

The Impact of the Chinese *Renminbi* on Korean and Japanese Exports to the United States*

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This paper examines the impacts of the real exchange rates of the Chinese *renminbi* against the US dollar on Japanese and Korean exports to the United States. Empirical test results, which have analyzed the quarterly data covering 1986Q1 to 2008Q2, show different long-run impacts of the *renminbi* in the export functions of the two countries. In particular, depreciation of the *renminbi* has a positive impact on Japanese exports but a negative impact on Korean exports. However, since some stability tests indicate a structural break in the export functions, the functions are re-estimated for the recent sub-period (1995Q1 to 2008Q2). Different from the estimation results for the whole sample period, in tests with the sub-period data, depreciation of the *renminbi* turns out to have a positive impact on Korean exports and insignificant impacts on Japanese exports. In addition, the coefficients of the real GDP of the US and the real exchange rate of the Japanese *yen* and the Korean *won* are estimated to be consistent with conventional predictions. Finally, it should be noted that only the estimated values of the *renminbi* coefficient change drastically across the two period data sets, while other coefficient values are quite stable.

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1. INTRODUCTION

Since the Chinese government announced that it would move to a managed float of the *renminbi* in 2005, the *renminbi* has appreciated against the US dollar by 18%, from 8.277 *yuan* per dollar in June 2005 to 6.828 in December 2009. Considering that China is often regarded as the major competitor among East Asian countries in the world market, the appreciation of the *renminbi* may be expected to have positive impacts on the exports of other East Asian countries. However, due to the complicated evolution of East Asian trade patterns and the production/distribution networks in the region, it is still quite vague whether and how the depreciating and/or appreciating *renminbi* will affect the exports of other Asian countries.

In fact, for the last decade, motivated by a growing concern in other Asian countries that an emerging China may crowd out their exports, several papers have empirically investigated the displacement effects of Chinese exports, and presented somewhat contradictory results. Some papers report that the emergence of China in the world market has only hurt less developed Asian countries (Eichengreen, Rhee, and Tong, 2004, 2007; Bhattacharya, Ghosh, and Jansen, 2001), while others argue that the exports of high-income Asian countries have been more adversely affected by the rise of China (Greenaway *et al.*, 2008). In addition, another group of papers concluded that China's export expansion has been not negatively but positively associated with the exports of other Asian countries (Athukorala, 2009; Ahearne *et al.*, 2003; Lall and Albaladejo, 2004).

Among these, Eichengreen, Rhee, and Tong (2004), using a panel of annual data covering 1981 to 2001, investigated whether the rise of China hurt Asian exports, and concluded that it hurt only less-developed Asian countries, because China's exports crowded out Asian exports, not in markets for capital goods, but in markets for consumer goods, implying that China was competing mainly with less-developed Asian countries. Their result is consistent with that of Bhattacharya, Ghosh, and Jansen (2001), who showed that increases in China's global market share of manufactured products had

been statistically correlated with decreases in six less-developed Asian countries' shares since 1994.

On the other hand, Eichengreen, Rhee, and Tong (2004) reported that the production and trade structure of China is rapidly changing toward more capital- and technology-intensive sectors. Therefore, they stated, China's exports crowd out the exports of only less-developed countries "at least at this stage,"¹⁾ implying that China could become a serious challenge to Korea and Japan at a later date.

Following the work of Eichengreen, Rhee, and Tong (2004), a substantial amount of literature has reported the growing similarity between the structure of China's exports and those of other advanced countries. Kim, Kim, and Lee (2006) showed that China's export structure was becoming similar to those of Korea and Japan, and they argued that these structural changes could turn China into Korea's major competitor in the world market. According to Wang and Wei (2008), "the level of dissimilarity between China's export structure and that of G3 economies (the US, the EU, and Japan) declined from 133.7 in 1996 to 121.5 by 2005." In a similar view, Rodrik (2006) writes that China has ended up with a more sophisticated export basket than is expected for its income level. In the findings of Greenaway *et al.* (2008), whose data cover the period from 1990 to 2003, China is competing not with less-developed Asian countries but with developed Asian countries.

However, even though the export structure of China is assimilating with those of developed countries, production/distribution networks and fragmentation of production processes in Asia,²⁾ especially between China and Japan/Korea, make it unclear whether China and Korea (or China and Japan) are competitors or cooperators in the world market. Recent research papers confirm that the huge growth in Chinese exports over the last two decades can be mainly ascribed to the contribution of foreign

¹⁾ Their data end at 2001.

²⁾ See Ando and Kimura (2003), Gaulier *et al.* (2005), Tong and Zheng (2008), and Nicolas (2009). Ando (2010) attributes the rapid recovery of the East Asian trade since the sub-prime mortgage crisis to the regional production/distribution networks.

multinationals,³⁾ and Japan and Korea are among those that have actively and aggressively invested in China. According to Koopman, Wang, and Wei (2008), the share of foreign content in China's overall exports is about 50%, and that share increases up to 80% in electronic devices.

As is well known, many Japanese (or Korean) IT companies have production facilities in both Japan (or Korea) and China. It is not believed that products produced in China and Japan (or Korea) by the same Japanese (or Korean) IT companies would be competitors in the world market. Athukorala (2009), who analyzed the trade data of manufacturers for the period from 1992 to 2005, reported that China's export expansion has been not negatively but rather positively associated with the exports of other Asian countries. Their findings are consistent with those found in Ahearne *et al.* (2003) and Lall and Albaladejo (2004), who also reported positive relationships between Chinese exports and other Asian countries' exports. Theoretically, Zhao and Xing (2006) show that, in a three-country model in which the three countries are connected by outsourcing activities, a currency devaluation (or revaluation) gives rise to contrasting and unconventional results. Arndt (2010) shows that the influences of the exchange rate on the trade balance may be reduced by the vertical intra-industry trade.

Therefore, developed Asian countries' exports and Chinese exports may be substitutes due to their similar production structure, complements due to outsourcing/fragmentation among them, or both.

This issue is important not only with regard to regional economies, but also with regard to the so-called global imbalance.⁴⁾ If Japanese/Korean exports and Chinese exports are not negatively but positively correlated with each other then, as Eichengreen, Rhee, and Tong (2004, p. 4) argued, a revaluation of the *renminbi* puts pressure on Japan and Korea not for appreciation but for depreciation. Accordingly, a revaluation of the *renminbi*

³⁾ See Bonham *et al.* (2007), Yao (2006), and their references.

⁴⁾ See Obstfeld and Rogoff (2005), Roubini and Setser (2004), Bernanke (2005), Edwards (2005), and Kawai (2007) concerning the global imbalance. See Cheung, Chinn, Fujii (2010) and their references for the misalignment of the Chinese *renminbi*, and Baak (2011) and his references for the misalignment of the Korean won.

would not help much to reduce the amount of global imbalance.

However, despite the importance of the impact of the emerging China on other Asian countries, as seen above, our understanding is still quite limited. Besides, even though more and more researchers and policy makers pay attention to the appreciating *renminbi*, none of the papers on this subject have directly focused on the impact of the *renminbi* on East Asian trade.⁵⁾

Against this background, the present paper explores whether and to what extent the *renminbi* affects Korea and Japan's export volume to the US. As is well known, the US is one of Japan and Korea's most important trading partners,⁶⁾ and the US's current account deficit is mirrored in the current account surplus of the three Asian countries analyzed in this paper. As of 2008, the share of the US market in Japanese exports was 17.7%, followed by that of the Chinese market at 16%. At the same time, the share of the US market in Korean exports was 10.9%, following that of the Chinese market at 21.4%.

To this end, this paper estimates the coefficients of the *renminbi* exchange rate in the respective Japanese and Korean export functions to the US. In each function, the dependent variable is the volume of the real exports from Japan or Korea to the US, and the explanatory variables are the bilateral real exchange rates between the exporting county (Japan or Korea) and the importing country (the US), a measure of the economic activity of the US, exchange rate volatility and, finally, the exchange rate of the *renminbi* against the US dollar. Similar forms of export functions are widely employed in the literature investigating the effects of exchange rates and/or exchange rate volatility.

In addition, considering the frequent and often drastic changes in the involved variables in the Japanese and the Korean export functions, this paper pays careful attention to the possibility of structural breaks in the

⁵⁾ Related work can be found in Baak (2008), Benassy-Quere (2003), Kawai and Rahman (2009), Thorbecke (2008), and Thorbecke and Zhang (2009), investigating the effects of real exchange rate changes in China and/or in East Asia.

⁶⁾ The following numbers were calculated by the author from data obtained from the *Direction of Trade Statistics (DOTS)* of the IMF.

variables and the functions. For example, the unit root tests and the cointegration tests adopted in the present paper are robust to the presence of a structural break.

In the following sections, the unit root test suggested by Saikkonen and Lutkepohl (2002) (S-L unit root test, hereafter) shows that the variables are $I(1)$. Then, the cointegration tests such as the test suggested by Saikkonen and Lutkepohl (2000a, 2000b, 2000c) (S-L cointegration test, hereafter), and the test suggested by Johansen *et al.* (2000) (J cointegration test, hereafter), indicate a cointegrating relationship among the variables in each export function.

Estimates of the export functions (or the cointegrating vectors) using the quarterly data covering 1986Q1 to 2008Q2 show different long-run impacts of the *renminbi* in the export functions of the two countries. Depreciation of the *renminbi* has a positive impact on Japanese exports but a negative impact on Korean exports, implying that Chinese products do not compete with those of Japan, but do compete with those of Korea.

However, because the CUSUM stability test illustrates that the export functions should be very unstable, indicating the presence of structural breaks,⁷⁾ the export functions are re-estimated for the recent sub-period (1995Q1 to 2008Q2). Different from the case of the estimation for the whole sample period, in empirical tests with the sub-period data, depreciation of the Chinese *renminbi* turns out to have an ambiguous impact on Japanese exports and a positive impact on Korean exports. Of interest is that the estimated coefficients of variables other than the *renminbi* are quite stable. Only the coefficients of the *renminbi* change drastically between the two samples (the whole period sample and the recent sub-period sample).

In both samples, the real GDP of the US turns out to have positive impacts on the exports of the two countries. The exchange rate volatility of the Korean *won* has a negative impact on Korean exports, while the exchange rate volatility of the Japanese *yen* has an insignificant impact on Japanese

⁷⁾ The CUSUM stability test and the Hansen (1992a, 1992b) stability test generate contradicting results. See section 3 for a more detailed description of the test results.

exports. Finally, the estimates show that depreciation of an exporting country's currency value increases that country's exports to the US.

The short-run dynamics examined by error correction models for the sub-sample period show that most of the explanatory variables have similar impacts to those in the cointegration vectors, and the CUSUM test indicates that the estimates are stable.

2. THE MODELS AND THE VARIABLES

2.1. The Export Functions

After performing the necessary tests for time series data such as unit root tests and cointegration tests, this paper focuses on estimating the coefficient of the *renminbi* in two export functions (the export function of Japan to the US and the export function of Korea to the US). Following the typical specifications adopted by other papers,⁸⁾ an export function (or a long-run equilibrium relation between exports and other economic variables) is assumed to have the following functional form:

$$Y_{ijt} = \xi_0 + \xi_1 \cdot g_{jt} + \xi_2 p_{ijt} + \xi_3 \sigma_{ijt} + \xi_4 p_{cjt} + \varepsilon_{ijt}, \quad (1)$$

where Y_{ijt} denotes real exports from country i to country j . Therefore, i is Japan or Korea, and j is the US. The variable g_{jt} denotes the measure of economic activity of the importing country, j . In this paper, the GDP of the US is used for g_{jt} .

The variables, p_{ijt} and p_{cjt} , are real bilateral exchange rates. p_{ijt} is the exchange rate of the exporting country i 's currency against the US dollar (that is, the importing country j 's currency). Therefore, if p_{ijt} rises, the

⁸⁾ Similar methodological approaches regarding export or import functions of various countries can be found in the papers of Chowdhury (1993), Hassan and Tufte (1998), Arize, Osang, and Slottje (2000), Chou (2000), Zhang (2001), Baum *et al.* (2002), Tang (2003), Baak *et al.* (2007), and Baak (2008).

products of exporting country i become cheaper. p_{cjt} is the exchange rate of the Chinese *renminbi* against the US dollar. The variable σ_{ijt} denotes the volatility of the real bilateral exchange rates between country i and country j , and ε_{ijt} a disturbance term. All variables are in natural logarithm and the subscript t symbolizes the time.

Because the GDP of the US is believed to be positively correlated with exports from Japan/Korea, the value for ξ_1 is expected to be positive. Since a higher p_{ijt} means a lower relative price of the products of country i , the value for ξ_2 is also expected to be positive. If Chinese exports are competing with the exports of Japan/Korea in the US market, the low prices of the Chinese products (that is, higher p_{cjt}) would have negative impacts on the exports of Japan/Korea. In this case, the value for ξ_3 is expected to be negative. As stated previously, this paper focuses on the value of ξ_3 to understand the impact of the *renminbi* on Japanese and Korean exports. The coefficient of exchange rate volatility, ξ_4 , would be negative, if economic agents are moderately risk averse, as De Grauwe (1998) shows.⁹⁾ 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. In the meantime, if the exchange rate volatility of a country's currency negatively influences that country's exports, it may be expected that volatility of the *renminbi* is positively correlated with Japanese and Korean export volumes if China is competing with the two. However, since preliminary empirical tests persistently showed that volatility of the *renminbi* is insignificant in the Korean and the Japanese export function, it is not included as an explanatory variable in equation (1).

If the variables in equation (1) are non-stationary and cointegrated, along with equation (1), which shows the long-run relationship, the following error correction (EC) model is also estimated to see the short-run impacts of the explanatory variables on exports:

⁹⁾ See Secru and Uppal (2000) and their references for more discussion concerning exchange rate volatility and its impacts on trade.

$$\begin{aligned} \Delta Y_{ijt} = & \alpha + \lambda EC_{ijt-1} + \sum_{h=0}^{nx} \beta_h \Delta Y_{ijt-h-1} + \sum_{h=0}^{np} \gamma_h \Delta P_{ijt-h} \\ & + \sum_{h=0}^{ng} \delta_h \Delta g_{jt-h} + \sum_{h=0}^{ns} \eta_h \Delta \sigma_{ijt-h} + \sum_{h=0}^{nc} \phi_h \Delta P_{cjt-h} + u_{ijt}, \end{aligned} \quad (2)$$

where nx , np , ng , ns , and nc are the lengths of included lags for each variable. If the variables in equation (1) are non-stationary but not cointegrated, the error correction term, EC_{ijt-1} , is eliminated from equation (2). In addition, numerous estimation experiments are performed to find a parsimonious structure for equation (2).¹⁰⁾ In other words, variables which are insignificant and do not generate, even though omitted, any noticeable difference in the estimation results are eliminated from equation (2).

2.2. The Variables¹¹⁾

2.2.1. Real exports (Y_{ijt})

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

$$Y_{ijt} = \ln \left(\frac{EX_{ijt}}{EXUV_{it}} \times 100 \right), \quad (i = \text{Japan or Korea}; j = \text{the US})$$

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 .

2.2.2. Real GDP (g_{jt})

The real GDP of the importing country (country j) is commonly used as a

¹⁰⁾ See Greene (1993, Ch. 19.6) for this process, and see Arize, Osang, and Slottje (2003) for an example.

¹¹⁾ In order to ensure consistency in 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 E-views 5. See the Appendix for the sources of the data used in this paper.

proxy measure for the economic activity of the importing country in much of the literature dealing with quarterly or annual data. Accordingly, the variable g_{jt} in equation (1) is defined to be the real GDP of the US.

2.2.3. Real bilateral exchange rates (p_{ijt} , p_{cjt})

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

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

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 exchange rate of country c 's currency against importing country j 's currency, p_{cjt} , is also computed in the same way, with the change that the subscript i is replaced by the subscript c in the formula above. Country c is a country which is competing with country i in the market of country j .

In the case of China, consumer price indices are not reported. 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 one year from December 2000 to November 2001.¹²⁾ Quarterly data are then computed from these monthly data.

2.2.4. Real exchange rate volatility (σ_{ijt})

The present study applies the standard deviation of exchange rates as the measure of exchange rate volatility.¹³⁾ Specifically, the real exchange rate

¹²⁾ The Chinese consumer price indices from December 2000 to November 2001 were kindly provided by Yuqing Xing at GRIPS.

¹³⁾ 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).

volatility σ_{ijt} is defined as the natural logarithm of the standard deviation of monthly real exchange rates for a certain time period:

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

where t represents a quarter and k a month. RER_{ijk} is a monthly real exchange rate, $\overline{RER_{ij}}$ 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 σ_{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.¹⁴⁾

3. EMPIRICAL TEST AND ESTIMATION RESULTS

3.1. Unit Root Tests

Table 1 reports the results of the augmented Dickey-Fuller (ADF) test with the variables included in equation (1) to detect the presence of a unit root in each variable. Based on the visual examination of the time series, it is decided whether a trend should be included in the test equation.¹⁵⁾ As shown in table 1a, the p -values of the statistics are higher than 10% except for σ_t^J and σ_t^K , accepting the null hypothesis of a unit root (or non-stationarity) at

¹⁴⁾ Numerous preliminary tests showed that this setting generated the best 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 does not improve the test results at all.

¹⁵⁾ Figure 1 illustrates all the 8 variables involved.

the 10% significance level. The null hypothesis is accepted for σ_t^K at the five percent significance level, but is rejected for σ_t^J even at the one percent significance level, indicating strong stationarity evidence for σ_t^J .

Table 1a ADF Unit Root Test for the Levels

Variable	Trend	ADF Statistic	P-Value
Y_t^J	included	-2.617	0.274
Y_t^K	included	-1.603	0.784
g_t	included	-1.966	0.611
p_t^J	not included	-1.347	0.605
p_t^K	not included	-1.995	0.289
p_t^C	not included	-2.196	0.209
σ_t^J	not included	-5.679	0.000
σ_t^K	not included	-2.788	0.064

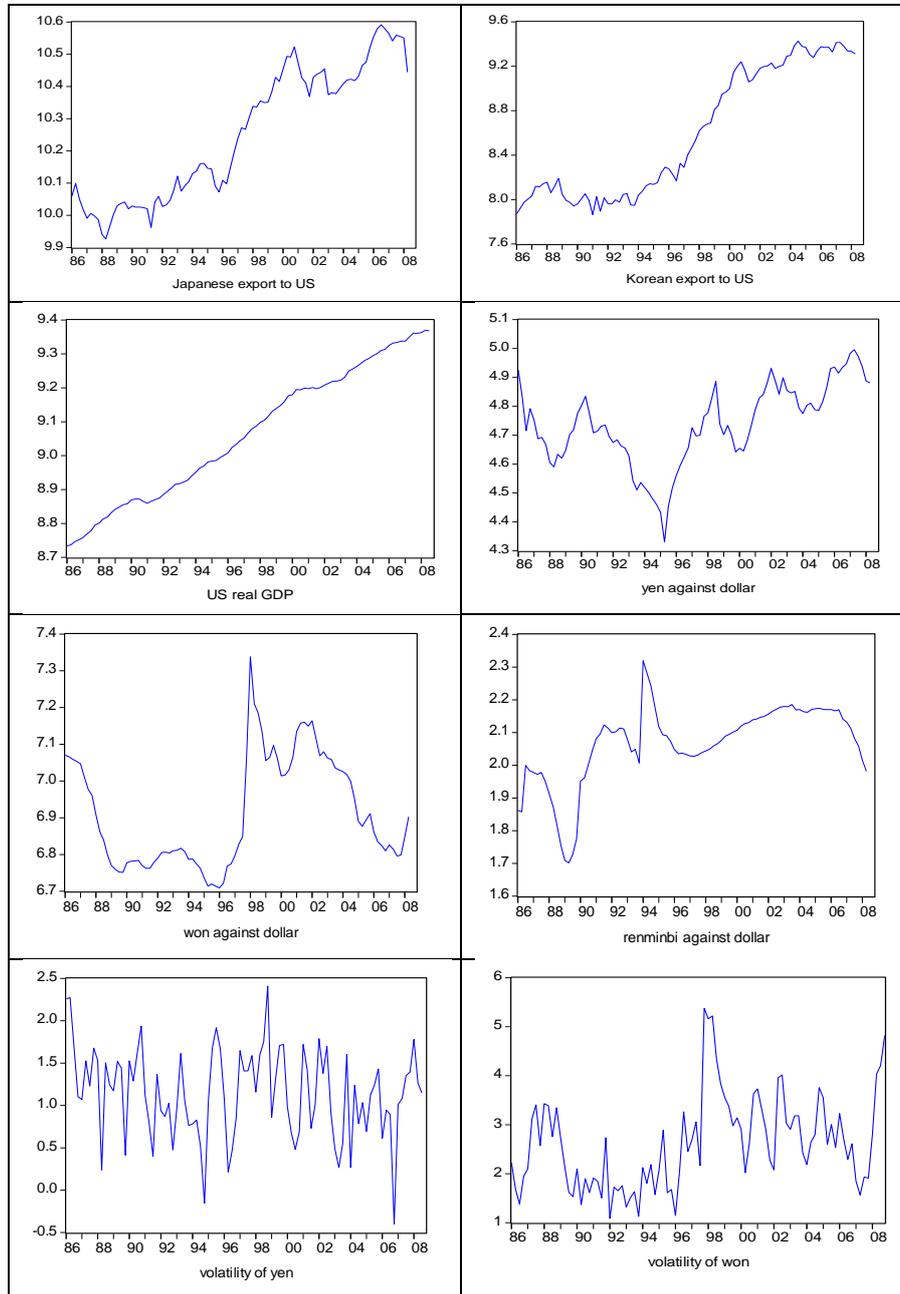
Notes: The lag length included in each test was fixed to be 2. The test result was sensitive to the lag length only in the case of σ_t^K .

Table 1b SL Unit Root Test with a Structural Break¹⁾

Variable	Trend	Suggested Break ²⁾	SL Statistic	Critical Values ³⁾		
				1%	5%	10%
p_t^J	not included	1998Q4	-0.947	-3.48	-2.88	-2.58
p_t^K	not included	1998Q2	-1.267	-3.48	-2.88	-2.58
p_t^C	not included	1994Q1	-2.484	-3.48	-2.88	-2.58
σ_t^J ⁴⁾	not included	1995Q1	-2.679	-3.48	-2.88	-2.58
σ_t^K	not included	1997Q4	-1.763	-3.48	-2.88	-2.58

Notes: 1) The lag length included in each test was fixed to be 2. The test result was sensitive to the lag length only in the case of σ_t^J . 2) The breaks reported in the table are those suggested by JMulTi. 3) Critical values for the null hypothesis of the unit root were obtained from Lanne *et al.* (2002). 4) Depending on the lag length included in the test, a different break is detected and the result of the unit root test is affected.

Figure 1 Graphs of the Variables



However, 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 exchange rates and related variables of East Asian countries may have structural breaks, this paper also performs the S-L unit root test suggested by Saikkonen and Lutkepohl (2002), which is robust in the presence of a structural break. As reported in table 1b, the null hypothesis of a unit root is accepted for σ_t^J at the 5% significance level, and is accepted for all other variables even at the 10% significance level. Table 1b does not show the test results for Y_t^J , Y_t^K , and g_t because there is no reason to believe they have structural breaks. But it should be noted that the S-L tests, whose results are not reported in table 1b, confirmed the results of the ADF test regarding Y_t^J , Y_t^K , and g_t .

Finally, concerning unit root test results, it should be reported that both the ADF test and the S-L test, whose test statistics are not reported in this paper, strongly indicate stationarity for the first differences of all the variables involved.

3.2. Cointegration Tests

As mentioned in previous sections, it is well known that exchange rates and related time series have drastically changed in East Asia, implying the possibility of structural changes in the series. However, this does not automatically mean that export functions including exchange rates have also changed in structure. For example, Nieh (2002) reported that the relationship among macroeconomic variables in some selected Asian countries did not change as a result of the 1997 Asian financial crisis, even though the structure of each macroeconomic variable changed considerably. Baak *et al.* (2007) also reported that there was no evidence of a structural change in East Asian export functions caused by the 1997 financial crisis. In contrast, the literature investigating Chinese exports points out changes in the structure of those exports from labor-intensive products to capital-and-technology-intensive products (See, for example, Kim, Kim, and Lee, 2006; Wang and Wei, 2008).

Table 2 Cointegration Tests with a Structural Break

Statistic	H_0 :	$r = 0$	$r \leq 1$	$r \leq 2$	$r \leq 3$	$r \leq 4$
	H_A :	$r \geq 1$	$r \geq 2$	$r \geq 3$	$r = 4$	$r = 5$
Japanese Exports to US ²⁾						
Johansen Statistic ³⁾		134.41*	74.81	39.16	18.21	7.71
(<i>p</i> -value)		0.001	0.189	0.690	0.868	0.734
S-L Statistic ⁴⁾		67.50*	25.11	11.44	2.65	1.18
(<i>p</i> -value)		0.038	0.878	0.944	0.989	0.745
Korean Exports to US ²⁾						
Johansen Statistic ³⁾		108.58*	61.78	33.09	18.76	7.83
(<i>p</i> -value)		0.092	0.646	0.906	0.844	0.722
S-L Statistic ⁴⁾		58.73	28.90	12.33	5.38	1.52
(<i>p</i> -value)		0.184	0.707	0.913	0.836	0.653

Notes: 1) r denotes the number of cointegrating vectors. 2) The lag length included in the test reported in the table is fixed to be 1, based on the lag length suggested by the four JM criteria. Different criteria suggested different lag lengths, but one lag was the most frequently suggested by the criteria. The results in preliminary tests were sensitive to the lag length, but the presence of one cointegrating vector was quite strongly detected in various lag selections. 3) Refer to Johansen *et al.* (2002). The Johansen test requires a break point designated by the researcher. In this research, 1994Q1 is designated as the break point. When 1998Q1 was used in preliminary tests, the results were quite similar to those reported in the table. 4) Refer to Saikkonen and Lutkepohl (2000a, 2000b, and 2000c). 5) The asterisk (*) indicates the rejection of the null hypothesis of no cointegration at the 10% significance level.

Because this paper explores the impact of the *renminbi* on Japanese and Korean exports, considering the possibility of any changes in the Japanese and the Korean export functions caused by the changes in the Chinese export structure, this paper performs cointegration tests such as the S-L cointegration test (Saikkonen and Lutkepohl, 2000a, 2000b, and 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 2.

In the case of the Japanese export function, 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, the J test indicates the presence of a long-term relationship at the 10%

significance level and the S-L test at the 20% significance level. Even though the S-L test does not indicate the presence of a cointegrating vector at the five or ten percent level, it should be noted that the p -value of the statistic for one cointegration is 71%, while the p -value of the statistic for no cointegration is much lower at 18%. Therefore, this paper concludes that the variables are cointegrated in both the Japanese and the Korean export function.

3.3. Estimating Export Functions (Cointegrating Vectors)

The cointegrating vectors (or the export functions) are estimated by the OLS and the fully modified OLS of Phillips and Hansen (1990).¹⁶⁾ The estimation results reported in table 3a for the OLS and in table 3b for the fully modified OLS show that the two different methods produce similar results for the data covering 1986Q1-2008Q2.

Of interest are the different long-term impacts of the *renminbi* in the export functions of the two countries. In particular, depreciation of the *renminbi* has a positive impact on Japanese exports but a negative impact on Korean exports. These results may be interpreted such that Korean exports are competing with Chinese exports in the US market, but that Japanese exports are not. Because Korean exports are less developed than those of Japan, these results also seem to be consistent with the findings of Eichengreen, Rhee, and Tong (2004) reporting China's impact on other countries' exports as dependent on the stage of development of the other countries. In this respect, the results are also consistent with the findings of Kim, Kim, and Lee (2006), who report that China's export structure is becoming similar to that of Korea.

¹⁶⁾ If the variables are cointegrated, the coefficient values estimated by the OLS are consistent (Hamilton, 1994, Ch. 19.3). The fully modified OLS corrects for correlation between shocks to dependent variable and shocks to explanatory variables. This paper employs these two estimating methods because they are useful to test for the stability of the estimated values. The CUSUM test, a test for the stability of estimated coefficient values using OLS estimates, is available in most statistics packages, and Hansen (1992a, 1992b) provides codes which can be used to test for stability of fully modified OLS estimates.

Table 3a Estimates of the Cointegrating Vectors by OLS for the Whole Period

	c	g_t	p_t	p_t^c	σ_t	Trend	R^2
Japanese Exports to the US							
Coeff.	-15.66***	2.831***	0.174**	0.198***	0.018	-0.015***	0.95
Std. Error	4.311	0.502	0.077	0.051	0.012	0.004	0.95 ²⁾
Korean Exports to the US							
Coeff.	-40.16***	5.003***	0.752***	-0.278*	-0.040	-0.016	0.95
Std. Error	10.921	1.349	0.193	0.153	0.037	0.010	0.95 ²⁾

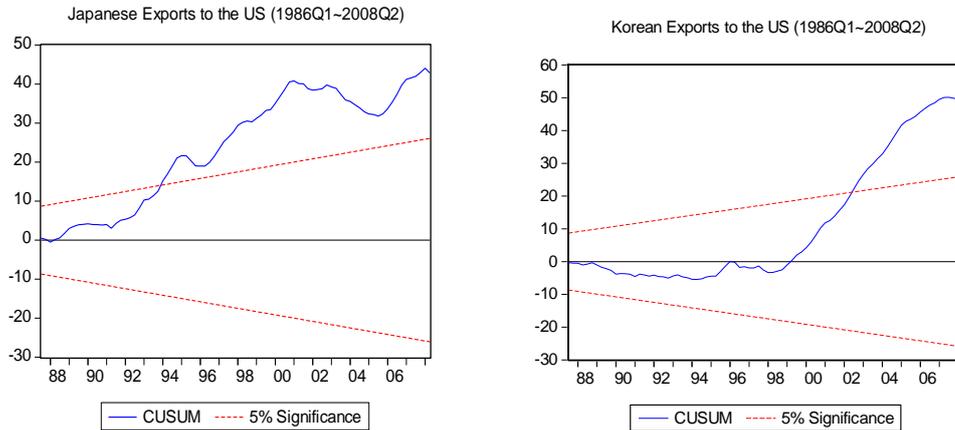
Notes: 1) The whole period is from 1986Q2 to 2008Q2. 2) Adjusted R -square. 3) The asterisks *, **, and *** indicate the rejection of the null hypothesis of zero coefficient at the 10%, 5%, and 1% significance level, respectively. 4) Standard errors were computed using the method of Newey and West (1987).

Table 3b Estimates of the Cointegrating Vectors by Fully Modified OLS for the Whole Period

	c	g_t	p_t	p_t^c	σ_t	Trend	L^c
Japanese Exports to US							
Coeff.	-20.91***	3.354***	0.187***	0.339***	0.033	-0.019***	0.400
Std. Error	5.161	0.584	0.083	0.107	0.018	0.004	0.2 ¹⁾
Korean Exports to US							
Coeff.	-46.90***	5.547***	1.080***	-0.550*	-0.080**	-0.020	0.324
Std. Error	16.58	1.949	0.238	0.294	0.035	0.014	0.2 ¹⁾

Notes: 1) p -value is higher than 0.2. Therefore, the null of stability is accepted. See also the notes for table 3a.

Figure 2a CUSUM Tests for the Cointegrating Vectors Estimated by OLS (1986Q1-2008Q2)



However, because the estimated export functions may be unstable, and because estimations using only recent data may generate different results, as mentioned before, stability tests (the CUSUM test and the Hansen (1992a, and 1992b) test) are performed. The CUSUM test results illustrated in figure 2a indicate that the estimated export functions are unstable, while the Hansen (1992a, and 1992b) stability test statistics, L^c , in table 3b indicate that the estimated functions are stable. Even though the Hansen test does not indicate instability, because the CUSUM tests show the possibility of a structural break, the export functions are re-estimated excluding some old data. The two stability tests are not designed to detect the break point and therefore do not give a hint for it. However, considering that China's trade with the US, Japan, and Korea drastically increased in the mid-1990s and that China's exchange rate system also changed in 1994, 1995Q1 is chosen as a possible structural break point.¹⁷⁾ Then the export functions are re-estimated using only the post-break data (that is, the second time period data or the sub-period data).

¹⁷⁾ Experimental estimations adopting 1997 as the break point, which are not reported in this paper, also generated very similar estimation results.

Table 4a Estimates of the Cointegrating Vectors by OLS for the Second Time Period

	c	g_t	p_t	p_t^c	σ_t	Trend	R^2
Japanese Exports to US							
Coeff.	-22.01***	3.622***	0.157*	0.021	0.005	-0.020***	0.93
Std. Error	3.759	0.441	0.091	0.131	0.013	0.003	0.92 ²⁾
Korean Exports to US							
Coeff.	-41.59***	4.996***	0.438***	1.351***	-0.033**	-0.014*	0.98
Std. Error	8.343	1.013	0.109	0.225	0.013	0.007	0.98 ²⁾

Notes: 1) The second time period is from 1995Q1 to 2008Q2. See also the notes for tables 3a and 3b.

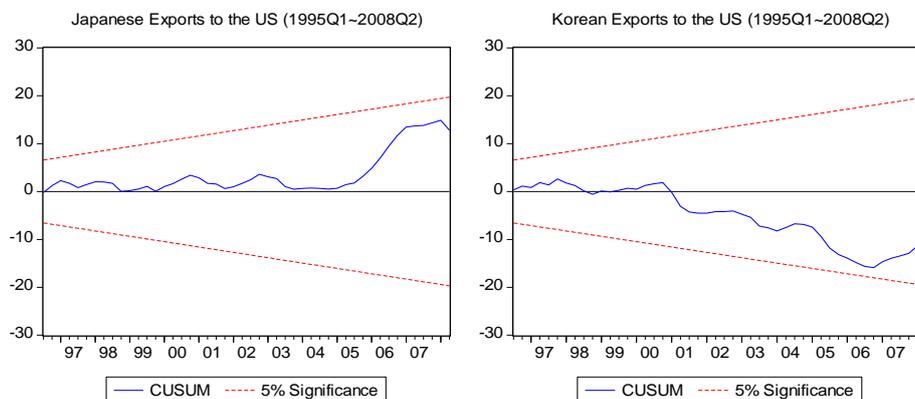
Table 4b Estimates of the Cointegrating Vectors by Fully Modified OLS for the Second Time Period

	c	g_t	p_t	p_t^c	σ_t	Trend	L^c
Japanese Exports to US							
Coeff.	-24.09***	3.823***	0.140	-0.379***	0.004	-0.020***	1.372
Std. Error	4.438	0.505	0.096	0.161	0.015	0.004	0.01 ¹⁾
Korean Exports to US							
Coeff.	-46.82***	5.463***	0.439***	1.490***	-0.048***	-0.018***	0.736
Std. Error	7.664	0.895	0.117	0.246	0.017	0.006	0.17

Notes: 1) p -value is lower than 0.01. Therefore, the null of stability is rejected. See also the notes for tables 3a, 3b, and 4a.

Tables 4a and 4b report the estimation results for the second time period, table 4a for the OLS estimation, and table 4b for the fully modified OLS estimation. One striking change from tables 3a and 3b is the estimated coefficient values of the *renminbi*. In fact, the estimation results for the second time period (1995Q1-2008Q2) are not very different from the results for the whole period (1986Q1-2008Q2) except for the coefficient of the *renminbi*. In other words, the coefficient of the *renminbi* is unstable, but the

Figure 2b CUSUM Tests for the Cointegrating Vectors Estimated by OLS (1995Q1-2008Q2)



coefficients of other variables are stable. This may explain why the CUSUM test and the Hansen test generated mixed results.

Different from the case of the estimation for the whole sample period, in estimations with the sub-period data depreciation of the Chinese *renminbi* turns out to have a positive impact on Korean exports. On the other hand, depreciation of the *renminbi* either does not affect Japanese exports (table 4a) or has a negative influence on them (table 4b). One thing which should be reported is the stability of the *renminbi* coefficient in the Korean export function for the second time period and the instability of the same coefficient in the Japanese export function for the second time period. In many experimental estimations that adopt slightly different time coverage (for example, 1999Q1-2008Q2) and specifications which are not reported in this paper, the sign of the *renminbi* coefficient in the Korean export function has been persistently and significantly positive. In contrast, the sign of the same coefficient in the Japanese export function has been quite unstable. The *renminbi* coefficient in the Japanese export function has been positive or negative and often insignificant depending on specifications and slight changes in time coverage. This respective stability and instability are confirmed by the CUSUM test illustrated in figure 2b and the Hansen test

reported in table 4b. Both the CUSUM and the Hansen tests accept the null of stability regarding the estimated Korean export function. On the contrary, the Hansen test rejects the null of stability regarding the estimated Japanese export function.

These findings are regarded as reflecting the complexity of the trade pattern and the production network among the three countries involved in the present research. As China develops, the Chinese industrial structure becomes similar to those of Korea and Japan, making China a challenging competitor to the two more developed Asian countries. On the other hand, China is an important cooperater to the two countries in the tightly connected production networks in Asia.

Ando and Kimura (2003) have described these production/distribution networks as a new and major characteristic of East Asian economies. Even though the whole picture of the production network is not thoroughly explored due to its complicated and ongoing evolution, a substantial number of recent papers depict some of its aspects. According to Thorbecke (2008), exports of electronic components from Korea and Taiwan rose from \$4.6 billion in 2000 to \$21.2 billion in 2005, and exports of the same products from Japan to China rose from \$3.8 billion to \$9.4 billion. In the same time period, China's exports of final electronic goods to the world increased from \$68.2 to \$266.7 billion. According to Tong and Zheng (2008), China's trade surplus in 2006 reached \$144.2 billion with the US and \$91.6 billion with the EU. In the same year, China's trade deficit reached \$24 billion with Japan and \$45 billion with Korea. In fact, as mentioned before, China is the second biggest market for Japan and the biggest market for Korea as of 2008. The share of the Chinese market in Japanese exports increased from 6.3% in 2000 to 16.3% in 2008, and the share of the Chinese market in Korean exports increased from 10.7% in the same time period. In addition, according to the surveys by KIET (2004), 46.3% of Korean companies in the electronics and telecomm equipment sector reply that low-cost labor is the chief motive for their FDI to China, implying that China is their production base for the world market.

Therefore, the drastic change in the coefficient of the *renminbi* exchange rate in the Korean export function is interpreted as reflecting the drastic change in the interdependence between Korea and China over the last decade. In addition, the estimation results imply that, as Eichengreen, Lee, and Tong (2004) conjecture, Korean companies which use China as their production bases may suffer rather than benefit from the revaluation of the *renminbi*.

In contrast, the unstable estimation results with regard to the same coefficient in the Japanese export function indicate that the impact of the *renminbi*'s value on Japanese exports is not certain, at least at this stage.

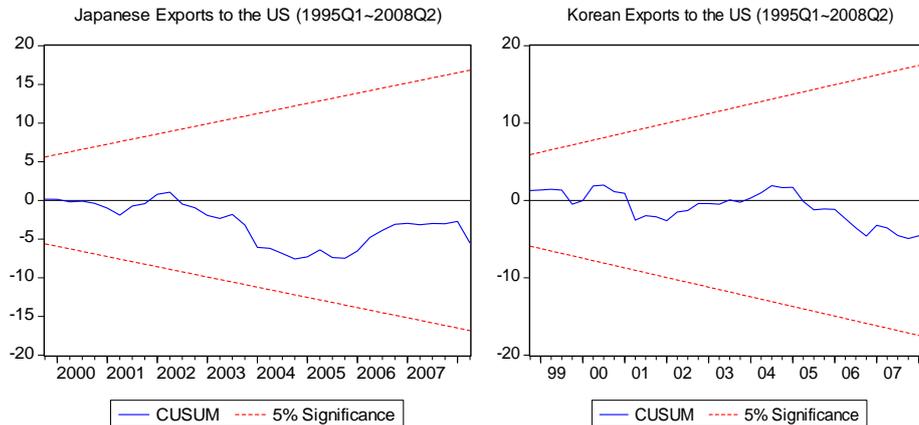
In the meantime, the coefficients of other variables are quite consistent with conventional expectations. The real GDP of the US turns out to have positive impacts on the exports of the two countries. The exchange rate volatility of the currency of the exporting country has a negative impact on Korean exports but an insignificant impact on Japanese exports. Depreciation of the currency value of the exporting country positively influences both functions, but the influence of the exchange rate is stronger in the Korean export function.

3.4. Error Correction Models

Since the cointegration tests in the previous section detected one long-term equilibrium relationship for each of the export functions, error correction models illustrated in equation (2) are estimated to see the short-term dynamics of the export functions. To see the dynamics of the recent time period (1995 to 2008), the error correction models are estimated using the second period data. Accordingly, the error correction terms are computed by the cointegration vectors reported in either table 4a or table 4b. Since the estimation results of the error correction models change only quantitatively but not qualitatively depending on whether we use table 4a or table 4b, this paper reports the results which used table 4a to compute the error correction terms.

Each error correction model is estimated in the first step with long lags of

Figure 3 CUSUM Tests for the Error Correction Models (1995Q1-2005Q2)



each explanatory variable, and the number of lagged variables is reduced in a way that increases the adjusted R^2 s. In other words, variables which are insignificant and do not generate, even when omitted, any noticeable difference in the estimation results are eliminated from equation (2) in order to find a parsimonious structure of the error correction models.¹⁸⁾

In addition, to examine the stability of the estimates, the CUSUM statistics of the estimations of the error-correction models are computed and illustrated in figure 3. As shown, the CUSUM statistics are within the 95% confidence bands, implying no structural break for the time period from 1995Q1 to 2008Q2.

The estimated values of the error correction models are presented in table 5. As can be seen from the tables, the estimated coefficient values of the error-correction terms in all the models are negative and significant at the five percent significance level, confirming the presence of one long-term relationship among the variables involved. Overall, the short-run dynamics examined by the error correction models show similar impacts of the explanatory variables to those found in the long-term relationships. One exception

¹⁸⁾ See Greene (1993, Ch. 19.6).

Table 5 Estimates of the Error Correction Models

Variables	[1] Japanese Exports to the US		[2] Korean Exports to the US	
	Coefficient	Std. Error	Coefficient	Std. Error
C	0.237*	0.138	0.371***	0.103
EC_{t-1}	-0.208*	0.111	-0.360***	0.096
ΔY_{t-1}				
ΔY_{t-2}	0.213*	0.126		
ΔY_{t-3}	0.239*	0.131	-0.272**	0.116
ΔY_{t-4}	-0.260**	0.121		
ΔY_{t-5}	0.295**	0.110		
Δg_t	1.888***	0.688	2.619**	1.208
Δg_{t-1}	1.912**	0.743		
Δg_{t-2}	2.804***	0.703		
Δg_{t-3}				
Δg_{t-4}	-3.513***	0.866	3.469***	1.256
Δg_{t-5}	-1.385*	0.774		
Δp_t	0.283***	0.079	0.459***	0.113
Δp_{t-1}	0.165**	0.065	-0.348**	0.132
Δp_{t-2}	0.100	0.066	0.441***	0.142
Δp_{t-3}	-0.146**	0.068	-0.311**	0.125
Δp_{t-4}			0.414***	0.135
Δp_t^C				
Δp_{t-1}^C	0.438**	0.202	1.534***	0.547
Δp_{t-2}^C			-0.892	0.537
Δp_{t-3}^C				
Δp_{t-4}^C	0.189**	0.078		
Δp_{t-5}^C	0.274***	0.084		
$\Delta \sigma_t^K$	0.010*	0.005	-0.021***	0.008
$\Delta \sigma_{t-1}^K$				
$\Delta \sigma_{t-2}^K$				
$\Delta \sigma_{t-3}^K$			-0.040***	0.010
$\Delta \sigma_{t-4}^K$				
$\Delta \sigma_{t-5}^K$			-0.026**	0.010
R^2	0.761		0.637	
Adjusted R^2	0.639		0.506	
Breusch-Godfrey (p -value)	1.235 (0.872)		2.131 (0.712)	

Note: The asterisks *, **, and *** indicate the rejection of the null hypothesis of a zero coefficient at the 10%, 5%, and 1% significance level, respectively.

exception is the coefficient of the *renminbi* in the Japanese error correction model, in which the coefficient is significantly positive. In the long-term relationship, it was either significantly negative or insignificantly positive. This contradiction also shows that the impact of the *renminbi* is not clearly detected in the Japanese export function.

Finally, the Breusch-Godfrey statistics at the bottom of table 5 imply that serial correlation in the disturbances should not be a concern in these estimations, and the R^2 and adjusted R^2 values are as high as typically reported in this kind of research.

4. CONCLUSION

Motivated by the appreciating *renminbi*, this paper investigated whether and how the value of the Chinese *renminbi* affects Japanese and Korean exports to the US. When the export functions were estimated using the data covering 1986 to 2008 (whole period data set), depreciation of the *renminbi* turned out to increase Japanese exports but decrease Korean exports, implying that the Korean products compete with the Chinese products but the Japanese products do not.

When the same functions were estimated using the data covering 1995 to 2008 (second period data set), the estimated values of other coefficients than the *renminbi* were similar to those estimated for 1986-2008. The estimation for the second time period (1995-2008) was performed following the estimation for the whole period (1986-2008), because the CUSUM tests indicated some instability in the estimation results for 1986-2008, and because there were some drastic changes from the mid-1990s in the structure of Chinese exports and the relations among the countries involved in this paper.

Different from other variables, the estimated values of the *renminbi* variable drastically changed across the two data sets. For 1995-2008, depreciation of the *renminbi* was consistently estimated to increase Korean

exports. In contrast, the influences of the *renminbi* on Japanese exports were uncertain, because the estimated values were quite sensitive to small changes in the covering period or the methodologies. Those results imply that Korean products do not compete with Chinese products, at least at the aggregate level in the recent economic environment. Regarding Japanese exports, we do not have enough evidence to determine competition levels at this stage.

Finally, the unstable estimation results in the Japanese export functions, along with the drastic changes in the *renminbi* coefficients across the two data sets, show the need to explore the export data at a disaggregated level, such as at an industrial or a sectoral level, in future work. The drastic changes and instability in the estimates might be caused by the contradicting effects of the *renminbi* in different sectors, depending on the level of sophistication and the degree of cross-country networking of the sectors.

APPENDIX

Data Sources

Consumer Price Indices (CPI) of Japan, Korea and the US, and the annual growth rates of monthly CPI in China, the quarterly real GDP of the US, Export Unit Value Indices of Japan and Korea, and exchange rates of involved countries have been collected from the *International Financial Statistics (IFS)* of the International Monetary Fund (IMF).

The data for the Japanese and the Korean exports to the US have been obtained from the *Direction of Trade Statistics (DOTS)* of the IMF.

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