The Impact of the Chinese Renminbi on the Exports of the ROK and Japan to the US

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This paper examines the impact of the real exchange rate of the Chinese renminbi against the US dollar on Japanese and South Korean exports to the US. Empirical test results analyzing quarterly data covering 1986Q1 to 2005Q2 show different long-run impacts of the renminbi in the export functions of the two countries. In particular, according to estimates of cointegrating vectors, the depreciation of the renminbi has a positive impact on Japanese exports but a negative impact on South Korean exports. However, some stability tests indicate a structural break in export functions. Unlike in the case of the estimate for the whole sample period, in empirical tests with recent sub-period data, the depreciation of the Chinese renminbi turns out to have a positive impact on both Japanese and South Korean exports. In addition, it transpires that the real GDP of the US has a positive impact on the exports of the two countries. The exchange rate volatility of the Korean won has a negative impact on South Korean exports but a positive impact on Japanese exports. The short-run dynamics examined using error correction models show similar impacts on the part of the explanatory variables.

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Keywords: Japanese exports, South Korean exports, Chinese renminbi, Cointegration, Error correction model, Structural break

1. Introduction

As is well known, China has maintained a de-facto fixed exchange rate of the Chinese renminbi against the US dollar since 1994. Because the value of the renminbi against the US dollar has been fixed despite the remarkable economic growth and accumulating trade and current account surplus of China for the last decade, the US and other trading partners of China, firmly believing the renminbi to be substantially undervalued, urged the Chinese government to revalue the renminbi or shift to a more flexible exchange rate regime (Chang and Parker, 2004; Funke and Rahn, 2005). Entering 2005, the US government was more vocal in demanding a revaluation of the renminbi, and the Chinese government finally announced that it would increase the value of the renminbi by 2.1% on July 21, 2005. In addition, the Chinese government announced that it would move to a managed float of the renminbi against a basket of currencies (*the New York Times*, 2005 July 22; *The Economist*, 2005 July 28).

The appreciation of the renminbi is, in general, expected to have a positive impact on the exports of other East Asian countries because China is known to be their major competitor in the world market. However, despite the hot debate surrounding the value of the renminbi and the importance of this issue, the effect of the value of the Chinese renminbi on the exports of other East Asian countries has rarely been explored.[1]

Against this background, this research aims to determine the effect of the value of the Chinese renminbi on the volume of Japanese and South Korean exports to the US. In fact, the US is one of the most important trading partners of Japan and the ROK[2]. As of 2004, the share of the US market in Japanese exports was 22.7%, exceeding that of the European Union (15.78 %) or China (13.1 %). In the meantime, the share of the US market in South Korean exports was 17.0%, slightly lower than only that of China (19.6 %) and exceeding that of the European Union (14.9 %) and Japan (8.6%).

To determine the impact of the exchange rate of the renminbi on Japanese and South Korean exports to the US, this paper analyzes quarterly trade data for the period from 1986Q1 to 2005Q2. Specifically, following the work of Arize, Osang and Slottje (2000), Baak et al. (2006), Baum et al. (2002), Chou (2000), Chowdhury

[1] Some papers investigate the impact of the renminbi on Chinese trade (Zhang, 2001; Chou, 2000; Tang, 2003). Wang, Wang and Zhang (2003) examine the effects of the Japanese yen's depreciation on Chinese exports. Bhattacharya, Ghosh, and Jansen (2001) investigate whether the emergence of China has hurt Asian exports.

[2] The following numbers were calculated by the author from data obtained from the IMF's *Direction of Trade Statistics (DOTS).*

(1993) and Hassan and Tufte (1998) among others, this study examines the long-run relationship between exports from one country to the other, as well as other economic factors, including the real exchange rate of the Chinese renminbi, by performing cointegration tests. In addition, the short-run impact of the real exchange rate is examined by estimating error-correction models, if the variables involved are cointegrated.

In particular, the volume of real exports from Japan or the ROK to the US is a function of the bilateral real exchange rate between the exporting county (Japan or the ROK) and the importing country (the US) and other economic variables, such as a measure of the economic activity of the US and exchange rate volatility. In addition, the exchange rate of the renminbi against the US dollar is also included as an explanatory variable in the two export functions.[3]

Empirical test results from an analysis of quarterly data covering 1986Q1 to 2005Q2 show different long-run impacts of the renminbi in the export functions of the two countries. In particular, according to the estimate of cointegrating vectors, the depreciation of the renminbi has a positive impact on Japanese exports but a negative impact on South Korean exports.

However, stability tests such as the CUSUM test and the tests suggested by Hansen (1992a, 992b) indicate that the export functions should be very unstable, implying the presence of structural breaks. Accordingly, cointegration tests such as the test (hereafter referred to as the S-L cointegration test) suggested by Saikkonen and Lutkepohl (2000a, 2000b, 2000c) and the test (hereafter referred to as the J cointegration test) suggested by Johansen et al. (2000), which allow a structural break in the cointegrating vector, are performed. The results also confirm that the variables are cointegrated in each export function. The export functions are then re-estimated for the recent sub-period (1994Q1 to 2005Q2). The CUSUM tests show that the export functions are stable for this sub-period.[4]

Unlike in the case of the estimate for the whole sample period, in empirical tests with sub-period data, the depreciation of the Chinese renminbi turns out to have a positive impact on both Japanese and South Korean exports. In addition, it transpires that the real GDP of the US has a positive impact on the exports of the two countries. The exchange rate volatility of the Korean won has a negative impact on South Korean exports but a positive impact on Japanese exports. The short-run dynamics

[3]A more detailed explanation will be provided in the following sections.
[4] The Hansen (1992a, 1992b) tests show mixed results.

examined using error correction models show similar impacts on the part of the explanatory variables.

2. Models and Data

2.1. Export Functions

This paper performs cointegration tests with export functions (the export function of Japan to the US and the export function of the ROK to the US) and estimates the coefficients of the functions to understand the long-run relationship between the export volumes and the explanatory variables. In addition, this paper examines the short-run dynamics of the export functions by estimating error-correction models, if the variables are cointegrated.[5]

Following the typical specifications of other papers, an export function (or, a long-run equilibrium relationship between exports and other economic variables) is assumed to have the following functional form:

$$Y_{ijt} = \xi_0 + \xi_1 . g_{jt} + \xi_2 p_{ijt} + \xi_3 \sigma_{ijt} + \xi_4 p_{cjt} + \varepsilon_{ijt} \qquad \text{------ (1)}$$

where Y_{ijt} denotes real exports from country *i* to country *j*. Therefore, *i* denotes the exporting country and *j* the importing country. In this paper *i* is Japan or the ROK, and *j* is the US. The variable g_{jt} denotes the measure of economic activity of the importing country, *j* (that is, the US).

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 importing country *j*'s currency. Therefore, if p_{ijt} rises, the products of exporting country *i* become cheaper. p_{cjt} is the exchange rate of country *c*'s currency against the importing country *j*'s currency, where country *c* is a competitor to country *i* in the market of country *j*.[6] In this paper, country *c* is China.

Finally, 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.

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[5] Similar methodological approaches regarding export or import functions of various countries can be found in the papers of Arize, Osang and Slottje (1999, 2000), Chowdhury (1993), Hassan and Tufte (1998), Chou (2000), Zhang (2001) and Tang (2003).

[6] The exchange rate of a competing country (p_{cjt} in this paper) is not included in the papers mentioned in footnote 5. However, various estimation experiments performed by the author showed that its coefficients are significant and cannot be ignored. The selection of country *c* and more detailed reports are presented in sections 3 and 4.

It is expected that the higher the economic activity in the importing country, the higher the demand for exports. Therefore, the value for ξ_1 is expected to be positive. Since a higher real exchange rate implies a lower relative price of the exported products, the value for ξ_2 is also expected to be positive. In contrast, since low pricing of the competitor's products (that is, higher p_{cjt}) will have a negative impact on the exports of country *i*, the value for ξ_3 is expected to be negative.

Extant theoretical and empirical papers have shown that exchange rate volatility may have either a positive or a negative influence on trade, depending on the economic and institutional environment.[7] However, if economic agents are moderately risk averse, it is generally expected that the impact of exchange rate volatility will be negative. In this case, the value for ξ_4 will be negative.

Subsection 2.3 shows in greater detail how the data for the variables are computed.

2.2. The error-correction model

After observing the results of cointegration tests with equation (1), the following dynamic error correction (EC) model was constructed and estimated to see the short-run impact of the explanatory variables on exports:

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

where *nx, np, ng, ns*, and *nc* are the lengths of included lags for each variable. If the variables in equation (1) are not cointegrated, the error correction term, EC_{ijt-1}, is eliminated from equation (2). In addition, lots of estimation experiments were performed to find a parsimonious structure for equation (2). 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).

[7] See Secru and Uppal (2000) and their references.

2.3. The variables[8]

Real exports (Y_{ijt})

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

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

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*.

Real GDP (g_{jt})

The real GDP of the importing country (country *j*) is commonly used as a proxy measure for the economic activity of the importing country in much literature dealing with quarterly or annual data. Accordingly, the variable g_{jt} in equation (1) is defined as the real GDP of the US.

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 the natural logarithm scale; E_{ijt} is the nominal quarterly exchange rate of country *i*'s currency against country *j*'s currency; 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 the 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. As mentioned above, country *c* is a country which is competing with country *i* in the market of country *j*.

[8] 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 Census X12 method available in the software package E-views 4.

In the case of China, consumer price indices are not reported. Instead, the annual growth rates of monthly indices from 1986 are reported. The Chinese monthly consumer price indices are computed using these growth rates and the consumer price indices for the year from December 2000 to November 2001.[9] Quarterly data are then computed from these monthly data.

Real exchange rate volatility (σ_{ijt})

This study applies the standard deviation of exchange rates as the measure of exchange rate volatility.[10] Specifically, real exchange rate volatility σ_{ijt} is defined as the natural logarithm of the standard deviation of monthly real exchange rates for a certain time period:

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

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 as 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 at 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.[11]

3. Empirical test results

3.1. Unit root tests

As preparation for cointegration tests, the presence of unit roots in the variables included in equation (1) was examined using the augmented Dickey-Fuller (ADF)

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[9] The Chinese consumer price indices from December 2000 to November 2001 were kindly provided by Yuqing Xing at the International University of Japan.

[10] 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. (2002).

[11] Many 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.

tests. Based on the visual examination of the time series, it was decided whether or not to include a trend in the test equation. The lengths of the lags included in the tests were determined by the Modified Akaike information criterion.

The ADF statistics for the levels of all the series are below the 5% critical values, implying the presence of unit roots. In contrast, the statistics obtained from the first differences of the variables reject the null hypothesis of a unit root at the 5% significance level with one exception. In the case of the first difference of the ROK's export volume, the null is rejected at the 10% significance level. Tables 1-1 and 1-2 present the ADF test statistics for all the variables in equation (1) for both the Japanese and South Korean exports.

<Table 1-1> ADF Unit Root Test for the Levels

Variable	Lags[1)]	Trend	ADF Statistic	P-Value
Y_t^J	1	included	-2.384	0.386
Y_t^K	0	included	-1.802	0.697
g_t	1	included	-2.451	0.352
p_t^J	1	included	-1.617	0.779
p_t^K	4	included	-1.942	0.625
p_t^C	0	included	-2.452	0.351
σ_t^J	5	not included	-2.800	0.062[2)]
σ_t^K	4	not included	-2.254	0.189

1) The lags were determined using the Modified Akaike Information Criterion.
2) AIC, lag length is 0. Then, no unit root.

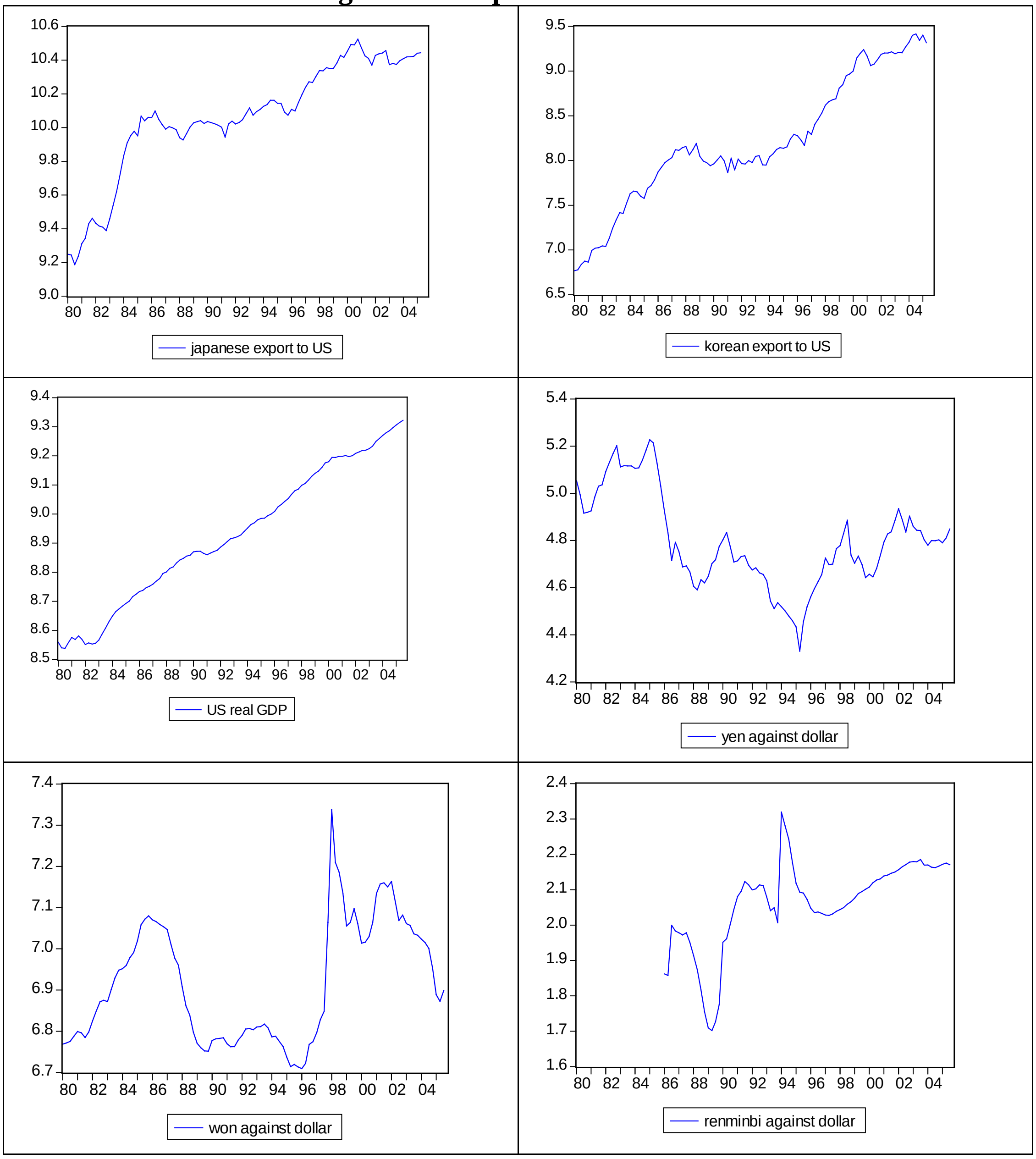
<Table 1-2> ADF Unit Root Test for the First Differences

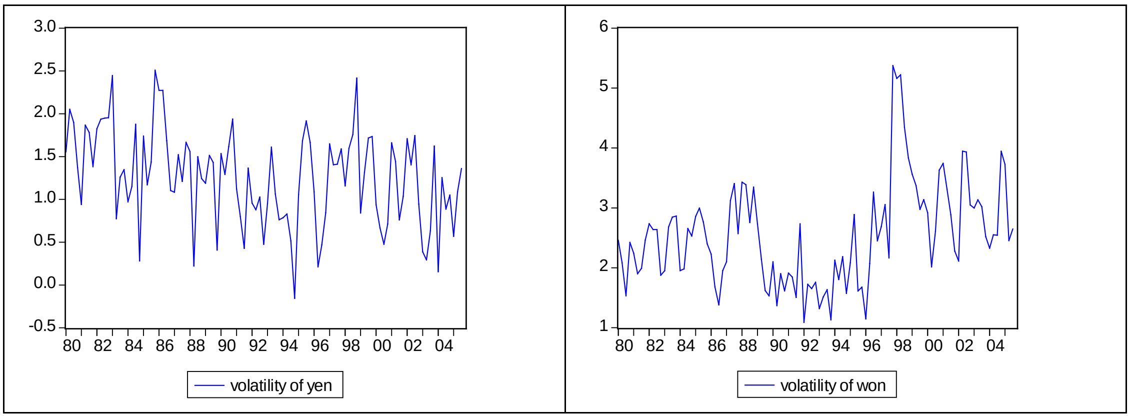
Variable	Lags	ADF Statistic	P-Value (5%)
$\Delta\, Y_t^J$	2	-4.296	0.001
$\Delta\, Y_t^K$	6	-2.695	0.079[1)]
$\Delta\, g_t$	1	-5.393	0.000
$\Delta\, p_t^J$	2	-4.177	0.001
$\Delta\, p_t^K$	0	-7.071	0.000
$\Delta\, p_t^C$	1	-5.503	0.000
$\Delta\, \sigma_t^J$	0	-14.471	0.000
$\Delta\, \sigma_t^K$	0	-12.601	0.000

1) Sensitive to lag length. According to AIC, lag length is 0. Then, the p-value is 0.000.
2) Only intercept is included in all tests.

However, because the dynamics of the exchange rate data and the volatility data, as shown in Figure 1, illustrate drastic change, the unit root tests with a structural break (S-L unit root test, hereafter) suggested by Saikkonen and Lutkepohl (2002) were also performed. The test statistics confirmed the results of the ADF tests as shown in Table 1-3.

<Figure 1> Graphs of the Variables





<Table 1-3> SL Unit Root Test with a Structural Break

Variable	Trend	Suggested break[1)]	SL Statistic	Critical values[2)]		
				1%	5%	10%
p_t^J	included	1995Q3	-1.879	-3.55	-3.03	-2.76
p_t^K	included	1998Q1	-1.480	-3.55	-3.03	-2.76
p_t^C	included	1994Q1	-2.641	-3.55	-3.03	-2.76
σ_t^J [3)]	not included	1995Q1	-1.657	-3.48	-2.88	-2.58
σ_t^K	not included	1997Q4	-1.256	-3.48	-2.88	-2.58

1) Break suggested by JMulTi.
2) Critical values for the null hypothesis of unit root suggested by Lanne et al. (2002).
3) Depending the lag length, a different break is detected. But the result of unit root test is not affected.
4) Lag length is 4. Different standards suggest different lags. Changing the lag sometimes changes the results, but evidence of unit root is stronger.

. 3.2. Cointegration tests

Because all the variables involved have unit roots, cointegration tests were performed to examine whether the variables in each export function illustrated in equation (1) (the function for exports from Japan to the US and the function for exports from the ROK to the US) have a long-run relationship.

The empirical test results[12] of an analysis of quarterly data covering 1986Q1 to 2005Q2 detected a cointegrating relationship between export volume and the explanatory variables; the cointegrating vectors estimated by the OLS are presented in Table 3-1. The estimation results show that the renminbi has different long-run impacts on the export functions of the two countries. In particular, the depreciation of

[12] The test results are not reported in this paper.

the renminbi has a positive impact on Japanese exports but a negative impact on South Korean exports.

However, stability tests[13], such as the CUSUM test and the tests suggested by Hansen (1992a, 992b), indicated that the export functions should be very unstable, implying the presence of structural breaks. Accordingly, cointegration tests such as the test (referred to hereafter as the S-L cointegration test) suggested by Saikkonen and Lutkepohl (2000a, 2000b, 2000c) and the test (referred to hereafter as the J cointegration test) suggested by Johansen et al. (2000), which allow a structural break in the cointegrating vector, were performed. The results, reported in Table 2, also confirmed that the variables are cointegrated in each export function. The export functions were then re-estimated for the recent sub-period (1994Q1 to 2005Q2). The estimation results are reported in Table 3-2 and Table 3-3. The OLS estimation and the fully modified OLS estimation proposed by Phillips and Hansen (1990) show similar results. The CUSUM tests illustrated in Figure 2 show that the export functions are stable for this sub-period.[14]

<Table 2> Cointegration Tests with a Structural Break

Statistic					
H_0:	$r = 0$	$r \le 1$	$r \le 2$	$r \le 3$	$r \le 4$
H_A:	$r \ge 1$	$r \ge 2$	$r \ge 3$	$r = 4$	$r = 5$
Japanese Exports to the US					
Johansen Statistic[(3)]	125.35*	71.64	38.63	20.72	5.00
(p-value)	0.006	0.294	0.733	0.765	0.947
S-L Statistic[(4)]	67.97*	27.50	12.22	3.39	0.02
(p-value)	0.034	0.779	0.917	0.969	0.999
South Korean Exports to the US					
Johansen Statistic[(3)]	109.01*	56.66	30.41	14.15	5.98
(p-value)	0.093	0.833	0.962	0.979	0.895
S-L Statistic[(4)]	63.79*	33.46	20.14	4.20	1.15
(p-value)	0.079	0.448	0.383	0.929	0.753

Notes: (1) r denotes the number of co-integrating vectors. (2) The asterisk (*) indicates the rejection of the null hypothesis of no cointegration at the 10% significance level. (3) Johansen et al. (2002). (4) Saikkonen and Lutkepohl (2000a,b,c)

[13] The test results are not reported in this paper.

[14] The Hansen (1992a, 1992b) tests show mixed results.

<Table 3-1> 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.	-19.44***	3.295***	0.120	0.253***	0.007	-0.019***	0.94
Std. error	5.819	0.668	0.090	0.076	0.008	0.005	0.93[2)]
South Korean Exports to the US							
Coeff.	-49.07***	5.984***	0.791***	-0.109	-0.034	-0.025*	0.94
Std. error	14.12	1.699	0.187	0.226	0.039	0.013	0.94[2)]

Notes: (1) The whole period is from 1986Q2 to 2005Q2. (2) Adjusted R-square. (3)Standard errors were computed using the method of Newey and West (1987). (4) The asterisks (*), (**) and (***) indicate the rejection of the null hypothesis of zero coefficient at the 10%, 5% and 1% significance level, respectively.

<Table 3-2> 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 the US							
Coeff.	-28.97***	4.306***	0.225**	0.544***	0.010	-0.029***	0.95
Std. error	4.320	0.485	0.102	0.168	0.006	0.004	0.94[2)]
South Korean Exports to the US							
Coeff.	-40.35***	5.013***	0.398***	0.700*	-0.037***	-0.010	0.98
Std. error	10.77	1.267	0.112	0.359	0.013	0.010	0.98[2)]

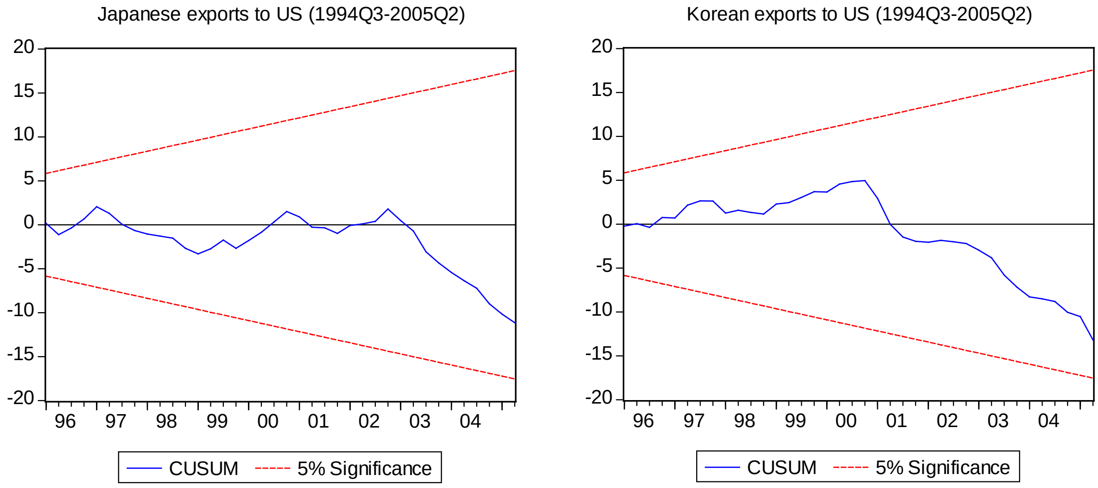
Notes: (1) The second time period is from 1994Q3 to 2005Q2. See also the notes of table 3-1.

<Table 3-3> 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 the US							
Coeff.	-34.39***	4.615***	0.267***	0.935***	0.009	-0.034***	0.655
Std. error	3.316	0.350	0.067	0.171	0.006	0.003	0.2[1)]
South Korean Exports to the US							
Coeff.	-49.11***	5.858***	0.397***	1.009***	-0.044***	-0.018***	1.275
Std. error	7.592	0.854	0.112	0.361	0.016	0.007	0.019

Notes: See the notes of table 3-1.
The second time period is from 1994Q3 to 2005Q2.
1) p-value is higher than 0.2. Therefore, the null of stability is accepted.

<Figure 2> CUSUM Tests for the Cointegrating Vectors Estimated by OLS (1994Q3-2005Q2)



Different from the case of the estimate for the whole sample period, in empirical tests with sub-period data, the depreciation of the Chinese renminbi turns out to have a positive impact on both Japanese and South Korean exports. In addition, it transpires that the real GDP of the US has a positive impact on the exports of the two countries. The exchange rate volatility of the Korean won has a negative impact on South Korean exports but a positive impact on Japanese exports.

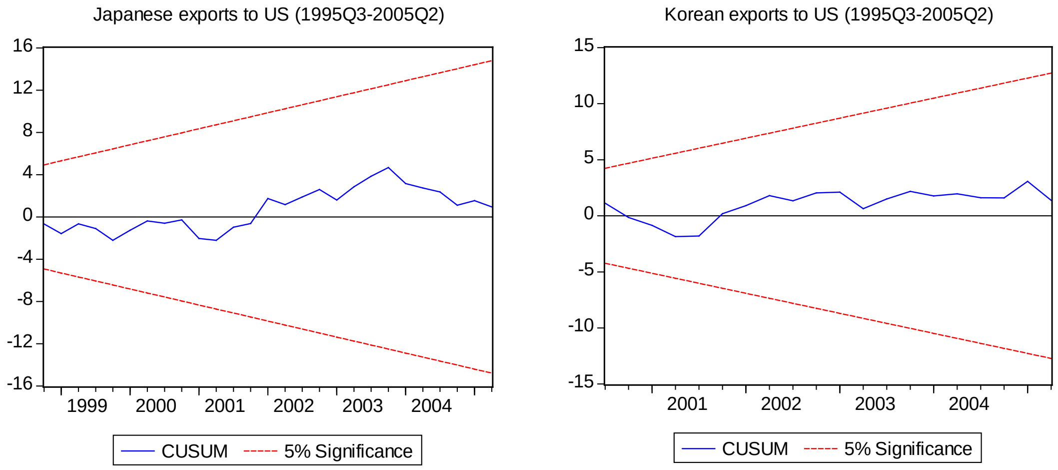
3.3. Error correction models

Since the cointegration tests in the previous section detected one long-run equilibrium relationship for each of the export functions, the error correction models illustrated in equation (2) were estimated to see the short-run dynamics of the export functions. The error correction terms are calculated by means of the cointegration vectors reported in Tables 3-3.

Each error correction model is estimated in the first step with long lags of each explanatory variable, and the number of lagged variables is reduced in such a way as to increase the adjusted R^2s. 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) to find a parsimonious structure for the error correction models.

In addition, to examine the stability of the estimates, the CUSUM statistics for the estimates 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 1994Q3 to 2005Q2.

<Figure 3> CUSUM Tests for the Error Correction Models (1994Q3-2005Q2)



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 of the models are negative and significant at the 5% significance level, confirming the presence of one long-run relationship among the variables involved. The short-run dynamics examined using error correction models show that the explanatory variables have similar impacts.

<Table 5> Estimates of the Error Correction Models

Variables	[1] Japanese exports to the US		[2] South Korean exports to the US	
	coefficient	Std. error	coefficient	Std. error
C	1.649***	0.314	0.413**	0.182
EC_{t-1}	-0.862***	0.162	-0.386**	0.164
ΔY_{t-1}	0.233*	0.121	-0.358*	0.175
ΔY_{t-2}	0.300***	0.104	0.413***	0.142
ΔY_{t-3}	0.269***	0.091		
ΔY_{t-4}	-0.308***	0.094	-0.337**	0.135
Δg_{t}	2.672***	0.684		
Δg_{t-1}	-1.443	0.919		
Δg_{t-2}			4.522**	1.634
Δg_{t-3}			4.900**	1.826
Δg_{t-4}			-2.508	1.588
Δg_{t-5}			-4.753***	1.468
Δp_{t}	0.227***	0.062	0.193*	0.101
Δp_{t-1}	-0.117*	0.062		
Δp_{t-2}			0.485***	0.149
Δp_{t-3}	-0.120**	0.058	-0.300**	0.113
Δp_{t-4}	0.180***	0.057		
Δp_{t}^{C}			2.459**	0.975
Δp_{t-1}^{C}			3.913***	1.078
Δp_{t-2}^{C}				
Δp_{t-3}^{C}	0.360**	0.159	-3.197***	0.568
Δp_{t-4}^{C}	-0.195***	0.062		
$\Delta \sigma_{t}^{K}$	0.012***	0.004	-0.028***	0.008
$\Delta \sigma_{t-1}^{K}$			-0.028**	0.013
$\Delta \sigma_{t-2}^{K}$			-0.023**	0.011
$\Delta \sigma_{t-3}^{K}$			-0.016	0.011
$\Delta \sigma_{t-4}^{K}$			0.023**	0.009
R^2	0.801		0.862	
Adjusted R^2	0.698		0.731	
Breusch-Godfrey (p-value)	4.795 (0.309)		6.065 (0.194)	

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

4. Conclusion and future studies

This paper examined the impact of the real exchange rate of the Chinese renminbi against the US dollar on Japanese and South Korean exports to the US. Empirical test results from an analysis of quarterly data covering 1986Q1 to 2005Q2 showed different long-run impacts of the renminbi in the export functions of the two countries. In particular, according to the estimate of cointegrating vectors, the depreciation of the renminbi had a positive impact on Japanese exports but a negative impact on South Korean ones.

However, stability tests such as the CUSUM test and the tests suggested by Hansen (1992a, 992b) indicated that the export functions should be very unstable, implying the presence of structural breaks. Accordingly, cointegration tests such as the S-L cointegration test and the J cointegration test, which allow a structural break in the cointegrating vector, were performed. The results also confirmed that the variables are cointegrated in each export function. Then, the export functions were re-estimated for the recent sub-period (1994Q1 to 2005Q2). The CUSUM tests show that the export functions are stable for this sub-period.

Unlike in the case of the estimate for the whole sample period, in empirical tests with sub-period data, the depreciation of the Chinese renminbi turned out to have a positive impact on both Japanese and South Korean exports. In addition, it transpired that the real GDP of the US had a positive impact on the exports of the two countries. The exchange rate volatility of the Korean won had a negative impact on South Korean exports but a positive impact on Japanese ones.

The short-run dynamics examined by means of error correction models showed similar impacts on the part of the explanatory variables. In addition, the estimated coefficient values of the error-correction terms in all the models were negative and significant at the 5% significance level, confirming the presence of one long-run relationship among the variables involved.

This paper found a structural break in the Japanese and South Korean export functions. In addition, analyses using relatively recent data revealed that the impact of the Chinese renminbi on Japanese and South Korean export was contradictory to our expectation. That is, the depreciation of the renminbi does not decrease export volumes from Japan and the ROK to the US, but, rather, increases them.

The results of this paper may imply that Chinese exports should not be substitutes for Japanese and South Korean exports in the US market. Or, if Chinese products become cheaper, the income effect may dominate the substitution effect. These conjectures and others will be investigated in a future research project, because this task requires a microscopic analysis rather than the time series analysis adopted in this paper.

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<u>Appendix</u>

Data Sources

Consumer Price Indices (CPI) of the US, annual growth rates of the monthly CPI of China, the quarterly real GDP of the US, the annual nominal GDP of China, the Chinese annual GDP deflators, the US Export Unit Value Indices, and the US Import Unit Value Indices have been collected from the *International Financial Statistics (IFS)* of the International Monetary Fund (IMF).

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

The data starts from the first quarter of 1980 and ends at the fourth quarter of 2003, except for the annual growth rates of the monthly CPI of China which are available only from 1986. Because of this restriction, the empirical tests in this paper cover the period from the first quarter of 1986 to the fourth quarter of 2003.