility ($\sigma_{ij}$)

The present study applies the standard deviation of exchange rates as the measure of exchange rate volatility.11 Specifically, the real exchange rate volatility $\sigma_{ijt}$ is defined

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10 The Chinese consumer price indices from December 2000 to November 2001 were kindly provided by Yuqing Xing at GRIPS.

11 As Sercu and Uppal (2000) mention, this is one of the major ways to measure exchange rate volatility. For example, see Akhtar and Hilton (1984), Côté (1994), and Baum et al. (2001).
as the natural logarithm of the standard deviation of monthly real exchange rates for a certain time period:

$$\sigma_{ijt} = \ln \left( \frac{1}{n-1} \sum_{k=tn}^{tm} \left( RER_{ijk} - \overline{RER}_j \right)^2 \right),$$

where $t$ represents a quarter and $k$ a month. $RER_{ijk}$ is a monthly real exchange rate, $\overline{RER}_j$ is the mean of $RER_{ijk}$ from $k=tm$ to $k=tn$. $tm$ and $tn$ are the last and the first month included in the computation of $\sigma_{ijt}$, respectively. $k=0$ is defined to be the last month in quarter $t$, $k=1$ is one month earlier than that, and so on. If $t$ is the first quarter of 2000, $tm$ is 1, and $tn$ is 4, for example, then $tm$ represents February 2000 and $tn$ November 1999. In empirical tests in Section 4, $tm$ and $tn$ are set to be 0 and 5, respectively. Therefore, the exchange rate volatility of a quarter is computed by the standard deviation of monthly exchange rates of the current and the one lagged quarter.\(^{12}\)

### 3.2.5. External demand for the products of country $j$ ($x_{jt}$)

The total real exports of a country are used for external demand for the products of the country. However, because the total real exports may be linearly correlated to the real GDP ($g_{jt}$), leading to the multi-linearity problem in the estimation of the export functions, only those parts of exports which are not linearly related to the GDP are used as $x_{jt}$. More specifically, $x_{jt}$ is the residuals from the regression of the real exports of each on the real GDP of that country.

In the case of China, because export unit value indices are not available, not the total exports of China but Chinese exports to the US are used to compute $x_{jt}$ for China. The real value of Chinese exports to the US is calculated from the nominal value of Chinese exports to the US and the import unit value indices of the US.

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\(^{12}\) Numerous preliminary tests showed that a slight change in the values of $tm$ and $tn$ generated only marginal differences in the test results. For example, if we set $tm=0$ and $tn=2$, the volatility is computed using the monthly exchange rates of only the current quarter, but this change did not improve the test results at all.
3.3. Empirical Test and Estimation Results

Since the Chinese real GDP data are available only from 2000Q1, the estimation of equation (1) is done with quarterly data from 2000Q1 to 2011Q4. Even though the data for other countries are available even before 2000, it might reduce the probability of structural changes in Korea’s export functions to confine our analysis to the data starting from 2000. Baak (2007) and Baak (2011) report that Chinese and Korean export functions experienced structural changes in the mid-1990s. However, since it is not certain that there has not been a structural change in Korea’s export functions since 2000, as well, the following sections pay careful attention to the possibility of structural breaks when implementing various empirical tests.

3.3.1. Unit Root Tests

Because conventional unit root tests such as the ADF test may fail to detect non-stationarity when a non-stationary series has a structural break, as Perron (2006) writes, and because the variables in equation (1), especially exchange rates, may have structural breaks, considering the drastic change in 2008, this paper performs the S-L unit root test suggested by Saikkonen and Lutkepohl (2002), which is robust in the presence of a structural break.\(^\text{13}\)

The null hypothesis of a unit root is accepted for all the variables involved except for two at the five percent significance level under reasonable settings of the test. The bilateral exchange rate between the Korean won and the euro turns out to be non-stationary at the one percent significance level, and the unit root test for the variable for Korean exports to Japan is sensitive to the lag length included in the test. Meanwhile, the S-L unit root tests strongly indicate stationarity for the first differences of all the variables involved.

\(^{13}\) The empirical tests and estimations in section 3 were all implemented using the computer software program, JMulti.
3.3.2. Cointegration Tests

As mentioned in previous sections, considering the possibility of a structural break in cointegrating relations among the variables in equation (1), this paper performs cointegration tests such as the S-L cointegration test (Saikkonen and Lutkepohl, 2000a, 2000b, 2000c) and the J cointegration test (Johansen et al., 2000), which are robust to a structural break in the long-term relationship. The test results are reported in Table 1.

<table>
<thead>
<tr>
<th>Importing Country</th>
<th>Statistic</th>
<th>H0: r=0</th>
<th>r&lt;=1</th>
<th>r&lt;=2</th>
<th>r&lt;=3</th>
<th>r&lt;=4</th>
<th>r&lt;=5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>HA: r&gt;=1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>r&gt;=5</td>
<td></td>
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</tr>
<tr>
<td>China</td>
<td>S-L</td>
<td>136.22</td>
<td>40.35</td>
<td>29.29</td>
<td>11.12</td>
<td>3.26</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(p-value)</td>
<td>0.0000</td>
<td>0.1475</td>
<td>0.0396</td>
<td>0.2461</td>
<td>0.3035</td>
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<td>Euro Area</td>
<td>S-L</td>
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<td>5.99</td>
<td>0.44</td>
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<tr>
<td></td>
<td></td>
<td>(p-value)</td>
<td>0.0186</td>
<td>0.7753</td>
<td>0.9336</td>
<td></td>
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<tr>
<td>Japan</td>
<td>Johansen</td>
<td>133.30</td>
<td>59.45</td>
<td>28.85</td>
<td>8.89</td>
<td>2.92</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>(p-value)</td>
<td>0.0000</td>
<td>0.0831</td>
<td>0.5925</td>
<td>0.9689</td>
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<td>US</td>
<td>S-L</td>
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<td></td>
<td></td>
<td>(p-value)</td>
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<td>0.0558</td>
<td>0.1500</td>
<td>0.2269</td>
<td></td>
</tr>
</tbody>
</table>

In the case of the Korean export functions for China, the Euro Zone, and the US, both the J test and the S-L test indicate the presence of a long-term relationship among the variables at the five percent significance level. In the case of the Korean export function for Japan, the J test indicates the presence of a long-term relationship at the five percent significance level.
3.3.3. Estimating Export Functions (Cointegrating Vectors)

Table 2 reports the coefficients of the four export functions (or the cointegrating vectors) estimated by the Johansen (1996) method. The Johansen method estimates the VECM, which includes the cointegrating vector as the error correction term. That is, four VECMs are estimated, and each of them includes the cointegrating vector (or the export function) for each trading partner of Korea as the error correction term. The coefficient of the error-correction term (ECT) in a VECM should be negative and significant if there is really a cointegrating relationship among the variables in the export function. Therefore, Table 2 reports the coefficient of the error correction term in each VECM along with the coefficients of explanatory variables in each export function.

Table 2. Estimates of export functions

<table>
<thead>
<tr>
<th>Imp. Coun.</th>
<th>ETC</th>
<th>GDP</th>
<th>Exch. rate</th>
<th>Volat.</th>
<th>Crisis</th>
<th>Earth quake</th>
<th>Exp. to W.</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>Coef. -0.771</td>
<td>1.648</td>
<td>0.532</td>
<td>-1.556</td>
<td></td>
<td>1.559</td>
<td>0.003</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(p-value) 0.000</td>
<td>0.010</td>
<td>0.006</td>
<td>0.005</td>
<td></td>
<td>0.000</td>
<td>0.864</td>
<td></td>
</tr>
<tr>
<td>Euro Area</td>
<td>Coef. -0.216</td>
<td>2.038</td>
<td>0.597</td>
<td></td>
<td>-0.473</td>
<td></td>
<td>0.024</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(p-value) 0.124</td>
<td>0.145</td>
<td>0.002</td>
<td>0.000</td>
<td></td>
<td></td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>Coef. -0.232</td>
<td>7.176</td>
<td>0.248</td>
<td></td>
<td>-1.972</td>
<td>0.277</td>
<td>1.311</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(p-value) 0.017</td>
<td>0.000</td>
<td>0.036</td>
<td>0.010</td>
<td></td>
<td>0.000</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>US</td>
<td>Coef. -0.385</td>
<td>3.830</td>
<td>1.149</td>
<td></td>
<td>-4.176</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(p-value) 0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.006</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3 reports the diagnostic test results to check for the mis-specification of the estimation equation. The null hypothesis of no autocorrelation and that of no heteroskedasticity are accepted at the conventional significance levels. The null hypothesis of normality is not accepted at the five percent significance level, but it is at the one percent significance level, except for the case of exports to the US. However, the non-normality comes from kurtosis in this case, and according to Paruolo (1997) the
results of the Johansen procedure are not affected in cases in which normality is rejected for kurtosis, rather than skewness. The stability of the estimation is tested by the eigenvalue method proposed by Hansen and Johansen (1999). The null of stability is accepted at the 10% significance level.14

Table 3. Diagnostic test results

<table>
<thead>
<tr>
<th>Importing Country</th>
<th>Statistic</th>
<th>Autocorrelation Portmanteau Test(1)</th>
<th>Non-Normality DH Test(2)</th>
<th>Heteroskedasticity ARCH-LM Test(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>Statistic</td>
<td>306.8693</td>
<td>19.1295</td>
<td>483.2060</td>
</tr>
<tr>
<td></td>
<td>(p-value)</td>
<td>0.3052</td>
<td>0.0386</td>
<td>0.1350</td>
</tr>
<tr>
<td>Euro zone</td>
<td>Statistic</td>
<td>90.0871</td>
<td>15.5051</td>
<td>81.6897</td>
</tr>
<tr>
<td></td>
<td>(p-value)</td>
<td>0.9886</td>
<td>0.0167</td>
<td>0.2036</td>
</tr>
<tr>
<td>Japan</td>
<td>Statistic</td>
<td>307.3026</td>
<td>9.6074</td>
<td>434.5788</td>
</tr>
<tr>
<td></td>
<td>(p-value)</td>
<td>0.9286</td>
<td>0.4756</td>
<td>0.6907</td>
</tr>
<tr>
<td>US</td>
<td>Statistic</td>
<td>223.4313</td>
<td>24.0990</td>
<td>216.4063</td>
</tr>
<tr>
<td></td>
<td>(p-value)</td>
<td>0.4229</td>
<td>0.0022</td>
<td>0.2027</td>
</tr>
</tbody>
</table>

Notes: (1) This test examines the null hypothesis of no autocorrelation up to $h^{th}$ lag against the alternative that at least one autocorrelation is non-zero. The lag length, $h$, is set to be 16, but the test result is not sensitive to the lag length. (2) The DH test statistic was proposed by Doornik and Hansen (1994). This test examines the null hypothesis of normality. (3) The multivariate ARCH-LM test examines the null hypothesis of homoskedasticity.

The coefficient of the error correction term is negative and significant in the VECM for China, Japan, and the US, reconfirming the presence of one cointegrating relationship in each export function. It is not significant at the 10 percent significance level in the case of Korean exports to the Euro Zone. However, it is negative and its p-value is only 0.124, close to 10%. Therefore, it is not believed that the estimation result of the error correction term in Table 2 is contradictory to the test result in Table 1, which concludes that there is one cointegrating relationship among the variables in the Korean export function to the Euro Zone. On interest is that the ECT coefficient is the highest in its absolute value in the VECM for Korean exports to China, implying the adjustment

14 We estimated equation (1) by the OLS and also by the fully modified OLS of Phillips and Hansen (1990) for comparison. It should be noted that the estimation results reported in Table 1 are only marginally different from the estimation results by the other two methods. On the other hand, the CUSUM test indicated stability of the OLS estimation, but the Hansen (1992a,b) test detected instability in the estimations of the fully modified OLS.
speed is the fastest in Korean exports to China when variables in the export function deviate from their long-run relationship.

The income elasticity (the coefficient for GDP) is positive and significant in three of the export functions, as expected in section 3.2. It is positive but not significant in the export function to the Euro Zone. But, considering the p-value is close to 10%, it may not be unreasonable to conclude that the income elasticity is positive in the Korean export function to the Euro Zone. The estimated coefficient value of GDP is relatively high in the export function to Japan, implying that Korean exports are more sensitive to domestic income in Japan than in other countries.

The estimated coefficient values for bilateral real exchange rates are all positive and significant as expected, indicating that depreciation of the Korean won increases Korean exports. Some recent papers doubt the impact of exchange rates on exports, but the findings in this paper confirm that the exchange rate is still an important factor affecting the export volume of Korea.

Exchange rate volatility has a negative impact on Korea’s exports except for its exports to the Euro Zone. Because the coefficient of exchange rate volatility is not significant in Korea’s exports to the Euro Zone, and because to drop it from the export function does not affect the coefficient values of other variables, exchange rate volatility is not included in the Korean export function to the Euro Zone as an explanatory variable.

The coefficients of external demands for the products of the Asian trading partners ($x_{jt}$) are positive, and they are significant even at the 1 percent significance level. Its coefficient is 1.56 for exports to China, and it is 1.3 for exports to Japan. The impact of external demand in the export function to China is almost as big as the income elasticity (1.645).

The crisis dummy for the period from 2009Q1 to 2011Q4 has a significant and negative coefficient value in the Korean export function to the Euro zone. A crisis dummy for a slightly different time period was included in the Korean export function to the US, too, at first. However, because it was insignificant and because to drop it did not change the estimation results, it is not included in the equation reported in Table 2.

15 See Ha et al. (2010), and references there, for example.
In the estimation of the Korean export function to Japan, the dummy for the earthquake in 2011 for the period from 2011Q2 to 2011Q3 is included. Its estimated coefficient value implies that Korea was able to export to Japan 27% more due to the earthquake. This explains the rapid increase of Korean exports to Japan in 2011.

4. Impacts of changes in the global economy on Korean exports

4.1. Korean exports to China

As previously shown, China is currently the biggest market for Korean products, and its share of Korea’s exports is expected to further rise considering the rapid economic growth of the country and the sluggish recovery of the US and the Euro Zone economies. Therefore, if a negative shock hits the Chinese economy, the Korean economy, which heavily depends on external demand, will be damaged severely.

China’s average GDP growth rate was 10.4% (quarter to quarter)\textsuperscript{16} from 2001 to 2011. Since the income elasticity of Korean exports to China is 1.65, economic growth of China increased Korean exports to China by 17.2% (1.65*10.4%) every year. The actual quarter-to-quarter growth rate of Korea’s exports to China has been 21.6%. Even though other variables such as exchange rates also affect Korean exports to China, in fact the biggest contribution was made by the rapid economic growth of China. This explains the extremely poor performance of the Korean economy in the first quarter of 2009, when China’s economic growth rate was only 6.5%.

Regarding the future prospects of the Chinese economy, both optimistic and pessimistic views coexist. In the case that the Chinese economy suffers from an unexpected negative shock, it would damage the Korean economy much more severely than the sub-prime mortgage crisis or the Euro Zone crisis.

4.2. Korean exports to the Euro zone

If the Euro countries completely recover from the current crisis, the estimation results imply that Korean exports to the area would be expected to increase by 47%. However, since it is not expected that the crisis will fade away quickly, in a quarter or in a year,
the positive effect of a Euro Zone recovery will not be fully realized. Instead, as the crisis fades away over a few years, the impact of the recovery will increase Korean exports by less than 47%.

In the meantime, because the price elasticity is 0.6 and because the Korean won is believed to be still undervalued, appreciation of the Korean won in the near future will undermine the effect of the economic recovery in the Euro Zone. If the Korean won against the euro appreciates by 10%, Korean exports to the Euro Zone will decrease by 6%. However, considering the income elasticity and the coefficient of the crisis dummy, gradual economic recovery in the euro-member countries will lead to an increase in Korean exports to the area even if the Korean won further appreciates.

4.3. Korean exports to Japan

The earthquake in the first quarter of 2011 badly damaged production facilities in Japan and ruined its supply chains. As a result, Korean exports to Japan in the machinery and chemical industries sharply increased, and the trade deficit of Korea declined. The estimation results reported in Table 2 show that the earthquake had the effect of increasing Korean exports to Japan by 28%. As Japan recovers from the damage of the earthquake, the trade deficit of Korea with Japan will widen again. However, because Japanese industries will try to secure their supply chains by importing more parts and intermediate goods from foreign countries, the effect of the earthquake will not completely disappear.

As Figure 8 illustrates and as discussed in section 2, the Korean won drastically depreciated in late 2008 and early 2009 and never returned to its level before the sub-prime mortgage crisis, while the Japanese yen appreciated more than 30% from 2007 to 2011. Recently the Korean won has been gradually appreciating while the Japanese yen depreciates. Even though the price elasticity in the Korean export function to Japan is not as big as the income elasticity, a substantial appreciation of the Korean won will cancel out the positive effects of economic recovery in Japan. Japan’s average GDP growth rate was 0.6% (quarter to quarter) from 2001 to 2011. If the economic growth rate increases by one percentage point, it will increase Korean exports by 7.2%. However, if the Korean won appreciates by 20%, it will decrease Korean exports by 5%. Moreover, since the effect of the earthquake may gradually fade away, if not completely,
the positive effect of economic recovery may be canceled out.\textsuperscript{17}

4.4. Korean exports to the US

Even though the shares of the US in both Korea’s exports and imports are shrinking, it is still one of the most important trading partners of Korea. Moreover, in the case that there is a problem in the economy of China, the US may be the only alternative to the Chinese market.

As the US economy recovers, it will import more from Korea. On the other hand, appreciation of the Korean won will undermine some of the income effect. Because the income elasticity is 3.83 and the price elasticity is 1.15, if US GDP increases by 1% and if the Korean won appreciates by 3.3%, these two effects will cancel each other out. Since the Korean won is expected to appreciate against the US dollar, Korean exports to the US will increase to a limited extent even if the US economy recovers from the current recession. However, the recovery of the US economy will indirectly increase Korean exports to China and Japan, since Korea will be able to export more to its Asian partners when they export more to the US.

5. Conclusion

This paper estimates bilateral export functions of Korea to its four major trading partners (China, the Euro Zone, Japan, and the US) and examines the impacts of changes in the global economic environment on the basis of the estimation results.

The coefficients of real GDP of importing countries are all estimated to be positive. The income elasticity of Korean exports to Japan was especially big. But, considering low GDP growth rates in Japan, the income effect will be limited.

The coefficients of exchange rates are also all positive, implying that depreciation of the Korean won has a positive impact on the country’s exports. Exchange rate volatility has a negative impact except in the Korean export function to the Euro Area. External

\textsuperscript{17} Korean Embassy (2013) argues that Korean products have better penetrated in the Japanese market due to the earthquake and the strong yen. If it is true, the earthquake effect on the Korean export will not completely disappear even though the Japanese economy fully recovered from it.
demand for the products of Korea’s Asian trading partners also plays an important role in determining Korean exports to those countries.

Although the recovery of the global economy is expected to contribute to an increase in Korean exports, appreciation of the Korean won will reduce its impact. Because Korea’s economy heavily depends on external demand, especially on imports of China, a negative shock to the Chinese economy would more severely damage the Korean economy than the recent financial crisis, which mainly damaged the Western economies.

Meanwhile, 27 percent of the sharp increase in Korean exports to Japan in 2011 is ascribed to the 3.11 earthquake. As its impact fades away and as the Korean won appreciates against the Japanese yen, Korean exports to Japan may not increase as rapidly as they did in recent years.
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