Industry Level Real Effective Exchange Rates for Korea*

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Abstract

This paper measures Korea's real effective exchange rate(REER) at industry level using industry-level producer price index in major trading partner countries of Korea. At the industry level, it analyzes the effects of changes in nominal exchange rate on REER and those of movements in REER on export volume. The results of this paper show interesting findings. First, each industry has substantially different movement in its REER and its influence on export volume is also different from industry to industry. The effects of changes in norminal exchange rate on REER vary from industry to industry, too. Second, the influence of the REER on export volume is in general reduced after the financial crisis in 1997. Lastly, in the post-crisis period, there was a time lag of more than 6 months for the REER to have an impact on export volume in most industries, especially in leading export industries in Korea. Our empirical studies suggest that the importance of non-price competitiveness will continue to increase in the internationally competitive market while the influence of nominal exchange rate on export volume gradually diminishes.

JEL Classification: F14; F31

Keywords: real effective exchange rates; REER; Won appreciation; exchange rates; export; price competitiveness

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1 Introduction

During the financial crisis in 1997, Korea changed its exchange rate system from managed floating exchange rate system to free floating one. After that, extent of fluctuation in Korean won's nominal value against major currencies widened. Changes in won's value have a considerable impact on the domestic economy through changes in price competitiveness in the world market and also in the domestic market.

It is generally accepted that the impact of exchange rate fluctuation on export and import is different depending upon trading partners and among industries. Especially in Korea where production and investment gap at industry level are worsening as economic polarization[1] appears after the financial crisis, it is imperative to understand industry-level price competitiveness to analyze the impact of changes in nominal exchange rate on domestic industry in a more precise way. Moreover, industry-level analysis may provide an important implication for the exchange rate policy.

In this paper, we measure industry-level Real Effective Exchange Rate (REER) for the first time in Korea. On the basis of the measure, we analyze the industry level impact of changes in exchange rate after the financial crisis. Lastly, we try to derive some policy implications.

The structure of this paper is as follows. First, in section 2, literature on REER in Korea are briefly reviewed. In section 3, the REER at industry as well as aggregate level is constructed from 1991 up to 2004 period at monthly frequency. In section 4, the effect of recent increase in won's nominal value against other currencies on international price competitiveness of each Korean industry is examined. We analyze how industry-level REER would change as won's nominal value increased at a fixed proportion based on price index and trade volume at the end of 2004. In section 5, the impact of REER on export volume and its trend at industry level are examined. Lastly, in section 6, summary and policy implications of this paper are briefly set out.

2 Literature

Researches on the REER for Korea mainly focus on the evaluation of exchange rate level in both pre- and post-crisis period based on aggregate REER. For example, Lee (1999) argues that won was over-valued by about 10% before the crisis in 1997 while it was under-valued after the crisis because of the drastic increase in nominal exchange rate. On the contrary, Chinn (1998), Goldfain and Baig (1998), and Stiglitz (1998) mention that won was not over-valued before 1997.

Domestic researches on the effect of changes in exchange rate at industry level can be divided into three categories in general. There are researches on the impact of exchange rate on profitability, those on exchange rate pass-through to export or import price, and finally, those on the influence of exchange rate on export. These existing researches employ nominal exchange rate of won against dollar or yen for all industries in the same

[1] See Institute for Monetary and Economic Research (2004) for economic polarization in Korea after financial crisis.

way. It is widely accepted that most of export and import transactions in Korea are settled with US dollar or Japanese yen.

For instance, Moon and Lee (2003)[2] use nominal exchange rate of won against dollar in estimating changes in operating profit margin at industry level when won appreciates. Kang and Oh (2001)[3] use nominal exchange rate of won against dollar or yen in analyzing the influence of exchange rate on unit price and volume of major export and import goods. Choi and Kim (2001)[4] also use nominal exchange rate of won against dollar when they estimate exchange rate pass-through to export and import price at industry level.

Researches on the impact of exchange rate on export volume at industry level are conducted by Han et al. (1996), and Lee and Han (2001). They also apply nominal exchange rate to all industries in the uniform way and can not analyze the impact of industry-level price competitiveness on export.

Recently, however, researches[5] emerge, which suggest the possibility to examine industry-level price competitiveness through industry-level REER. Goldberg (2004) constructs REER for 20 industries in the United States and interprets it as industry-level price competitiveness. She argues that REER at industry level is better than REER at aggregate level in explaining the relationship between exchange rate and firm profitability.

If the interpretation that industry specific REER represents industry-level price competitiveness is correct, and if we can construct industry specific REER, we can analyze both the effect of changes in exchange rate on international price competitiveness and the impact of changes in price competitiveness on export volume at industry level.[6]

While Goldberg (2004)[7] uses consumer price index (CPI) which includes non-tradable goods, we use producer price index (PPI) in order to reflect the trend of industry-level price competitiveness more realistically. Especially, we expect that industry level PPI

[2] Moon and Lee (2003) mention that about 80% of Korean export and import transactions are settled with U.S. dollar.

[3] Additional information is not avaialable in their paper, but it seems that they keep in mind the proportion of currency of settlement in Korean export and import.

[4] They mention that changes in nominal exchange rate of won against dollar won are similar to those of won's REER.

[5] There are researches on industry specific real effective exchange rate(RER) and pass-through of the United States exchange rate to industry-level import price. Pollard and Coughlin (2003 a) argue that industry-level RER is more effective than aggregate RER in estimating exchange rate pass-through to import price in the United States when major trading partners' currency exchange rate against U.S. dollar is considered. Moreover, Pollard and Coughlin (2003 b) prove that exchange rate pass-through to import price is symmetrical against both appreciation and depreciation of U.S. dollar when aggregate RER encompassing all industries is used. On the contrary, when industry specific RER is employed, it turns out to be asymmetrical.

[6] Industry specific REER can also be used for researches from industry structure perspective. For example, researches on the relationship between exchange rate and investment, or that between exchange rate and employment.

[7] Goldberg (2004) applies industry-level export or import amount. But she uses aggregate consumer price index available on the International Financial Statistics and applies it to all industries. Lee (1999) argues that trend of REER can not properly reflect price competitiveness of tradable goods when consumer price index is employed.

would present the characteristics of each industry in more precise way than an aggregate index.

3 Trend of international trade and producer price index

3.1 Trend of International trade

As table 1 shows, there has been a huge change both in export and import at industry level in Korea since 1991. In 1991 major export items were textiles, leather products and footwear. In 2000 they were communication equipment, automobiles, electronic tubes, computers, and so on. Annual average growth rate of export amount from 1991 to 2004 is also significantly different. That of the former items recorded as -0.3% and -7.8% while that of the latter items registered as 14.2%, 18.2%, 10.5% and 16.6%, respectively.

Second, composition of import items changed drastically. From 1991 to 2004, import of electrical machinery increased at the annual average growth rate of 13.7%. Their import amount surged at the fastest pace. Import of electronic tubes, communication equipment showed high annual growth rate of 12.0% and 11.6%, respectively and they emerged as major import items.

When trend of industry specific export and import is examined by trading partners as in table 2, it is not difficult to infer that the competitiveness of Korea's products in trading partner country's market would be different from industry to industry.

First, share of export to the Chinese market overwhelmingly increased from 1991 to 2004 in most of major export items except transport equipment while that to Japan and the United States reduced in many items. During the same period, export share of chemical products (D24) to China increased from 5.7% to 45.3%, basic metals (D27) from 3.1% to 30%, general machinery and equipment (D29) from 2.2% to 25.1% and computers and office machinery (D30) from 0.1% to 26.3%. During that period, export share of computers and office machinery (D30) to the United States drastically contracted from 45.8% to 16.7% and electronic tubes (D32) from 29.8% to 14%. Although export share of textiles (D17, D18) to Japan substantially decreased from 19.7% to 0.5%, in case of other items, extent of decrease in export share to Japan was lower than that to the United States.

Second, in terms of major import items, import share from China drastically increased over the last 10 years while that from the United States and Japan reduced except a couple of products. The import share of computers and office machinery (D30), electronic tubes (D32a), communication equipment (D32b) from China significantly expanded from 0.3% to 40.5%, from 0.2% to 12.6% and from 1.0% to 28.5%, respectively. Over the same period, import share of the same items from the United States contracted from 33.9% to 10.4%, from 31.5% to 20.1% and from 26.1% to 13.1%, respectively. In addition, that from Japan greatly decreased from 40.5% to 12.4%, from 43% to 27.8% and 56.7% to 31.6%, respectively.

In summary, major export and import items in Korea have changed from textiles to computers, electronics and telecommunication equipment. Export and import depen-

Table 1: Korean export and import trend by major industry

	KSIC	1991	1995	2000	2004	change[1)]
Export			(Millions of dollars)			(%)
Textile products and apparel	D17,18	14,720	17,270	17,737	14,230	-0.3
Leather products and footwear	D19	4,356	3,054	2,168	1,512	-7.8
Wood and wood products	D20	117	133	121	98	-1.4
General machinery and equipment	D29	3,082	7,240	10,060	17,409	14.2
Computers and office machinery	D30	2,918	4,967	19,633	21,539	16.6
Electronic tubes and electronic components	D32a	6,645	19,373	24,688	24,446	10.5
Electronic components, radio, TV, and communication equipment	D32b	6,536	8,877	14,364	36,600	14.2
Motor vehicles	D34	3,617	10,122	15,436	31,960	18.2
Transportation Equipment, N.e.c.	D35	4,432	5,933	8,946	15,825	10.3
Import						
Pulp, paper products and publications	D21	1,433	2,748	2,371	2,159	3.2
Coke and petroleum products	D23	12,748	19,013	38,077	50,278	11.1
Non-metallic mineral products	D26	1,243	1,556	1,395	2,845	6.6
General machinery and equipment	D29	13,649	22,026	14,699	20,928	3.3
Computers and office machinery	D30	1,995	3,570	7,711	5,882	8.7
Electrical machinery and apparatus	D31	2,578	4,712	7,391	13,664	13.7
Electronic tubes and electronic components	D32a	5,309	9,838	20,470	23,061	12.0
Electronic components, radio, TV, and communication equipment	D32b	1,537	3,057	5,830	6,405	11.6
Motor vehicles	D34	1,103	1,910	1,560	3,360	8.9
Transportation equipment, n.e.c.	D35	2,077	4,323	1,417	2,062	-0.1

Note: 1) Anual average rate of change during 1991-2004.
Data: Korea International Trade Association.

Table 2: Share of Korean export and import by key industry and by major partner country (1991→2004)

KSIC	U.S.	Japan	China
Export			
D17,18	23.0→ 1.9	19.7→ 0.6	1.2→ 1.7
D24	2.4→ 6.2	19.1→ 9.9	5.7→45.3
D27	13.5→ 9.0	39.5→13.3	3.1→30.0
D29	33.5→15.0	12.8→ 8.4	2.2→25.1
D30	45.8→16.7	5.0→ 6.8	0.1→26.3
D32a	29.8→14.0	11.6→13.3	1.0→15.4
D32b	27.8→26.1	9.6→ 3.8	0.3→12.9
D34	46.5→34.4	4.3→ 1.1	0.1→ 6.6
D35	4.7→ 4.5	0.4→ 0.1	0.0→ 2.7
Import			
D17,18	1.9→ 2.9	24.4→ 6.9	26.0→54.9
D24	24.6→19.9	31.7→28.5	2.6→ 9.5
D27	10.1→ 3.2	29.7→31.2	5.3→21.5
D29	22.3→19.3	45.0→40.4	0.4→ 5.5
D30	33.9→10.4	40.5→12.4	0.3→40.5
D32	31.5→20.1	43.0→27.8	0.2→12.6
D32	26.1→13.1	56.7→31.6	1.0→28.5
D34	23.1→12.6	46.7→30.2	0.8→ 4.0
D35	65.0→40.6	4.2→19.2	0.0→ 3.0

dency of those products on China has been continuously on the rise.

3.2 Trend of producer price index

After 1991, producer price index (PPI) has been different by industry to a great extent. Table 3 shows that trend of PPI by industry and by region is quite consistent with that of industry and region specific export and import.

From 1991 to 2004, PPI of computers and office machinery (D30), electronic tubes (D32a), communication equipment (D32b), which emerged as major export industries, generally declined. Moreover, the extent of the decrease in PPI in Korea was relatively bigger than those of major trading partners such as the United States, Japan and China. For instance, PPI of communication equipment (D32b) in Korea dropped at the annual average rate of 4.7%, but that in the United States, Japan and China only fell 0.7%, 4.4% and 6.5%, respectively.

On the other hand, PPI of textiles, which were a major export item in 1991, and that of fabricated metal products, which have been a constant key import item, overall increased. The extent of the increase in Korea was comparatively bigger than that in

Table 3: Annual average growth rate of PPI by industry and by country

KSIC	US	JP	CH	HK	TW	KR
D15	1.5	0.2	-0.2	0.1	1.4	3.9
D17,18	0.2	-1.0	-0.9	0.3	0.8	1.8
D19	1.0	-1	-1.2	0.3	2.3	3.9
D20	2.9	-0.3	-1.2	0.1	2.8	3.8
D21	1.5	-0.2	2.2	0.9	0.8	4.5
D23	4.3	1.1	4.9	0.1	3.3	9.9
D24	2.4	-0.4	0.1	0.7	2.1	3.0
D25	1.1	-1.0	-1.9	0.7	1.1	2.5
D26	1.7	-0.6	-0.9	-0.4	0.6	1.6
D27	1.7	-0.3	1.7	-0.4	3.2	4.3
D28	1.4	-0.3	-0.8	-0.4	2.1	2.8
D29	0.0	-0.7	-0.9	-1.0	1.1	-0.6
D30	-10.4	-4.4	-6.5	-3.4	-10.2	-14.1
D31	0.8	-4.4	-2.1	-3.4	-0.1	1.9
D32a	-0.7	-4.4	-6.5	-3.4	-1.2	-4.7
D32a	-2.1	-4.4	-6.5	-3.4	-3.5	-6.6
D33	0.8	-0.6	-1.8	-1.0	0.6	1.5
D34	1.0	-0.9	-1.8	0.1	1.2	0.3
D35	1.9	-0.9	-1.8	0.1	0.4	1.7
D36	1.6	-0.3	-0.7	0.1	1.9	2.4

Unit: percent.
Note: Anual average percentage changes for 1991-2004

major partner countries. For instance, PPI of textiles in Korea rose at the annual average growth rate of 1.8%, but that in the United States increased only 0.2% while that of Japan and China dropped 1.0% and 1.2%, respectively.

4 Construction of real effective exchange rate

In this Section, industry-level real effective exchange rate (REER) from 1991 to 2004 is measured. We follow the REER construction method used in previous researches[8]. As was mentioned earlier, in our work, there are some differences from existing researches, however. First, we measure industry specific REER, as far as we know, for the first time in Korea. Second, for price index, we employ PPI by partner country and by industry instead of aggregate consumer price index adopted in Goldberg (2004). For trade weight,

[8] The construction methods of Lee (1999), who estimated aggregate REER for Korea, and that of Godlberg (2004), who produced industry specific REER for the US, are adopted.

we use Korean trade data by partner country and by industry.

4.1 Methodology and data

Real exchange rate at a time point t is indexed against real exchange rate at the reference point 0 and weighted average is calculated. The measure of the REER can be summarized as follows.

$$REER_t^i = \Pi_c \left(\frac{E_t^c P_t^{ic} / P_t^i}{E_0^c P_0^{ic} / P_0^i} \right)^{w_t^{ic}} \tag{1}$$

In equation (1), E^c represents an exchange rate of won which can be exchanged with one unit of trading partner c's currency. Except exchange rate of won against dollar, cross rates are employed for other rates. All rates are monthly average. i denotes industry and t denotes time. w_t is a weight to average out and it is a monthly industry level trade data.

If $REER_t^i$, REER of i industry at the time point t, is bigger than 1, it means that won's value decreases (or price competitiveness improves) compared with that in the reference time point. If the law of one price holds in every industry and at every time point, the above equation will be 1 regardless of i or t.[9]

The weight, w, is calculated using share of industry specific export or import amount between Korea and trading partner countries. Export weight reflects competitive relationship between Korean exporters and import substitute producers in the trading partner country market. Import weight reflects competitive relationship between Korean import substitute producers and foreign exporters in Korean market. Lastly, trade weight is used, taking into account overall impact of the first two variables and the equations are like the following. The equation (2) stands for export weight, the equation (3) for import weight and the equation (4) for trade weight.[10] For example, ex_t^{ic} means the the share of Korea's export to country c at time t for industry i. im_t^{ic} can be interpreted in the same fashion. tr_t^{ic} is the mean of ex_t^{ic} and im_t^{ic}.

$$w_t^{ic} = ex_t^{ic} = \frac{X_t^{ic}}{\sum_c X_t^{ic}} \tag{2}$$

$$w_t^{ic} = im_t^{ic} = \frac{M_t^{ic}}{\sum_c M_t^{ic}} \tag{3}$$

$$w_t^{ic} = tr_t^{ic} = 0.5\frac{X_t^{ic}}{\sum_c X_t^{ic}} + 0.5\frac{M_t^{ic}}{\sum_c M_t^{ic}} \tag{4}$$

[9] If price of all the goods is the same when the same goods are evaluated by the same currency unit assuming that there is no transaction cost, $E_c P_c = P$ holds for every i and t.

[10] FRB uses dual weighted average method which includes a factor in consideration of competitive relationship between one country's exporters and trading partners' exporters in the third market. We do not consider dual weight in our work due to timeliness and availability of data. FRB's dual weighted average method can be found in Leahy (1998).

Table 4: Korea's major trading partners

Rank	Partner	Trade Amount (2000~2004, million U$)	Share (%)	Cumulative Share (%)
1	United States	306,893	17.1	17.1
2	Japan	261,867	14.6	31.8
3	China	240,266	13.4	45.2
4	Hong Kong	73,273	4.1	49.3
5	Taiwan	64,408	3.6	52.9
6	Germany	57,578	3.2	56.1
7	Australia	44,589	2.5	58.6
8	Indonesia	43,048	2.4	61.0
9	Singapore	42,953	2.4	63.4
10	Malaysia	40,666	2.3	65.7
11	U.A.E	37,816	2.1	67.8
12	U.K.	36,598	2.0	69.8
13	Philiphine	24,784	1.4	71.2
14	Italy	22,739	1.3	72.5
15	Canada	22,691	1.3	73.8
	all countries	1,789,633	100.0	100.0

Data: Korea International Trade Association.

For export and import amount by industry and by trading partner, we use monthly trade statistics from Korea International Trade Association (KITA). Industry classification is based upon SITC 2 digit (Standard International Trade Classification, Rev.3).

To reflect Korea's trade relationship with other countries more precisely, we try to include as many countries as possible. Total of 12 countries are selected ranged from the 1st rank to the 12th rank by total trade amount from 2000 to 2004. The sum of Korea's trade amount with the 12 countries amounts to about 70% of Korea's total trade amount from 2000 to 2004.

Basically, we use industry-level PPI. When it is not available for a trading partner country, aggregate PPI is employed. For five major trading partners, the United States, Japan, China, Hong Kong and Taiwan, industry-level PPI is used[11] while aggregate PPI on the International Financial Statistics(IFS) is used for the other 7 countries due to the lack of data.

Korea Standard Industry Classification (KSIC) which is the industry-level classification standard for PPI, is different from SITC industry classification used for Korean trade data. Furthermore, classification for PPI is different from country to country. To circumvent this, we reclassify industries into 20 industries on the basis of KSIC, which

[11] Data sources of the five countries' PPI can be found in the appendix. Total trade amount with the five countries amounts to 52.6% of Korea's total trade amount from 2000 to 2003.

Table 5: Principal Economic Indicators of Korea

	1985	1989	1990	1993	1995	2000	2004
GDP growth rate[1)](%)	6.8	6.7	9.2	6.1	9.2	8.5	4.6
Inflation rate(PPI, %)	0.88	1.46	4.15	1.57	4.65	2.04	6.11
Inflation rate(CPI, %)	2.4	5.64	8.55	4.8	4.48	2.25	3.61
Current account balance (Milliions of U$)	-795	5,344	-2,014	821	-8,665	12,251	27,613
Current account balance (% of GDP)	-0.82	2.32	-0.76	0.23	-1.67	2.39	3.54

Note: 1) 2000=100, real GDP growth rate.
Data: Economics Statistics System(ECOS), the Bank of Korea.

is the Bank of Korea's industry-level PPI classification standard.[12]

We choose the year 2000 as the reference year since many trading partner countries use it as the reference year for their PPI. Korea, Japan and Hong Kong use the year 2000 as the reference year for PPI. The reference year for PPI on IFS is also the year 2000. We also consider that we cannot get the Chinese PPI before 1996. As seen in table 5, we may not be able to say that external and internal economic performance in that year is balanced in terms of economic growth, price, and current account. Especially current account surplus was 2.39 percent of GDP. However, it may not be a big problem for us to use it as the reference since we do not focus on optimality test but on industry level comparison.

4.2 Result

4.2.1 Aggregate REER

We first measure an aggregate REER according to the equation (1) with aggregate trade amount, and aggregate PPI. Then we compare our aggregate REER with existing REER published by other institution to check possible errors in the calculation.

Table 6 shows the correlation between JP Morgan's and our aggregate REER. Judged from that the correlation coefficient turns out to be 0.97˜0.98, it seems that the calculation method of REER in this paper is reasonable. When China is included in the calculation, the correlation between the two indexes proves to be lower than that without China[13]. But the extent of fall is not that significant.

[12] The relation between KSIC and SITC is based on Choi and Kim (2001)'s classification. While Choi and Kim (2001) sort out 13 industries, 7 industries are added and total of 20 industries are analyzed in our work. Although the top five trading countries' industry classification for PPI is different one another, we attempt to classify industries as similar as possible to each other. Tables in the appendix show the relation between classification codes by country and by industry.

[13] We measure the REER including China only for 1996 through 2004 due to data availability.

Table 6: The correlation coefficient between JP Morgan's index and measured REER index[1)]

Excluding China (1991~2004)			Including China (1996~2004)		
export -weighted	import -weighted	trade -weighted	export -weighted	import -weighted	trade -weighted
0.97245	0.98187	0.98098	0.97043	0.96843	0.97314

Note: 1) Since increase in JP Morgan's REERI means won's appreciation while rise in REERI in this paper represents won's depreciation, after some adjustment between the two indexes, the correlation coefficients are calculated.

Figure 1 and 2 illustrate trend of JP Morgan's REER and that of our aggregate REER from 1991 to 2004. As is shown in the figure, our REER shows a little underestimated won compared with JP Morgan index before the financial crisis while ours shows somewhat overestimated won in comparison with JP Morgan's after the crisis. But the differences are not significant.

After aggregate REER fell by a large scale from the year right after the financial crisis to early 2000, it maintained a steady trend. After 2004, it has again shown a downward trend. Aggregate REER fell about 36% from 1996 January to 2000 January and it increased approximately 10% in early 2001 compared with the reference year. Until 2003 December, it stayed in general at a constant level but dropped again through the end of 2004. As of December 2004, it was lower than that in the reference year.

4.2.2 Industry specific REER

The construction result of industry specific REER using trade weight is shown in Figure 3[14]. REER is significantly different among industries but some similar characteristics are found as follows. First, REER indexes in most of industries have been on the decrease after the peak in 2003. That is, international price competitiveness has been declining.

Second, while movement of REER in most of industries was similar before the financial crisis, gaps among industry specific REER have widened after the crisis. The indexes of Korea's major export industries, such as computer and office machinery (D30), electronic tubes (D32a), communication equipment (D32b), general machinery (D29), and automobiles (D32) substantially increased between 2000 and 2003 even though nominal exchange rate remained at a stable level. During the year 2004, it changed to the downward trend along with fall in nominal exchange rate. However, level of REER in these industries at the end of 2004 was still higher than that in 2000. On the other hand, REER indexes for non-metallic mineral products (D26), wood (D20), and leather and footwear (D19) declined in general, and hence export price competitiveness of these industries has been deteriorating.

[14] Detailed results can be found in Appendix H and I.

Table 7: Fluctuations of Industry Specific REER[1)]

	Excluding China			Including China	
KSIC	1991-96[2)]	2000-04[2)]	2004[3)]	2000-04[2)]	2004[3)]
D32a	0.0888	0.2750	1.3611***	0.3012	1.3907***
D30	..	0.1877	1.3938***	0.2603	1.4509***
D32b	0.1502	0.1033	1.1737***	0.1835	1.1812***
D29	0.0955	0.0218	1.2426***	0.0247	1.3174***
D23	-0.1045	-0.0068	1.0252	-0.0212	1.0146
D34	0.1807	-0.0196	1.0919***	-0.0341	1.0789***
D21	0.0184	-0.1036	0.9998*	-0.1216	0.9875**
D25	0.0537	-0.1122	1.0027	-0.1409	0.9808**
D15	-0.0148	-0.1235	0.9999	-0.1540	0.9722***
D24	0.0935	-0.1337	0.9756***	-0.1684	0.9549***
D19	0.0385	-0.1352	1.0086	-0.2339	0.9108***
D28	0.0875	-0.1641	0.9599***	-0.1862	0.9455***
D27	0.0642	-0.1758	0.9330***	-0.2225	0.9088***
aggregated	0.0595	-0.0911	1.0227	-0.1052	1.0188

Notes: 1) Trade-weighted indices.
2) Changes between the years' December.
3) Average in 2004. ***, **, and * indicates that we can reject the null hypothesis of no difference in mean between the industry REER and the aggregated one at 1%, 5% and 10% level, respectively.

Third, when China is included in the construction of REER, REER index especially in traditional industries such as light industry tends to be lower than that without China.[15] In terms of average index in 2004, out of 20 industries surveyed, indexes for 16 industries such as processed food (D15), textile (D17, D18), wood (D20), non-metallic minerals (D26), basic metals (D27), and automobiles (D34) prove to be lower with China in the construction than otherwise. To the contrary, REER indexes for four industries, computer and office machinery (D32), general machinery (D29), electronic tubes (D32a), and communication equipment (D32b) turn out to be higher when China is added. In brief, trade with China has a negative effect on price competitiveness in traditional industries while it does not have much impact on the recent major export industries, such as information and technology (IT) industry.

Table 7 summarizes the fluctuations of industry-level REER. Changes between 2000 and 2004 show that indexes in electronic tubes (D32a), computer and office machinery (D32), communication equipment (D32b), general machinery (D29), and automobiles (D34) generally rose and hence external price competitiveness of these industries greatly

[15] Korean trade amount with China increased considerably in late 1990s. China was the fifteenth largest trading partner in 1990, the sixth in 1991, the forth in 1992 through 1994, and the third in 1996.

improved. To the contrary, indexes in basic metal products (D27), chemical products (D24), and processed food (D15) turned out to fall substantially i.e., external price competitiveness of these industries worsened. Between 2000 and 2004, the extent of increase or decrease in indexes, proves to be bigger when China is included in the calculation than otherwise. It implies that trade with China widened the competitiveness gap among industries in Korea.

4.3 Causes of wider gaps among industry specific REER

To analyze major causes of differences between aggregate REER indexes and industry specific REER indexes and differences in REER indexes among industries, similar alternative indexes are measured and compared.

4.3.1 Trade weight

To examine whether different trade weight among industries has something to do with different REER indexes among industries, industry-level export and import amount for trade weight in the equation (4) are replaced with aggregate export and import amount uniformly to all industries. Figure 5 depicts trend of industry specific index based upon above calculation. It does not show any big difference from that of Figure 3 on which industry-level export and import amount are employed as trade weight. Therefore, it seems that the fact that trade weight is different among industries does not have significant influence on the differences in industry specific indexes.

4.3.2 Producer price index

To see whether differences in PPI by industry and by country are contributing to differences in industry specific REER, industry-level PPI is replaced with aggregate PPI. For trade weight, industry-level data is used.

Figure 6 shows the result. When we compare it with Figure 3, we can easily note that differences between aggregate indexes and industry-level indexes as well as differences among industry-level indexes are greatly reduced. It appears that differences in PPI among industries and among countries are major causes of differences in industry-level REER indexes.

We may ascribe differences in industry-level PPI between Korea and trading partners to differences in industry-level productivity between them[16]. Kim (2005) researches growth rate of industry-level per capita value added using 'Report on Mining and Manufacturing Survey' by Korea National Statistical Office. She finds out that, after 2000, growth rate of per capita value added in computer and office machinery, electronic tubes and communication equipment has been higher than average for all industries. Moreover,

[16] Apart from productivity improvement, strategic pricing, production cost reduction with advanced production technology can cause relative differences in PPI. Therefore, to analyze causes of differences in PPI by country and by industry precisely, we need more detailed information and elaborate models about price setting structure, differences in production technology and trend of production cost.

in those industries, labor to capital ratio and growth rate of total factor productivity after the financial crisis maintained at a relatively higher level compared with other industries. REER of these industries have greatly increased as mentioned ahead.

4.3.3 Nominal exchange rate

Lastly, to examine how nominal exchange rate influences movement of industry-level indexes, nominal exchange rate in the equation (1) is excluded. We apply industry-level PPI and trade weights to REER construction equation. Figure 7 shows the result. Figure 7 and Figure 3 present similarities as well as differences. They are similar in that there are wide gap among industry-level indexes. However, two figures are somewhat different in pre-crisis period and during the crisis period of 1997 through 1998.

In summary, it seems that nominal exchange rate had a great influence on REER index both before the financial crisis and during the crisis when exchange rate fluctuation was quite substantial. However, differences in PPI seem to have a bigger influence on industry-level REER after year 2000 as stated ahead.

Since indexes in Figure 7 are based upon only the relative level of PPI compared to that of trading partner countries, it can be said that they reflect relative competitiveness trend which may have resulted from difference in industry-level productivity. The indexes show a rapid upward trend until 2003 with the help of fall in domestic producer price. But in 2004, they showed stagnant or slowdown trend in many industries. Judged from this, drop in industry-level REER in 2004 may be attributable to stagnation of productivity improvement. Being coupled with the decline of nominal exchange rate in 2004, the extent of decrease in REER slowed down, and REER even increased in some industries.[17]

5 Analysis of exchange rate fluctuations using industry specific REER

5.1 The relationship between nominal exchange rate and industry-level competitiveness

5.1.1 Strong won against the United States dollar and changes in industry-level price competitiveness

Assuming that REER reflects international price competitiveness, we examine the impact of won's nominal appreciation against dollar on industry-level price competitiveness through changes in REER. We assume that industry-level trade weight and each country's PPI are the same as those at the end of 2004 and that won's nominal value against the United States dollar increases by 10% from the end of 2004. Under this assumption,

[17] For example, won appreciated 15.2% against the U.S. dollar in 2004 at Seoul foreign exchange market. However, PPI of manufacturing goods as of 2004 December increased 8.1% from a year earlier.

we calculate the rate of change in industry-level REER.[18]

Indexes for motor vehicles (D34), other transport equipment (D35), and pulp and paper products (D21) drop 4.2%, 3.6% and 3.6%, respectively. It turns out that price competitiveness in transport equipment sector weakens most. Indexes for basic metal products (D27), textile products (D17, D18), electronic tubes (D32a), and communication equipment (D32b) decline 0.7%, 1.8%, 2.0% and 2.8%, correspondingly. It seems that increase in won's nominal value has a relatively smaller impact on price competitiveness of these industries.

As shown in Figure 8 and Appendix J, the impact of strong won against the United States dollar is different from industry to industry. Naturally, it is ascribed to different industry-level trade weight[19] with the United States. The bigger the trade weight is, the more significant the impact of won's appreciation becomes. For instance, in terms of export and import amount in 2004, trade weight with the United States of motor vehicles (D34) and other transport equipment (D35) were 41.1% and 31.1%. In comparison, those of basic metal products (D27), textile products (D17, D18), and electronic tubes (D32a) were 7.9%, 16.9% and 19.6%, respectively.

5.1.2 Chinese yuan's revaluation and changes in industry-level price competitiveness in Korea

The impact of yuan's revaluation is examined in this section. As is in the previous section, we assume that industry-level trade weight and PPI are the same as those at the end of 2004 and that won's nominal value will fall about 10% against the Chinese yuan. Under these assumptions, we measure the rate of changes in industry-level REER.

REER indexes of leather products and footwear (D19), textile products (D17, D18), and furniture (D36) rise 6.6%, 4.9% and 4.2%, respectively. We expect that the price competitiveness of light industry would improve more relative to the other industries. On the other hand, REER indexes of electronic tubes (D32a), communication equipment (D32b), computers and office machinery (D30) increase 1.1%, 2.3% and 2.9% correspondingly. It turns out that the impact of yuan's revaluation on price competitiveness in these industries would be relatively smaller.

Just as the case of won's appreciation against the United States dollar, the greater trade weight with China is, the bigger the impact of yuan's revaluation on price competitiveness becomes. In terms of export and import amount in 2004, trade weight with China of leather products and footwear, textile products, and furniture were 66.6%, 49.9% and 42.9%, respectively while that of electronic tubes, communication equipment, computers and office machinery were 11.5%,23.9% and 30.5%, respectively.

[18] It can be looked upon as examining static effect, i.e. the effect before the changes in exchange rate brings about changes in PPI and trade volume.

[19] Trade weight refers to arithmetic mean of export amount share and import amount share.

5.1.3 Strong won against yen and changes in industry-level competitiveness

Similarly, other things being equal, it is assumed that won's nominal value against Japanese yen would increase 10% from the end of 2004. Then the rate of change in industry-level REER is calculated. Indexes of precision instrument (D33), coke and petroleum products (D23), non-metallic mineral products (D26) fell 3.5%, 3.5% and 3.0% respectively. It appears that capital goods sector would be affected more severely than the other sectors from strong won against yen. When we compare Figure 6 and Figure 8, we can see that won's nominal appreciation against yen on average has a more deteriorating effect on international competitiveness of domestic industries than won's appreciation against dollar. More specifically, won's 10% appreciation against dollar leads to average of 2.1% fall in REER while won's 10% appreciation against yen causes average of 2.3% drop in REER. As is the case against dollar, the impact of won's appreciation against yen on price competitiveness is different among industries depending on the trade weight with Japan by industry.

5.2 The relationship between industry-level REER and industry-level export volume

5.2.1 Model and data

To analyze the effect of REER on export volume at industry level, a reduced form of regression equation is used, which is the same as the one in Rose and Yellen (1989), Rose (1991), and Choi (1998).[20]

$$LogX_t^i = c + \alpha LogREER_{t-s}^i + \beta LogY_t^* + \epsilon_t \quad (5)$$

In other words, the export volume X_t^i in i industry at time t, is assumed to be related to REER and income of trading partners for export, Y_t^*. Industry-level nominal export amount is transformed into volume using the Bank of Korea's export price index. As stated ahead, industry-level nominal export amount is from Korea International Trade Association (KITA). REER is industry-level REER index calculated according to the equation (1), using industry-level trade weight and PPI by industry and by country in the equation (4). For income of export trading partners, GDP would be the most suitable variable but its monthly data is not available. Thus we use a weighted average of nominal import amount of a trading partner as an alternative[21]. It is weighted by

[20] Goldstein and Kahn (1978) set up a model in a different way. They say that changes in exchange rate do not directly affect export volume, but that exchange rate influences unit export price and then unit export price has an effect on export volume. Yoon (2005), Han et al. (1996), and Lee and Han (2001) use this model for Korean case.

[21] When Yoon (2005) estimates export volume function, he adds RCA index (Revealed Comparative Advantage index) as a dependent variable. He assumes RCA index be a proxy for production capacity. According to him, if production capacity is not included in the model, demand function of export volume would be derived. However, we do not consider production capacity since monthly world export amount data by industry is not easily available. We do not use Yoon(2005)'s data since he uses quarterly data

the share of Korea's export to the partner country in Korea's total export[22]. Expected signs of coefficients are $\alpha > 0$ and $\beta > 0$.

Ahead of empirical analysis, unit root test and seasonality test for each variable are conducted. Augmented Dickey-Fuller test shows that export volume, REER index, and income variable of trading partner have a unit root. To avoid spurious regression, the variables are first-differenced. Variables with seasonality are adjusted.

A time lag between export volume and REER is assigned. A lag s is to be chosen based on a statistical significance for each industry step-wisely. We use Cochrane-Orcutt's method to deal with regression error ϵ_t's serial correlation.

As for regression analysis period, January 1991~June 1997 is set as the first half and July 1998~December 2004 as the latter half. The model is analyzed against the first half, the latter half and total period respectively.

5.2.2 Estimation result

Table 8 summarizes the empirical result. In general, it is consistent with the theory in that coefficients turn out to be positive and statistically significant, as expected. However, size and signs of coefficients and the length of time lag are greatly different among industries. there are also differences between pre- and post- crisis period.

First, when pre- and post- crisis are compared, the influence of REER on export volume turns out to be reduced after the crisis. At aggregate level, the coefficient that shows the influence of REER on export volume, is 0.59 before the crisis and 0.30 after the crisis. This trend is more obvious at industry level. Eight industries show reduced coefficient after the crisis. They are processed food (D15), basic metal products (D27), computers and office equipment (D30), electronic tubes (D32a), and communication equipment (D32b). Especially in chemical products (D24), basic metal products (D27), computers and office machinery (D30), electrical machinery (D31), and communication equipment (D32b), the extent of fall in the coefficients is bigger than that of other industries. Moreover, in four industries, such as chemical products (D24), rubber and plastic products (D25), fabricated metal products (D28), and precision instruments (D33), the influence of REER on export volume is statistically significant before the crisis but is not after the crisis. Other transport equipment (D35) is the only one that shows increased influence of REER on export volume after the crisis.

Second, when only years after financial crisis are considered, the influence of REER on export volume in major export industries turns out to be very small. After the financial crisis, there are only 2 industries out of 8 major export industries with statistically significant coefficient over 0.5. They are general machinery (D29), and motor vehicles (D34). This is comparable to 6 industries with coefficient over 0.5 before the crisis. It proves that the effect of exchange rate on export volume gradually diminishes.

Third, in general, in industries which emerged as major export industries in Korea, the ripple effect of REER on export volume tends to lag behind. As is explained ahead,

and his industry classification is also different from ours. He classifies industry based upon HS code, while we use KSIC and SITC.

[22] We use monthly import amount of 12 largest trading partners, reported by KITA.

Table 8: The impact of REER on export volume

KSIC	Before the crisis (A)	After the crisis (B)	(B-A)	Whole sample
D15	2.43 (0)***	0.93 (1)***	-1.50	0.37 (4)**
D17,18	0.13 (2)	0.16 (7)	0.03	0.14 (8)*
D19	0.52 (1)	0.05 (8)	-0.47	0.10 (2)
D20	0.74 (2)	0.58 (9)	-0.16	0.46 (9)
D21	1.01 (1)	0.25(12)**	-0.76	0.75 (1)***
D23	0.70 (9)	1.02 (4)	0.32	0.83 (9)**
D24	1.06 (1)***	0.14 (8)	-0.92	0.16 (2)
D25	0.85 (1)**	0.28 (0)	-0.57	0.22 (2)***
D26	0.61 (2)	0.21 (9)	-0.40	0.39 (2)***
D27	1.33 (4)***	0.28 (6)*	-1.05	0.39 (2)***
D28	3.40 (0)***	0.21 (9)	-3.19	0.66 (3)*
D29	0.78(10)**	0.61 (2)*	-0.17	0.29 (2)*
D30	3.54 (3)**	0.26(11)*	-3.28	-0.36 (1)*
D31	1.24 (7)*	-0.28(10)***	-1.52	0.17 (2)
D32a	0.83 (3)*	0.39 (7)***	-0.44	0.21 (7)
D32b	0.69 (1)***	0.41 (5)**	-0.28	0.54(14)***
D33	0.67 (8)*	0.22(12)	-0.45	0.24 (8)
D34	1.34 (3)	0.52 (9)**	-0.82	0.49 (7)*
D35	1.21 (0)*	-0.22(10)***	-1.43	1.52 (0)***
D36	0.52 (6)	0.42(12)	-0.10	0.20(12)
aggregated	0.59(10)*	0.30 (1)*	-0.29	0.32 (1)***

Notes:
1) Data is splited into two sample periods. 'Before crisis' means January 1991~ June 1997. 'After crisis' means July 1998~December 2004. Whole sample is for January 1991~December 2004.
2) ***, **, * indicate that the null hypothesis is rejected at 1%, 5%, 10% significance level, respectively. ( ) indicates the lag length in months. Trade-weighted real effective exchange rates are used.

time lag of the impact of REER on export volume is selected based upon statistical significance. In recent major export industries, such as computers and office machinery (D30), electrical machinery (D31), and electronic tubes (D32a), the time lag was 1 through 7 month before the crisis. It was extended 7 through 11 months after the crisis.

6 Conclusions and policy implications

In this paper, we measure industry specific REER in Korea using industry-level PPI and trade data. In addition, with industry specific REER, we analyze the effect of nominal exchange rate on industry-level price competitiveness and the effect of REER on export volume. The results of our work reveal some interesting findings.

First, it turns out that trend of price competitiveness and the influence of won's appreciation on price competitiveness are considerably different among industries. REER shows similar movement among industries before the crisis but gaps in REER among them has widen after the crisis. After 2000, in major export industries such as computer and office machinery, communication equipment, and electronic tubes, price competitiveness strengthens. REER goes up greatly even though won's nominal exchange rate falls against major currencies. However, in light industries such as textile, furniture, wood, and processed food, REER continuously declines after 2001.

Second, as is expected in theory, the impact of REER on export volume turns out to be positive in most of industries. However, the influence of REER on export volume generally reduces after the crisis. Especially in computer and office machinery, electrical machinery, motor vehicles, and electronic tubes, this tendency is more significant.

Third, the time lag with which changes in REER have an influence on export volume is different among industries. Especially for computer and office machinery, electronic tubes, communication equipment, and electrical machinery, the time lag turns out to be 7 through 11 month. In other words, the time lag of REER's ripple effect on export volume in recently emerged major export industries tends to be getting longer.

This result suggests that the impact of changes in won's nominal exchange rate on international price competitiveness of export goods is widely different among industries. In case of major export industries, the influence is smaller than in other industries. In addition, the influence of price competitiveness on export volume is gradually weakening. Consequently, when foreign exchange rate policy is concerned, its impact on each industry needs to be considered in a more specific way rather than its average impact on all industries as a whole. The empirical study also suggests that, for export promotion, it is more important to improve price competitiveness through improvement of productivity and to secure non-price competitiveness through quality improvement of products such as improvement of quality, design, warranties, varieties of products, and localization.

we can not but admit that our REER construction and its interpretation in this paper have some limitations and need continual improvement. Productivity gap is suggested as one of the possible causes of the variations in industry-level PPI. However, elaborate analyses for the causes are not suggested. Industry-level PPI can be different by strategic pricing or cost reduction through production technology improvement. We need to establish a more elaborate model to analyze PPI gap among industries. In order to do that, more specific information on pricing mechanism by country and by industry, production technology gap and production cost will also be necessary. In addition, we show only the static effect of changes in nominal exchange rate on the REER. We need an considerable improvement to show a dynamic effect of it. Furthermore, our subjective adjustment to adjust reference year and industry classification for some countries is inevitable in this paper. It is because the reference year for industry-level PPI and industry classification system are different from country to country. Therefore, more specific data will be required for future improvement.

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A Industry classification code conversion table for Korea

Korea	KSIC (PPI)	SITC (Trade statistics)
Processed foods and tobacco	D15	01,02,04,06,07,09,11
Textile products and apparel	D17, D18	65,84
Leather products and footwear	D19	61,85
Wood and wood products	D20	24,63
Pulp, paper products and publications	D21	25,64
Coke and petroleum products	D23	32~34
Chemical products	D24	51~56,59
Rubber and plastic products	D25	23,57,58,62
Non-metallic mineral products	D26	66
Basic Metal products	D27	67,68
Fabricated Metal products	D28	69
General machinery and equipment	D29	71~74
Computers and office machinery[1)]	D30[1)]	75
Electrical machinery and apparatus	D31	77
Electronic tubes and electronic components[2)]	D32a[2)]	77
Electronic components, radio, television and communication equipment[2)]	D32b[2)]	76
Precision instruments	D33	87,88
Motor vehicles	D34	78
Transportation equipment, n.e.c.	D35	79
Furniture[3)]	D36[3)]	82

Notes: 1) One of the subcategories of the General machinery and equipment.
2) One of the subcategories of the Electronic components, radio, television and communication equipment.
3) One of the subcategories of the furniture and manufacturing industry products, N.e.c.

Data: PPI is from Economics Statistics System(ECOS), the Bank of Korea.
Trade data is from Korea Trade Statistics,
Korea International Trade Association.

B Industry classification code conversion table for the United States

Korea	United States (SIC)	United States (NAICS)
Processed foods and tobacco	PDU20_	311,312
Textile products and apparel	PDU22_	313,314,315
Leather products and footwear	PDU31_	316
Wood and wood products	PDU24_	321
Pulp, paper products and publications	PDU26_	322
Coke and petroleum products	PDU29_	324
Chemical products	PDU28_	325
Rubber and plastic products	PDU30_	326
Non-metallic mineral products	PDU32_	327
Basic metal products	PDU33_	331
Fabricated metal products	PDU34_	332
General machinery and equipment	PDU35_	333,3341
Computers and office machinery	PDU357	3341
Electrical machinery and apparatus	PDU361~364,369	335
Electronic tubes and electronic components	PDU367	3344
Electronic components, radio, television and communication equipment	PDU366	3342,3343
Precision instruments	PDU38_	3345,3391
Motor vehicles	PDU371,3792	3361~3363
Transportation equipment, n.e.c.	PDU372~374	3364~3366,3369
Furniture	PDU25_	337

Data: Korea: Producer Price Index Basic Groups, Economics Statistics System(ECOS), the Bank of Korea.
United States: Bureau of Labor Statistics, Producer Price Index Industry Data. PPI from 1991~2003 use SIC, and that in 2004 are extended from SIC using NAICS.

C Industry Classification Conversion Table for Japan

Korea	Japan
Processed foods and tobacco	Processed foodstuffs
Textile products and apparel	Textile products
Leather products and footwear	Textile products[1)]
Wood and wood products	Lumber and wood products
Pulp, paper products and publications	Pulp, paper and related products
Coke and petroleum products	Petroleum and coal products
Chemical products	Chemicals and related products
Rubber and plastic products	Plastic products
Non-metallic mineral products	Ceramic, stone and clay products
Basic metal products	Iron and steel, nonferrous metals
Fabricated metal products	Metal products
General machinery and equipment	General machinery and equipment
Computers and office machinery	General machinery and equipment
Electrical machinery & apparatus	General machinery and equipment[1)]
Electronic tubes and electronic components	General machinery and equipment[1)]
Electronic components, radio, television & communication equipment	General machinery and equipment[1)]
Precision instruments	Precision instruments
Motor vehicles	Transportation equipment
Transportation equipment, n.e.c.	Transportation equipment
Furniture	Lumber and wood products

Notes: 1) Due to the lack of industry classification and data, a similar industry data is used.

Data: Korea: Producer Price Index Basic Groups, Economics Statistics System(ECOS), the Bank of Korea.
Japan: Domestic Corporate Price Index, Bank of Japan

D Industry classification conversion table for China(1)

Korea	China (1996~2000)
Processed foods and tobacco	Food, beverages, tobacco manufacturing
Textile products and apparel	Textile, tailoring
Leather products and footwear	Leather, fur, down and related products
Wood and wood products	Timber processing, bamboo, cane, etc.
Pulp, paper products and publications	Paper making and paper products
Coke and petroleum products	Petroleum, coaking, coal gas related
Chemical products	Chemical industry
Rubber and plastic products	Rubber products, plastic products
Non-metallic mineral products	Non-metal minerals products
Basic metal products	Smelting and pressing of ferrous & non-ferrous metals
Fabricated metal products	Metal products
General machinery and equipment	Machine building industry
Computers and office machinery	Communication, computer and Other electronic equipment[1)]
Electrical machinery and apparatus	Electric machinery and equipment
Electronic tubes and electronic components	Communication, computer and other electronic equipment[1)]
Electronic components, radio, television and communication equipment	Communication, computer and other electronic equipment[1)]
Precision instruments	Instrument, meter and other measuring equipment
Motor vehicles	Transportation equipment
Transportation equipment, n.e.c.	Transportation equipment
Furniture	Furniture manufacturing

Notes: 1) Due to the lack of industry classification and data, a similar industry data is used.

Data: Korea: Producer Price Index Basic Groups, Economics Statistics System(ECOS), the Bank of Korea.
China: Producer Price Index, CEIC Economic Databases, CEIC Data Company Limited.

E Industry classification conversion table for China(2)

Korea	China (2001~2004)
Processed foods and tobacco	Food, beverages, tobacco manufacturing
Textile products and apparel	Textile, garment-footwear-headgear
Leather products and footwear	Leather, fur, down and related products
Wood and wood products	Timber processing, bamboo, cane, etc.
Pulp, paper products and publications	Paper making and paper products
Coke and petroleum products	Petroleum, coaking and nuclear fuel processing
Chemical products	Raw chemical materials and chemical products
Rubber and plastic products	Rubber products, plastic products
Non-metallic mineral products	Non-metal minerals products
Basic metal products	Smelting and pressing of ferrous and non-ferrous metals
Fabricated metal products	Metal products
General machinery and equipment	Universal equipment manufacturing
Computers and office machinery	Communication, computer and other electronic equipment[1)]
Electrical machinery and apparatus	Electric machinery and equipment
Electronic tubes and electronic components	Communication, computer and other electronic equipment[1)]
Electronic components, radio, television and communication equipment	Communication, computer and other electronic equipment[1)]
Precision instruments	Instrument, meter, cultural and office machinery
Motor vehicles	Transportation equipment
Transportation equipment, n.e.c.	Transportation equipment
Furniture	Furniture Manufacturing

Notes: 1) Due to the lack of industry classification and data, a similar industry data is used.

Data: Korea: Producer Price Index Basic Groups, Economics Statistics System(ECOS), the Bank of Korea.
China: Producer Price Index, CEIC Economic Databases, CEIC Data Company Limited.

F Industry classification conversion table for Hong Kong

Korea	Hong Kong
Processed foods and tobacco	PPI for manufacturing[1)]
Textile products and apparel	Textiles including knitting
Leather products and footwear	Textiles including knitting[1)]
Wood and wood products	PPI for manufacturing[1)]
Pulp, paper products and publications	Paper products and printing
Coke and petroleum products	PPI for manufacturing[1)]
Chemical products	Plastic products[1)]
Rubber and plastic products	Plastic products
Non-metallic mineral products	PPI for manufacturing[1)]
Basic metal products	Fabricated metal products, excluded machinery and equip[1)]
Fabricated metal products	Fabricated metal products, excluded machinery and equip
General machinery and equipment	Machinery, equipment, apparatus, parts and components
Computers and office machinery	Consumer electrical and electronic products[1)]
Electrical machinery and apparatus	Consumer electrical and electronic products[1)]
Electronic tubes and electronic components	Consumer electrical and electronic products[1)]
Electronic components, radio, television & communication equipment	Consumer electrical and electronic products[1)]
Precision instruments	Machinery, equipment, apparatus, parts and components[1)]
Motor vehicles	PPI for manufacturing[1)]
Transportation equipment, n.e.c.	PPI for manufacturing[1)]
Furniture	PPI for manufacturing[1)]

Notes: 1) Due to the lack of industry classification and data, a similar industry data is used.

Data: Korea: Producer Price Index Basic Groups, Economics Statistics System(ECOS), the Bank of Korea.
Hong Kong: Manufacturing Producer Price Index, CEIC Economic Databases, CEIC Data Company Limited.

G Industry classification conversion table for Taiwan

Korea	Taiwan
Processed foods and tobacco	Food and beverages
Textile products and apparel	Textile products, ready made garments, apparel
Leather products and footwear	Hides, skins, leather and related products
Wood and wood products	Lumber and wood products
Pulp, paper products and publications	Pulp, paper and allied products
Coke and petroleum products	Petroleum and coal products
Chemical products	Chemicals, chemical products
Rubber and plastic products	Rubber and plastic
Non-metallic mineral products	Non metallic mineral products
Basic metal products	Primary metal
Fabricated metal products	Metal products
General machinery and equipment	Machinery equipment
Computers and office machinery	Computer and peripheral equipment
Electrical machinery and apparatus	Electrical equipment and apparatus
Electronic tubes and electronic	Electronic components and parts
Electronic components, radio, television and communication equipment	Communication equipment and apparatus, audio and video equip
precision instruments	Precision instruments
Motor vehicles	Motor vehicles, motor vehicles parts
Transportation equipment, n.e.c.	Motorcycles and parts, other transportation equipment
Furniture	Furniture and fixtures

Data: Korea: Producer Price Index Basic Groups,
Economics Statistics System(ECOS), the Bank of Korea.
Taiwan: Whole Sale Price Index, CEIC Economic Databases,
CEIC Data Company Limited.

H Real effective exchange rate index (1)

Excluding China

	D15	D17,18	D19	D20	D21	D23	D24	D25	D26	D27
1991	0.8689	0.7929	0.8428	0.8876	0.9329	1.0584	0.7934	0.8178	0.6643	0.8422
1992	0.8966	0.8525	0.9094	0.9760	0.9893	1.0831	0.8714	0.9143	0.7207	0.9078
1993	0.9219	0.8839	0.9291	0.9239	1.0056	1.0706	0.9146	0.9509	0.8293	0.9633
1994	0.9234	0.8928	0.9350	0.9586	1.0228	1.1159	0.9410	0.9749	0.8997	0.9767
1995	0.8853	0.8478	0.8925	0.9108	0.9799	1.0825	0.9074	0.9281	0.9065	0.9586
1996	0.8701	0.8378	0.9019	0.9380	0.9503	1.0348	0.8932	0.9026	0.8359	0.9200
1997	0.9486	0.9364	0.9986	0.9836	1.0609	1.0044	0.9761	0.9908	0.8962	0.9853
1998	1.1370	1.1007	1.1328	1.0215	1.2036	0.9396	1.1030	1.1671	1.0943	1.1297
1999	1.0321	1.0313	1.0496	1.0240	1.0978	0.9716	1.0473	1.0604	1.0176	1.0336
2000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2001	1.0754	1.0973	1.1025	1.0697	1.0702	1.0347	1.0714	1.0771	1.0358	1.0484
2002	1.0304	1.0830	1.0853	1.0668	1.0427	1.0303	1.0496	1.0360	0.9800	1.0112
2003	1.0301	1.0769	1.0696	1.1035	1.0292	1.0530	1.0285	1.0317	0.9574	1.0057
2004	1.0000	1.0350	1.0086	1.0638	0.9998	1.0252	0.9756	1.0027	0.9671	0.9330

Including China

	D15	D17,18	D19	D20	D21	D23	D24	D25	D26	D27
1991	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
1992	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
1993	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
1994	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
1995	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
1996	0.8794	0.8467	0.9484	0.9838	1.0001	1.0344	0.9295	0.9282	0.8467	0.9303
1997	0.9487	0.9416	1.0323	1.0003	1.0850	1.0328	0.9875	1.0071	0.9048	0.9859
1998	1.1432	1.1601	1.2069	1.0564	1.2296	0.9723	1.1307	1.1944	1.1060	1.1367
1999	1.0332	1.0305	1.0430	1.0343	1.1045	0.9831	1.0539	1.0639	1.0191	1.0280
2000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2001	1.0780	1.1311	1.0973	1.0924	1.0765	1.0438	1.0847	1.0846	1.0483	1.0597
2002	1.0285	1.0929	1.0339	1.0622	1.0452	1.0262	1.0593	1.0339	0.9863	1.0121
2003	1.0109	1.0567	0.9668	1.0856	1.0197	1.0444	1.0161	1.0138	0.9443	0.9951
2004	0.9722	1.0115	0.9108	1.0306	0.9875	1.0146	0.9549	0.9808	0.9467	0.9088

Notes: Anual average of trade-weighted index

I Real effective exchange rate index (2)

	Excluding China									
KSIC	D28	D29	D30	D31	D32a	D32b	D33	D34	D35	D36
1991	0.7767	0.7233	N.A.	0.7093	0.6640	0.5931	0.7551	0.6467	0.7473	0.8603
1992	0.8446	0.7905	N.A.	0.7824	0.7371	0.6480	0.8203	0.7260	0.7764	0.9317
1993	0.8885	0.8233	N.A.	0.8238	0.7613	0.7001	0.8626	0.7817	0.8240	0.9074
1994	0.9062	0.8559	N.A.	0.8480	0.7702	0.7142	0.8732	0.8072	0.8520	0.9114
1995	0.9124	0.8664	0.9027	0.8359	0.7538	0.7265	0.8705	0.8391	0.8175	0.8854
1996	0.8791	0.8453	0.8971	0.8185	0.7508	0.7282	0.8348	0.8513	0.8543	0.8538
1997	0.9659	0.9268	0.9817	0.9154	0.8705	0.8207	0.9164	0.9319	0.9723	0.9261
1998	1.1899	1.1563	1.1860	1.1403	1.0774	1.0667	1.1692	1.2138	1.2702	1.0587
1999	1.0504	1.0352	1.0154	1.0286	1.0113	1.0051	1.0229	1.0648	1.0735	1.0264
2000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2001	1.0788	1.1552	1.3032	1.1142	1.2237	1.1796	1.0971	1.0812	1.1286	1.0829
2002	1.0428	1.1626	1.3681	1.1007	1.2867	1.2095	1.0660	1.0596	1.1362	1.0548
2003	1.0243	1.1951	1.4105	1.1119	1.3497	1.2562	1.0796	1.0846	1.1467	1.0796
2004	0.9599	1.1737	1.3938	1.0665	1.3611	1.2426	1.0632	1.0919	1.1190	1.0576

	Including China									
KSIC	D28	D29	D30	D31	D32a	D32b	D33	D34	D35	D36
1991	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
1992	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
1993	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
1994	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
1995	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
1996	0.9012	0.8457	0.9083	0.8453	0.7858	0.7579	0.8383	0.8755	0.8761	0.8669
1997	0.9756	0.9242	0.9794	0.9202	0.8729	0.8346	0.9177	0.9313	0.9720	0.9167
1998	1.2032	1.1685	1.1841	1.1470	1.0799	1.0774	1.1840	1.2151	1.2723	1.0773
1999	1.0533	1.0374	1.0186	1.0312	1.0127	1.0093	1.0265	1.0652	1.0736	1.0296
2000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2001	1.0852	1.1668	1.3233	1.1107	1.2356	1.2191	1.1073	1.0820	1.1271	1.0877
2002	1.0451	1.1744	1.4058	1.0880	1.3086	1.2824	1.0697	1.0588	1.1315	1.0501
2003	1.0144	1.2019	1.4836	1.0825	1.3805	1.3441	1.0618	1.0755	1.1396	1.0322
2004	0.9455	1.1812	1.4509	1.0308	1.3907	1.3174	1.0296	1.0789	1.1146	1.0064

Notes: Anual average of trade-weighted index

J Rate of changes in real effective exchange rate with respect to nominal exchange rates change

KSIC	U.S. Dollar (-10%)	Chinese Yuan(+10%)	Japanese Yen(-10%)
D15	-3.048	2.009	-2.378
D17,D18	-1.768	4.869	-1.003
D19	-0.792	6.554	-0.378
D20	-1.282	2.659	-1.970
D21	-3.627	1.511	-1.539
D23	-0.545	1.356	-3.515
D24	-1.590	3.436	-2.308
D25	-1.860	2.302	-3.209
D26	-1.562	3.348	-3.041
D27	-0.723	3.317	-3.212
D28	-2.990	1.994	-2.941
D29	-1.830	2.952	-1.240
D30	-2.597	2.206	-2.992
D31	-2.065	1.576	-2.473
D32a	-2.049	1.105	-2.443
D32b	-2.831	2.307	-2.359
D33	-1.967	2.064	-3.514
D34	-4.241	0.667	-2.082
D35	-3.629	0.205	-1.181
D36	-1.825	4.176	-2.107
aggregated	-2.542	2.710	-2.326

Notes: Numbers show percentages changes in real effective exchange rates when Korean Won appreciates by ten percent against U.S. Dollar, depreciates by ten percent against Chinese Yuan, and appreciates by ten percent against Japanese Yen, respectively.
Units: percent

K Unit root test result

KSIC	Export volume	Real effective exchange rate	Foreign import index
D15	cannot reject	reject	cannot reject
D17,18	cannot reject	cannot reject	cannot reject
D19	cannot reject	reject	cannot reject
D20	cannot reject	cannot reject	cannot reject
D21	cannot reject	reject	cannot reject
D23	cannot reject	cannot reject	reject
D24	cannot reject	cannot reject	cannot reject
D25	cannot reject	reject	cannot reject
D26	cannot reject	reject	cannot reject
D27	cannot reject	reject	cannot reject
D28	reject	cannot reject	cannot reject
D29	cannot reject	cannot reject	cannot reject
D30	cannot reject	cannot reject	cannot reject
D31	cannot reject	reject	cannot reject
D32a	cannot reject	cannot reject	cannot reject
D32b	cannot reject	cannot reject	cannot reject
D33	cannot reject	cannot reject	cannot reject
D34	cannot reject	cannot reject	cannot reject
D35	cannot reject	cannot reject	cannot reject
D36	cannot reject	cannot reject	cannot reject
aggregated	cannot reject	cannot reject	cannot reject

Notes: Augmented Dickey-Fuller test results for unit root in level. ‘cannot reject’ means we cannot reject the null hypothesis of no unit root at 1 % significance level.

L Estimation result (1)

KSIC	Period[1)]	Real effective exchange rate (α)	Foreign import index (β)	Adjusted R^2
D15	Before crisis	2.43(0)***	0.38**	0.46
	After crisis	0.93(1)***	0.15	0.23
	Whole sample	0.37(4)**	0.33***	0.26
D17,D18	Before crisis	0.13(2)	0.28***	0.36
	After crisis	0.16(7)	0.40***	0.43
	Whole sample	0.14(8)*	0.30***	0.43
D19	Before crisis	0.52(1)	0.39***	0.41
	After crisis	0.05(8)	0.32***	0.37
	Whole sample	0.10(2)	0.44***	0.41
D20	Before crisis	0.74(2)	0.62***	0.28
	After crisis	0.58(9)	0.57*	0.09
	Whole sample	0.46(9)	0.41***	0.13
D21	Before crisis	1.01(1)	0.22	0.06
	After crisis	0.25(12)**	0.16	0.09
	Whole sample	0.75(1)***	0.23***	0.11
D23	Before crisis	0.70(9)	0.78**	0.24
	After crisis	1.02(4)	0.14	0.34
	Whole sample	0.83(9)**	0.34*	0.29
D24	Before crisis	1.06(1)***	0.35***	0.32
	After crisis	0.14(8)	0.17*	0.18
	Whole sample	0.16(2)	0.21***	0.21
D25	Before crisis	0.85(1)**	0.19**	0.12
	After crisis	0.28(0)	0.16*	0.22
	Whole sample	0.22(2)***	0.18***	0.18
D26	Before crisis	0.61(2)	0.72***	0.31
	After crisis	0.21(9)	0.14	0.17
	Whole sample	0.39(2)***	0.32***	0.18
D27	Before crisis	1.33(4)***	0.02	0.27
	After crisis	0.28(6)*	0.12	0.08
	Whole sample	0.39(2)***	-0.05	0.16
D28	Before crisis	3.40(0)***	0.16	0.1
	After crisis	0.21(9)	0.49***	0.38
	Whole sample	0.66(3)**	0.52**	0.16

Notes:
1) Data is splitted into two sample periods. ‘Before crisis means January 1991~June 1997. ‘After crisis’ means July 1998~December 2004. Entire sample is for January 1991~December 2004.
2) ***, **, * indicate that the null hypothesis is rejected at 1%, 5%, 10% significance level, respectively. ( ) indicates the lag length in months. Trade-weighted real effective exchange rates are used.

M Estimation result (2)

KSIC	Period[1)]	Real effective exchange rate[2)] (α)	Foreign import index (β)	Adjusted R^2
D29	Before crisis	0.78(10)**	0.08	0.1
	After crisis	0.61(2)*	0.42***	0.14
	Whole sample	0.29(2)*	0.19**	0.04
D30	Before crisis	3.54(3)**	0.32	0.07
	After crisis	-0.26(11)*	0.25*	0.19
	Whole sample	-0.36(1)**	0.21	0.15
D31	Before crisis	1.24(7)*	0.65***	0.28
	After crisis	-0.28(10)***	0.39***	0.29
	Whole sample	0.17(2)	0.46***	0.27
D32a	Before crisis	0.83(3)*	0.21*	0.06
	After crisis	0.39(7)***	0.31***	0.22
	Whole sample	0.21(7)	0.21***	0.09
D32b	Before crisis	0.69(1)***	0.11	0.21
	After crisis	0.41(5)*	0.22**	0.15
	Whole sample	0.54(14)***	0.39***	0.1
D33	Before crisis	0.67(8)*	0.33***	0.32
	After crisis	0.22(12)	0.02	-0.01
	Whole sample	0.24(8)	0.27*	0.02
D34	Before crisis	1.34(3)	0.15	0.1
	After crisis	0.52(9)**	0.48*	0.23
	Whole sample	0.49(7)*	0.42***	0.16
D35	Before crisis	1.21(0)*	-0.21	0.29
	After crisis	-0.22(10)***	0.35***	0.45
	Whole sample	0.85(0)**	0.10	0.3
D36	Before crisis	0.52(6)	0.4***	0.35
	After crisis	0.42(12)	0.10	0.17
	Whole sample	0.2(12)	0.23*	0.23
Aggregated	Before crisis	0.59(10)*	0.25***	0.27
	After crisis	0.30(1)*	0.28***	0.27
	Whole sample	0.32(1)***	0.28***	0.32

Notes:
1) Data is splitted into two sample periods. 'Before crisis means January 1991~June 1997. 'After crisis' means July 1998~December 2004. Entire sample is for January 1991~December 2004.
2) ***, **, * indicate that the null hypothesis is rejected at 1%, 5%, 10% significance level, respectively. ( ) indicates the lag length in months. Trade-weighted real effective exchange rates are used.

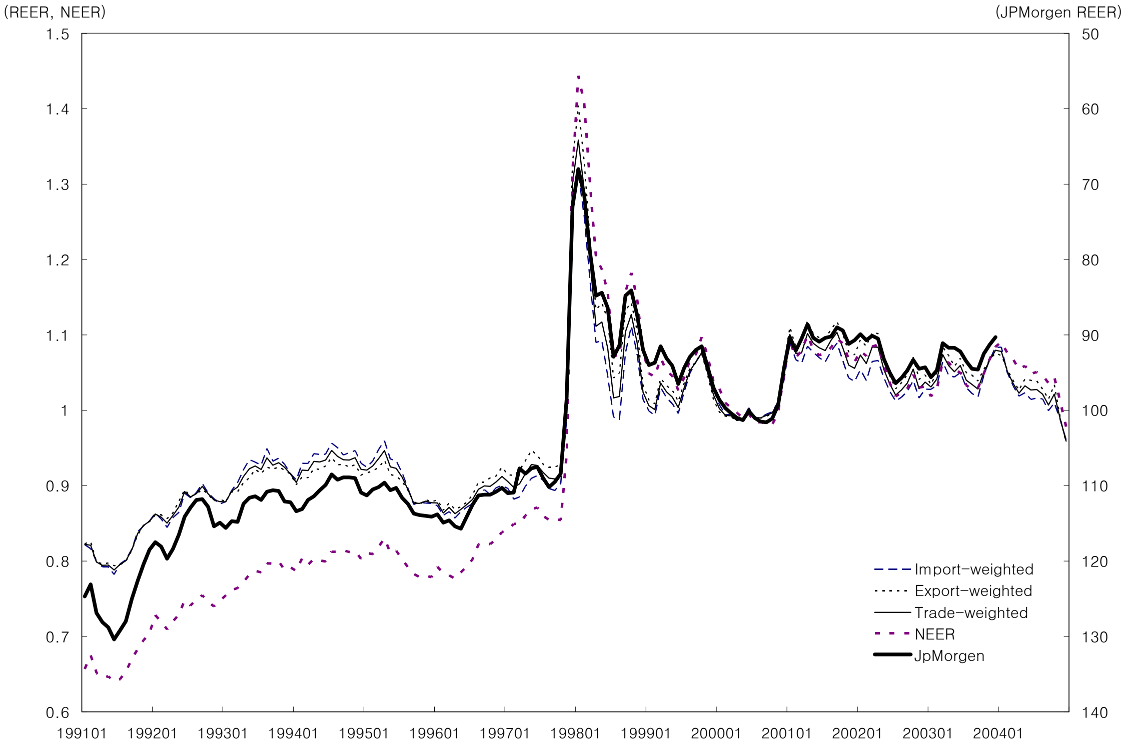

Figure 1: Aggregated Real Effective Exchange Rate (excluding China)

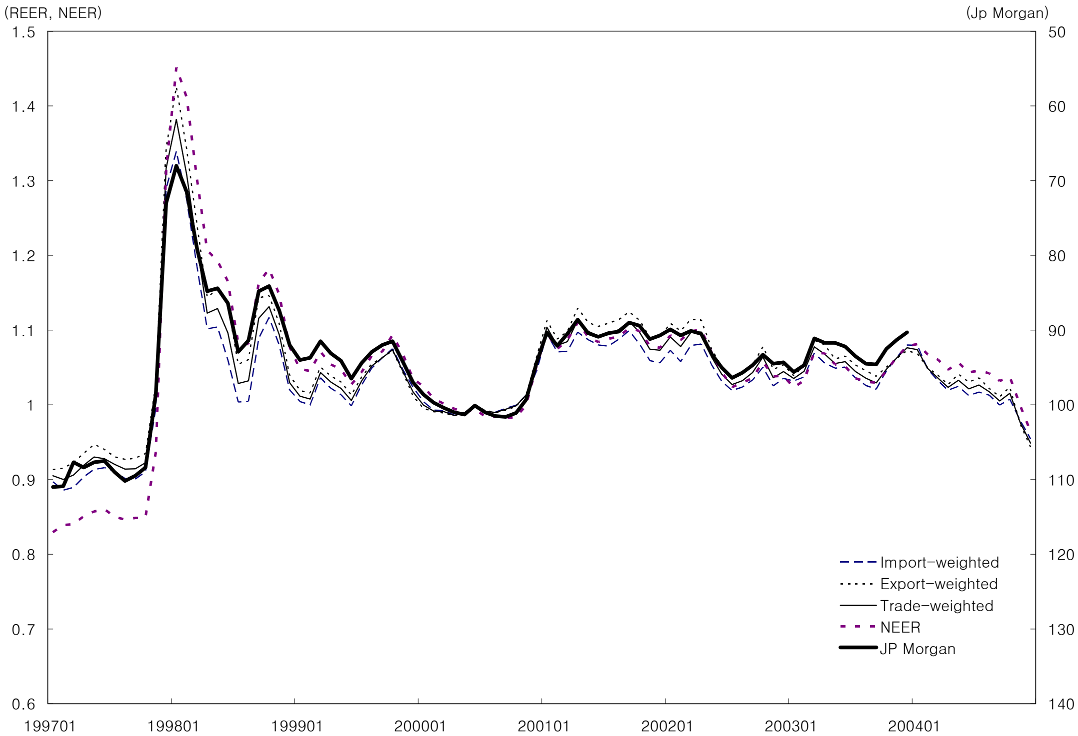

Figure 2: Aggregated Real Effective Exchang Rate (including China)

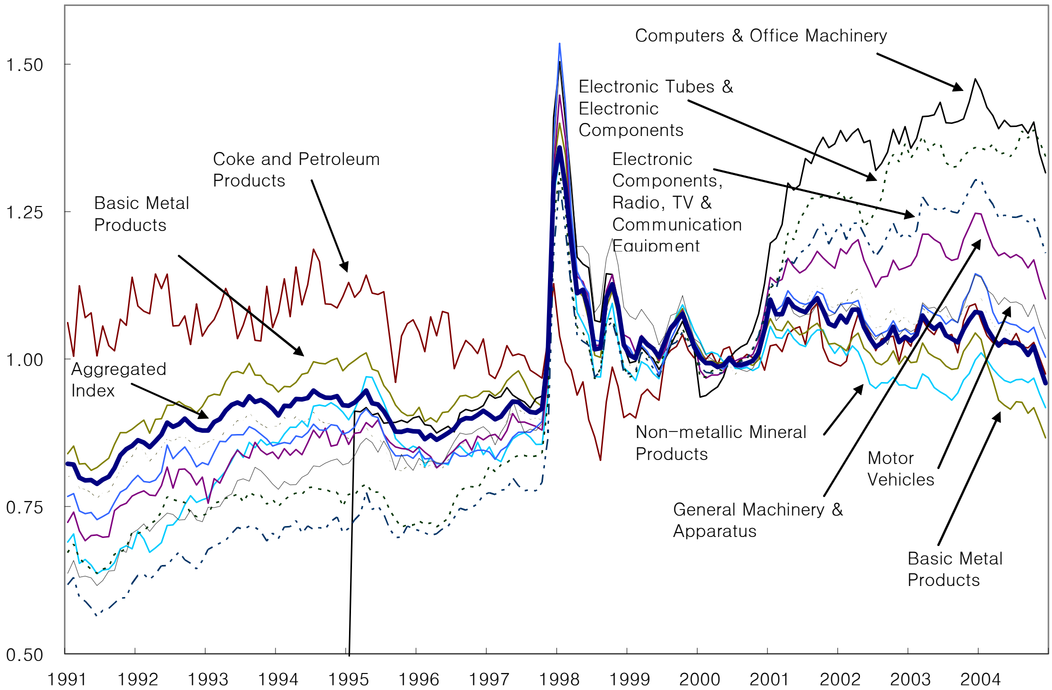

Figure 3: Industry Specific REER (trade-weighted, excluding China)

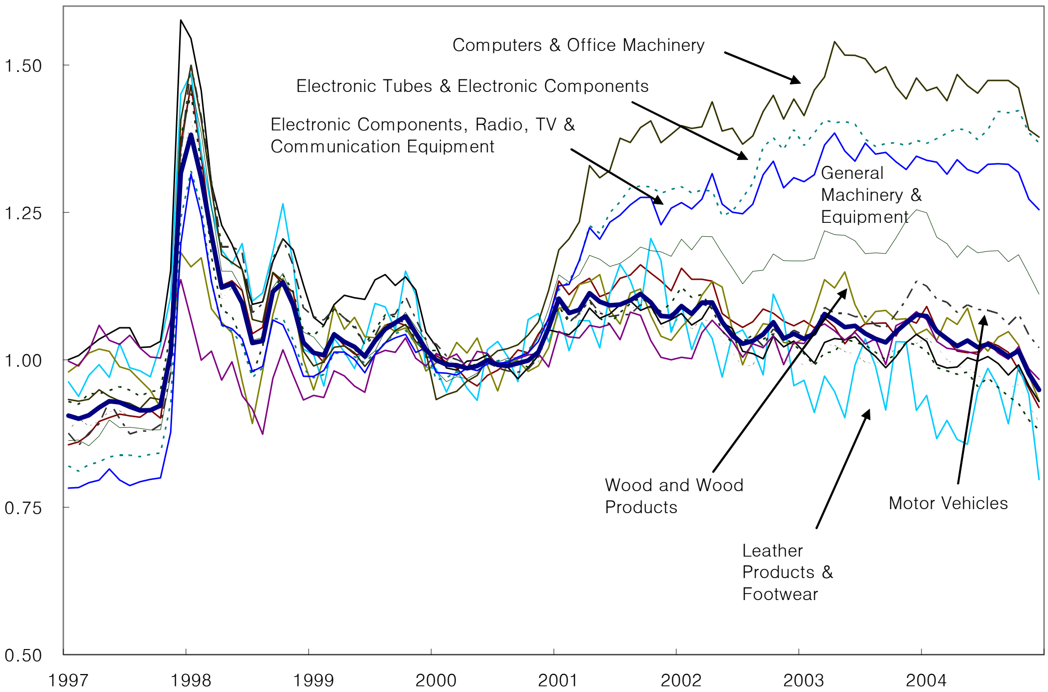

Figure 4: Industry Specific REER(trade-weighted, including China)

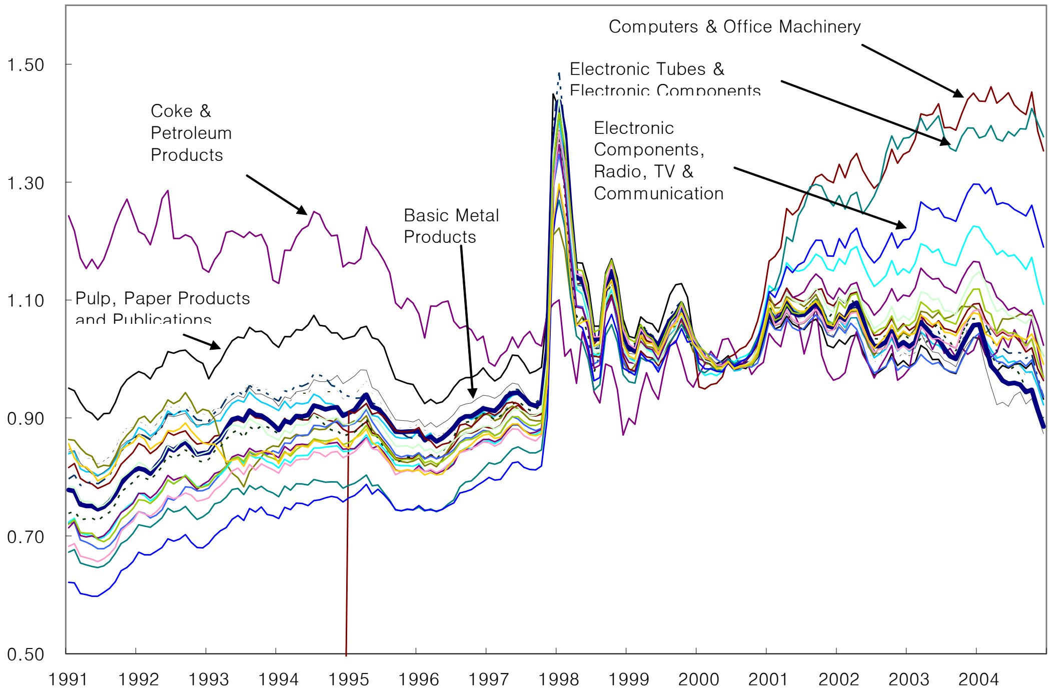

Figure 5: Industry Level REER (with aggregate trade-weight aggregated level and without China)

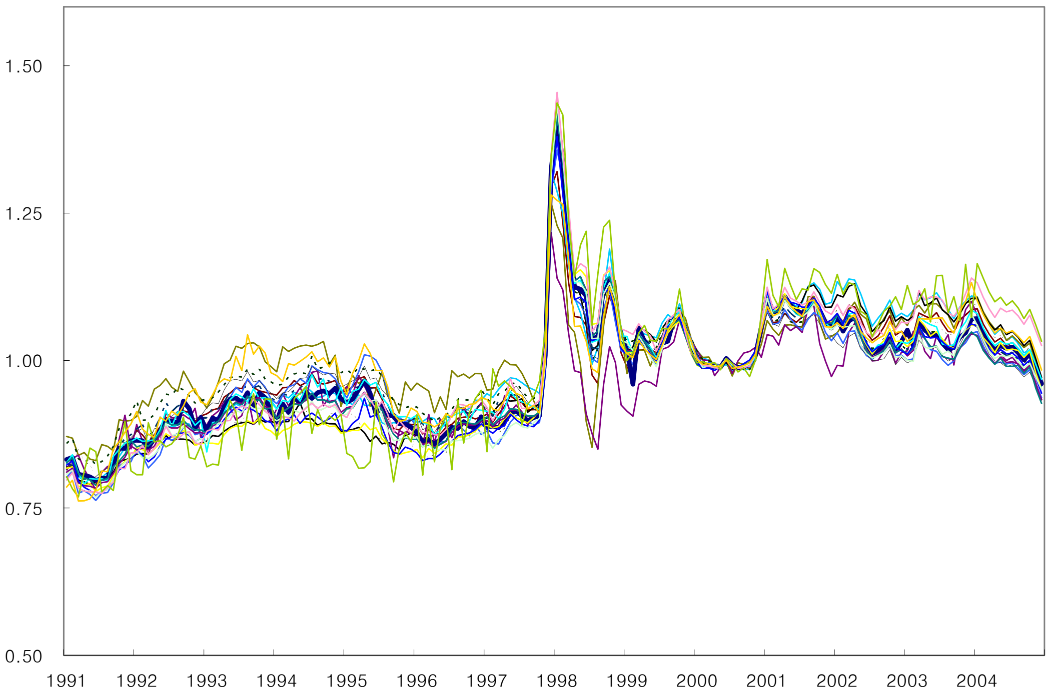

Figure 6: Industry Level REER (with aggregate PPI and without China)

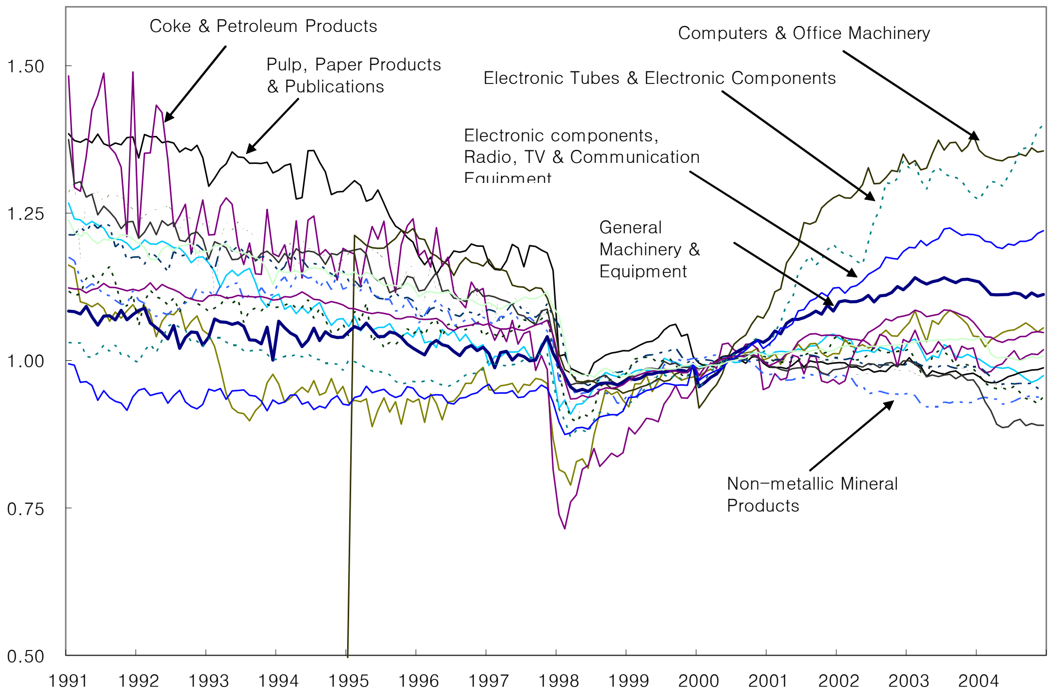

Figure 7: Industry Level Real Effective Rate (trade-weighted, excluding China)

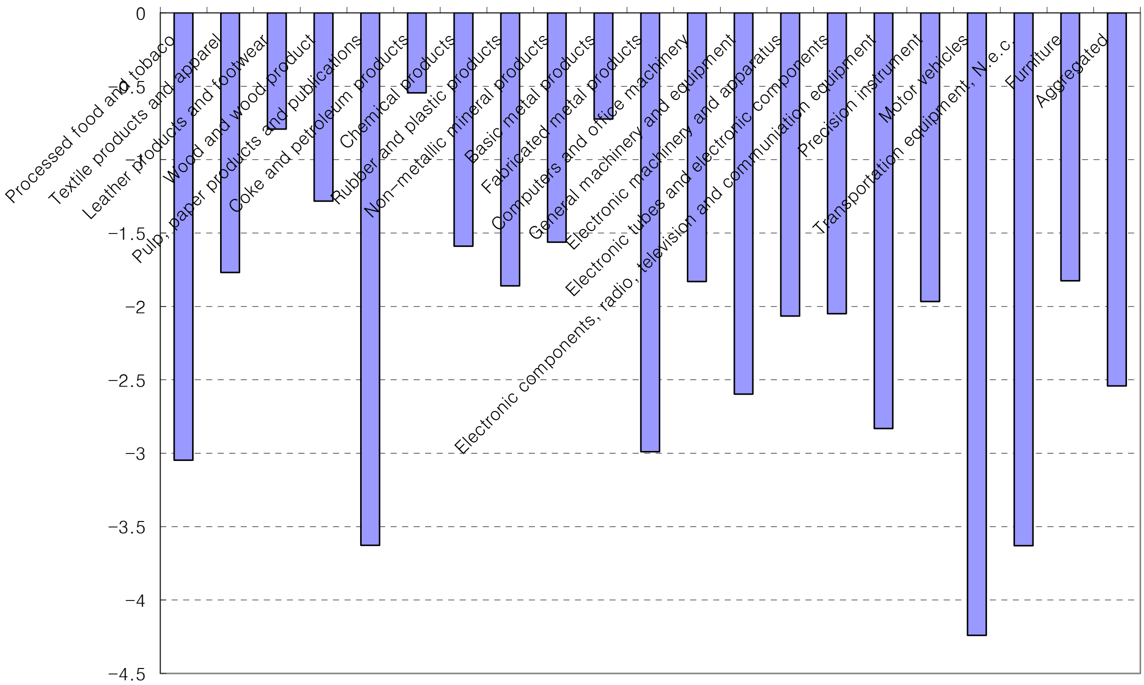

Figure 8: Percentage changes in REER in response to 10 percent appreciation against the U.S. dollar

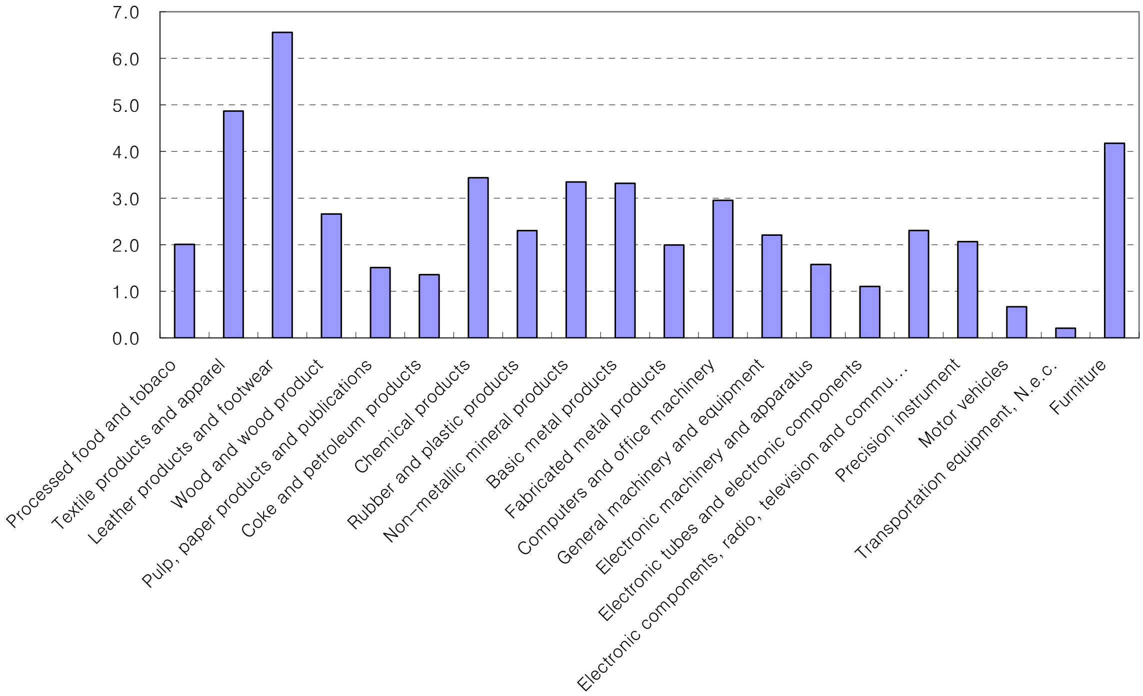

Figure 9: Percentage changes in REER in response to 10 percent deppreciation against Chinese yuan

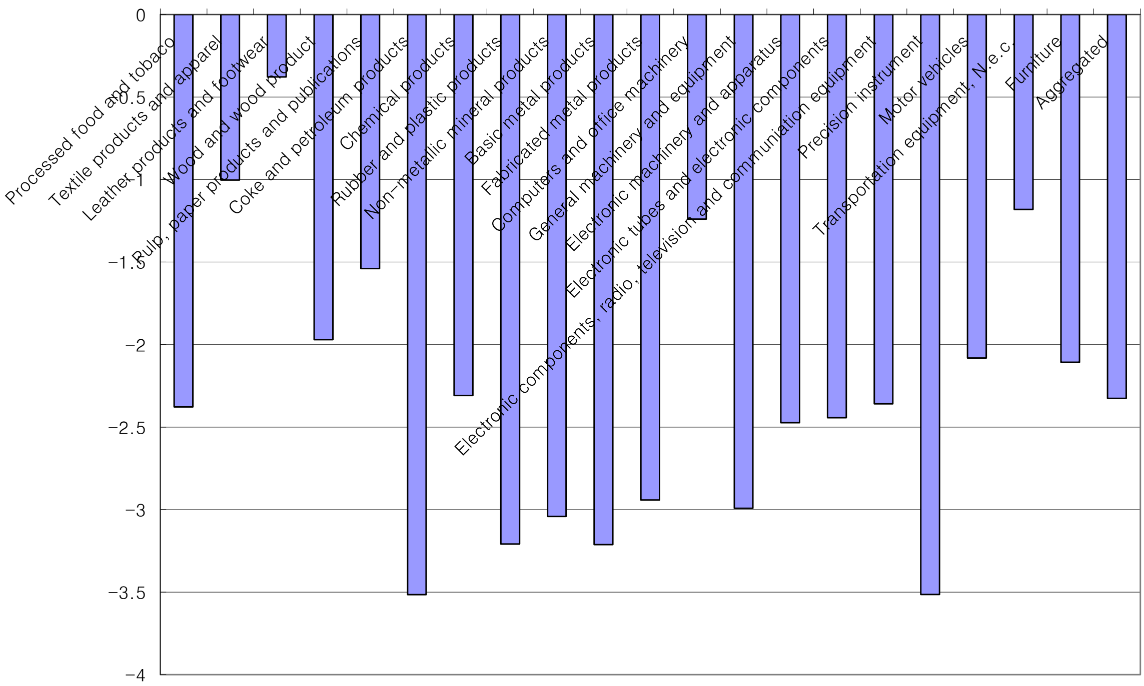

Figure 10: Percentage changes in REER in response to 10 percent appreciation against Japanese yen