Doctoral Dissertation

Exchange Rate Fluctuations and Trade in East Asia

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A dissertation submitted in partial fulfillment of the requirements of the degree of
Ph.D in Economics

Graduate School of International Social Scieces
Yokohama National University

March, 2015

Acknowledgements

I would like to express my deep gratitude to the following people who have given me great support and encouraged to complete this study.

First of all, I am deeply grateful to my supervisor Professor Kiyotaka Sato, for his valuable guidance and advices. Without his knowledge and intellectual guidance, the completion of this study would not have been possible.

I'm also indebted to Professor Eiichi Tomiura and Professor Tsunao Okumura, for their supports, constructive comments and suggestions, which have led me to finish this thesis. I would also like to thank other members of my dissertation committee, Professor Craig Parsons and Doctor Taiyo Yoshimi. I have also benefited from their discussions throughout the dissertation process.

I would also like to express my appreciation to Professor Junko Shimizu and Dr Nagendra Shrestha, for their supports, encouragement and suggestions.

I am very grateful to Rotary Yoneyama Memorial Foundation who have offered scholarship to me and facilitated my concentration on study. I would also like to express my deep gratitude to the Graduate School of International Social Scieces, Yokohama National University for providing me favorable study environment and useful learning course.

Finally, I would like to thank my parents and my husband, friends for their love, encouragement, understanding and supports while I was doing My PhD research.

Abstract

This thesis empirically examines the impact of exchange rate fluctuations on exports of East Asia region, mainly focus on the difference in its impact across industries. For this purpose, as for exchange rate data, I applied a unique data set conducted by Sato *at. el* (2013), namely, industry-specific exchange rate, which can capture the heterogeneity in the movements of exchange rate across industry, to eliminate the bias caused by aggregated exchange rate. The exchange rate fluctuation is widely considered to have a negative impact on emerging Asia countries. Given a rapid progress of economic integration through trade and investment, a good understanding of the impact of exchange rate fluctuations is good for regional cooperation. This thesis contain three topics and mainly there three main finding of this thesis. Firstly, the exchange rate volatility has negative and significant effect only on the general machinery industry and a part of the electric machinery industry with more differentiated products, even when taking into account the world's demand for the final processed exports. These results suggest that the different impact of the exchange rate volatility across industries has to do with the growing intra-firm trade and the characteristics of traded goods in respective industries. Given that the growing cross-border fragmentation and processing trade are driven by intra-firm trade, the real exchange rate volatility will have weaker impact on regional trade of intermediate goods along the production chain. This evidence has important policy implications for the recent debate on possible regional exchange rate arrangements in Asia against the background of deepening economic integration. Second, the nominal exchange rate changes have significant influences on export performance and competitiveness. It may be necessary to stabilize the regional exchange rate volatility to avoid regional trade imbalances, since exchange rate appreciation has negative impact on export performance, regional exchange rate stability will help to prevent beggar-thy-neighbor policy and facilitate further intra-regional trade. Third, the results from Chapter 3 suggest the negative impact of exchange rate fluctuations is not a linear and is conditional on the financial sector development of the exporting country. Accommodative financial environment can help firms with higher internal financial constraints alleviate the impact of yen appreciation on its exports.

Declaration

A version of Chapter 2 has been published in the following journal.

- Sato, Kiyotaka, Junko Shimizu, Nagendra Shrestha and Shajuan Zhang (2013) "Industry-specific Real Effective Exchange Rate and Export Price Competitiveness: The Case of Japan, China and Korea," *Asian Economic Policy Review*, 8(2), pp.298-321.

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Introduction

After the collapse of the Bretton Woods agreements, the exchange rate fluctuation has been a center concern of policymakers and academics. The increase in exchange rate fluctuation is widely believed to harm international by increasing uncertainty. However, there is no consensus on the impact exchange rate fluctuations may have on exports. While most of studies focusing on developing countries find that exchange rate have a negative fluctuations have a negative effect on exports (Chit et al., 2010; Thorbecke; 2008), those studies which focus on the developed countries tend to find either insignificant effect or significant but small effect on their exports (Hooper and Kohlhagen, 1978; Grier and Smallwood, 2007). However, these results may be biased by using aggregated exchange rate as pointed out by Byrne et al. (2008).

This thesis empirically examines the impact of exchange rate fluctuations on the exports of East Asian countries employing a unique dataset conducted by Sato *et al*. (2012), so called industry-specific real effective exchange rate (I-REER), to take account of the different movements of real effective exchange rates across industries, which can eliminate the bias caused by using aggregated exchange rate. Why the impact of exchange rate fluctuation is important for Asian countries? First of all, most of Asian countries heavily rely on exports for their economic growth. Second, the financial markets in most of Asian countries are underdeveloped, which will cause Asian economy more likely affected by exchanger rate fluctuations according to the theory of this literature.

The main objective of the thesis is to understand the impact of exchange rate fluctuations on the exports of East Asian countries. Recently, Asian trade has been remarkably increasing with active investment and trade of foreign multinational firms. Given a rapid progress of economic integration through trade and investment, regional exchange rate stability has gained a growing attention. Especially after the 1997-98 currency crisis, Asian countries have pursued the possibility of a regional monetary and exchange rate coordination. A good understanding of the impact of exchange rate on exports contributes to apply a proper regional cooperation.

For this purpose, this dissertation consists of three chapters that study the impact of exchange rate fluctuations on exports focusing on different issue.

Chapter 1, co-authored with Kiyotaka Sato, Junko Shimizu and Nagendra Shrestha, is to investigate whether and to what extent the volatility of exchange rate affects intra-regional production and distribution networks, characterized by trade of intermediate goods, in Asia by using a new industry-breakdown dataset of the bilateral real exchange rate from 2001 to 2013. It novel finding is that, in contrast to the recent studies, the exchange rate volatility has negative and significant effect only on two industries, general machinery and electrical machinery, which are characterized by more differentiated export products, even when taking into account the world's demand for the final processed exports. These findings are supported by various kinds of the exchange rate volatility in the short- and long-run. The different impact of the exchange rate volatility across industries has to do with the characteristics of traded goods in respective industries. It can also be ascribed to an increase in intra-firm trade where exchange rate risk is well managed by the parent company. Thus, as long as the growing cross-border fragmentation and processing trade are driven by intra-firm trade, the effect of real exchange rate volatility will be weaker. This evidence has important policy implications for regional exchange rate arrangements in Asia given deepening regional production network.

Chapter 2, Kiyotaka Sato , Junko Shimizu , Nagendra Shrestha, is to construct a new data set of the industry-specific real effective exchange rate (I-REER), based on the producer price indices, for Japan, China and Korea on a monthly basis from January 2001 to February 2013 in order to provide a better indicator for export price competitiveness. By conducting simulation analysis, it is found that Korean Electrical Machinery firms substantially improved cost competitiveness by lowering the production cost during the Korean won appreciation period, while Japanese firms' large plant investment caused by misjudgment of the management led to excessive production capacity, which resulted in the deterioration of Japanese export competitiveness. Structural vector autoregression (VAR) analysis also reveals that the nominal exchange rate changes have significant influences on export performance and competitiveness. The prolonged nominal appreciation of the yen have seriously negative impact on export performance and even firms' business performance, especially when foreign competitors enjoy the nominal depreciation of their currency. Third, it may be necessary to stabilize the regional exchange rate volatility to avoid regional trade imbalances. The yen and won moved in an opposite direction after the Lehman Brothers collapse in September 2008, which caused large difference in export competitiveness. Since exchange rate appreciation has negative impact on export performance, regional exchange rate stability will help to prevent beggar-thy-neighbor policy and facilitate further intra-regional trade.

Chapter 3 is to empirically investigate whether and how financial constraints influence the response of Japanese sectoral exports to the exchange rate shock employing the industry-breakdown data of financial constraints on Japanese firms obtained from Bank of Japan, Tankan (Short-Term Economic Survey of Enterprises in Japan). To compare the difference in the response of Japanese exports to exchange rate shock with different level of financial constraints, I employed a Panel-VAR approach augmented by adding interaction terms with financial constraints. It is found that financial constraints have significant influences on the exporter's behavior in response to the exchange rate changes. Japanese exporters with higher liquidity are less affected by the exchange rate appreciation. If exporters have the lower liquidity, accommodative lending attitudes of financial institutions, and easy financial position make their exports less affected by the exchange rate appreciation. Thus, higher liquidity position and accommodative financial environment play an important role in alleviating the impact of yen appreciation on Japanese exports.

Chapter 1: Industry-specific Exchange Rate Volatility and Intermediate Goods Trade in Asia

1.1 Introduction

Asian trade has been remarkably increasing with active investment and trade of foreign multinational firms. In particular, regional production networks are primarily driven by these multinationals not only from Japan but also from other East Asian countries such as Korea and Taiwan. These multinational firms located in the Mainland China and ASEAN countries, on one hand, import higher-skilled parts/components and capital goods from Japan, other East Asian and neighboring ASEAN countries and, on the other hand, export the finished goods to the US and European countries. Asia is thus characterized by the "triangular" trade with growing cross-border production fragmentation in the region.

Meanwhile, Asian countries have pursued the possibility of a regional monetary and exchange rate coordination especially after the 1997-98 currency crisis. Given a rapid progress of economic integration through trade and investment, regional exchange rate stability has gained a growing attention. However, it is not necessarily clear whether the exchange rate volatility affects intra-regional trade based on the production network. It is well known that what we observe in Asian trade cannot be explained properly by the textbook version of the theory of international trade.[1] The Asian production network consists of intricate combinations of intra-firm and arms-length trade transactions, where the production process of an industry is split into fragmented production blocks. A natural question is whether the volatility of regional exchange rates deteriorates the vertical intra-industry trade (VIIT) in Asia.

The purpose of this study is to investigate whether and to what extent the volatility of exchange rate affects intra-regional production and distribution networks, characterized by trade of intermediate goods, in Asia by using a new industry-breakdown dataset of the bilateral real exchange rate. There is no clear consensus, both theoretically and empirically, as to whether the exchange rate volatility has a negative or positive impact on international trade. When assuming a partial equilibrium model where exporting firms determine the volume of trade before the exchange rate is known, the effect of exchange rate uncertainty depends on the firms' risk-taking behavior and the shape of the profit function.[2] Even empirical studies have

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[1] See Kimura and Obashi (2011) for a good survey of the international production fragmentation.

[2] Clark (1973), for instance, theoretically demonstrates the negative impact of the exchange rate

not yet demonstrated a clear-cut relationship between the exchange rate volatility and international trade, likely due to differences in the coverage of sample countries, sample period, model specifications, estimation techniques and types of the data. Interestingly, recent studies using the disaggregated trade data have found significantly negative impacts of the exchange rate volatility on intra-Asian trade (e.g., Thorbecke, 2008; Hayakawa and Kimura, 2009; Chit *et al*., 2010; and Tang, 2011).

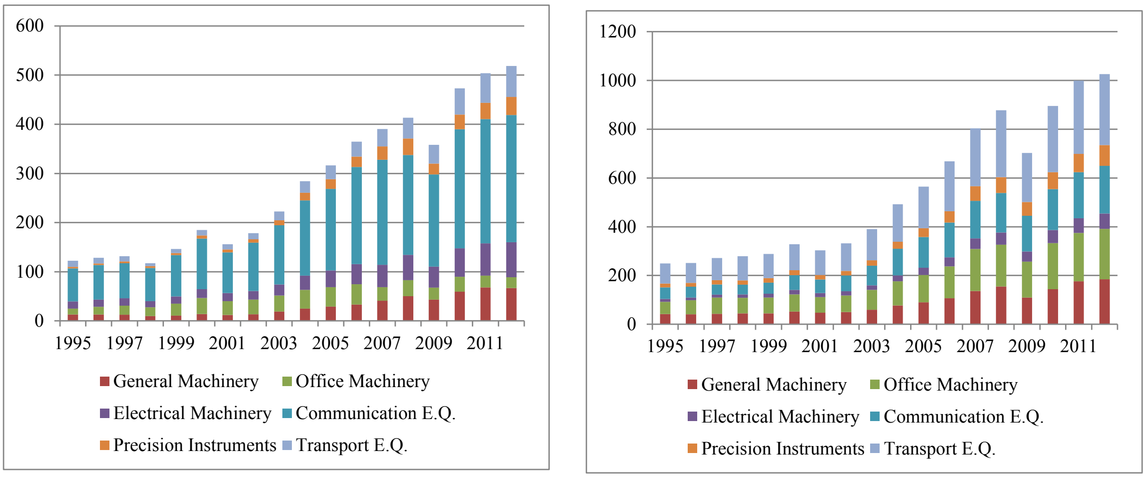
This paper differs from the previous studies in three respects. First, we use more detailed industry-breakdown data. Previous studies typically focus on one industry or aggregated intermediate goods trade. This paper deals with six industries, general machinery, office machinery, electrical machinery, communication equipment, transport equipment, and precision instruments, based on the 2-digit level of the International Standard Industrial Classification (ISIC) Rev.3. As argued by Kimura *et al*. (2007), production and distribution networks of these industries are qualitatively and quantitatively the most important in Asia. Second, we construct a new dataset of the industry-specific bilateral real exchange rate to evaluate whether and how the impact of exchange rate volatility on trade of intermediate goods differs across industries. To our knowledge, this is the first study to employ the industry-specific bilateral real exchange rate. The aggregate exchange rate cannot capture any differences in both price level and inflation across industries. Third, as the final processed exports are destined for countries outside the Asian region, not only the exchange rate but also the world demand for Asian exports of finished goods are considered as a possible driving force in the cross-border fragmentation and processing trade. Following Thorbecke (2008), we include the world's demand for the final processed exports in the regression specification as a possible explanatory variable.

Our novel finding is that, in contrast to the recent studies, the exchange rate volatility has negative and significant effect only on two industries, general machinery and electrical machinery, which are characterized by more differentiated export products, even when taking into account the world's demand for the final processed exports. These findings are supported by various kinds of the exchange rate volatility in the short- and long-run. The different impact of the exchange rate volatility across industries has to do with the characteristics of traded goods in respective industries. It can also be ascribed to an increase in intra-firm trade where exchange rate risk is well managed by the parent company. Thus, as long as the growing cross-border fragmentation and processing trade are driven by intra-firm trade, the effect of real

volatility on international trade, while Frank (1991) shows that a positive relationship can exist between the exchange rate volatility and trade.

Figure 1: Asian Triangular Trade: 1995-2012

1a. Intra-Regional Trade of Intermediate Goods 1b. Finished Goods Exports to the World



Note: Amounts of both intra-regional trade (USD billion) and finished goods exports to the world (USD billion) are calculated using the total machinery exports in 10 Asian economies: China, Indonesia, India, Japan, Korea, Malaysia, the Philippines, Singapore, Thailand and Taiwan. The machinery exports are based on the ISIC 2-digit classification that ranges from 29 to 34 (see Table 1 below). The "world" in Figure 1b is defined as the all countries except the above 10 Asian economies.

Source: Authors' calculation based on the OECD STAN database.

exchange rate volatility will be weaker. This evidence has important policy implications for regional exchange rate arrangements in Asia given deepening regional production network.

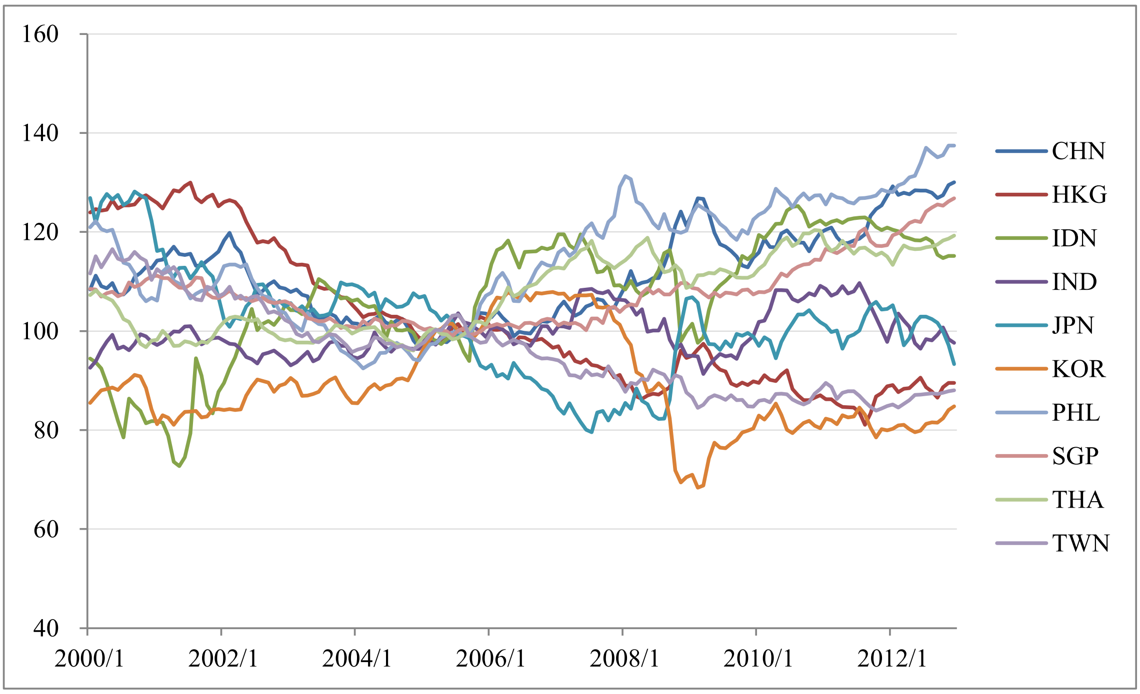
The paper is organized as follows. Section 2 presents the preliminary evidence of the Asian trade and exchange rates. Section 3 discusses the research methodology, definition of variables and description of the data. Section 4 presents our estimated results and robustness check. Finally, Section 5 concludes.

1.2 Preliminary Evidence of the Asian Trade and Exchange Rates

Let us first look at the recent trend of Asian trade. Figure 1 clearly shows that the triangular trade is actively conducted in Asia. Not only intra-Asian trade of intermediate goods but also finished goods exports to the world increased substantially from the early 2000s. While they fell sharply in 2009, both intra-Asian trade and exports to the world recovered quickly in 2010. Such large fluctuations have to do with a rapid and deep decline in the import demand of advanced countries, as these countries are seriously affected by the collapse of Lehman Brothers and the subsequent financial crisis. This observation indicates that intermediate goods trade in Asia is likely to be driven by the import demand of US and European countries that are the final destination for Asian finished goods exports.

Asian trade may also be affected by the exchange rate fluctuations. As shown in Figure 2, the real effective exchange rate (REER) of Asian economies fluctuated to a large extent, which suggests large exchange rate fluctuations of intra-Asian currencies. Indeed, previous studies such as Thorbecke (2008), Hayakawa and Kimura (2009) and Tang (2011) analyze the effect of intra-Asian exchange rate volatility on intra-Asian trade. However, these studies use the overall exchange rate in real terms, and the industry-specific exchange rate is not considered at all.

Figure 2: Real Effective Exchange Rate of Asian Economies



Note: CPI-based real effective exchange rates (broad indices) from January 2000 to December 2012 (monthly average: 2005=100).

Source: Bank for International Settlements.

The REER in practice fluctuates differently across industries. Sato *et al*. (2012, 2013) construct the industry-specific REER of the yen, Korean won and Chinese renminbi, and show large differences in the level of REER of the three currencies across industries.[3] For illustrative purposes, we use the same dataset of the industry-specific producer price index (PPI) and calculate the industry-specific bilateral real exchange rate of the yen vis-à-vis the Asian currencies from January 2000 to April 2014. Figure 3 indicates that the bilateral real exchange rate between the yen and other Asian currencies exhibits different movements across industries. As shown in Appendix Figure A1, the PPI in level has also changed differently across industries in all Asian countries. This observation suggests that the conventional use of the real exchange rate is not sufficient for an analysis of the exchange rate impact on trade transactions. Industry-specific exchange rate is necessary for rigorous empirical examination of the effect of exchange rate changes on intra-Asian trade.

1.3 Research Methodology

1.3.1 The Benchmark Model

The main purpose of this study is to investigate whether the exchange rate volatility has a negative impact on intra-Asian trade of intermediate goods and whether the effects differ across sectors Following a number of existing studies such as Clark *et al*. (2004), Tenreyro (2007) and Hayakawa and Kimura (2009), we employ a gravity approach to empirically analyze the relationship between the exchange rate volatility and bilateral trade. However,In our gravity equation, we don't include the GDP of exporter and importer, since we use the time varying exporter and importer effects to control not only for the multilateral effects proposed by Anderson and van Wincoop (2003)[4], which canabsorb the time-varying factors of both exporter and importer, such as GDP. It is a relatively strong control to take account of not only the country-specific time-varing factors but also the unobserved time-invaryingfactors. The rest of traditional variables, such as distance between two countries, sharing of a common border[5], common language, are included.

Our empirical approach differs from the previous studies. First, we use the industry-specific bilateral real exchange rate between exporting and importing countries. As observed in the previous section, the level of the bilateral real exchange rate changes

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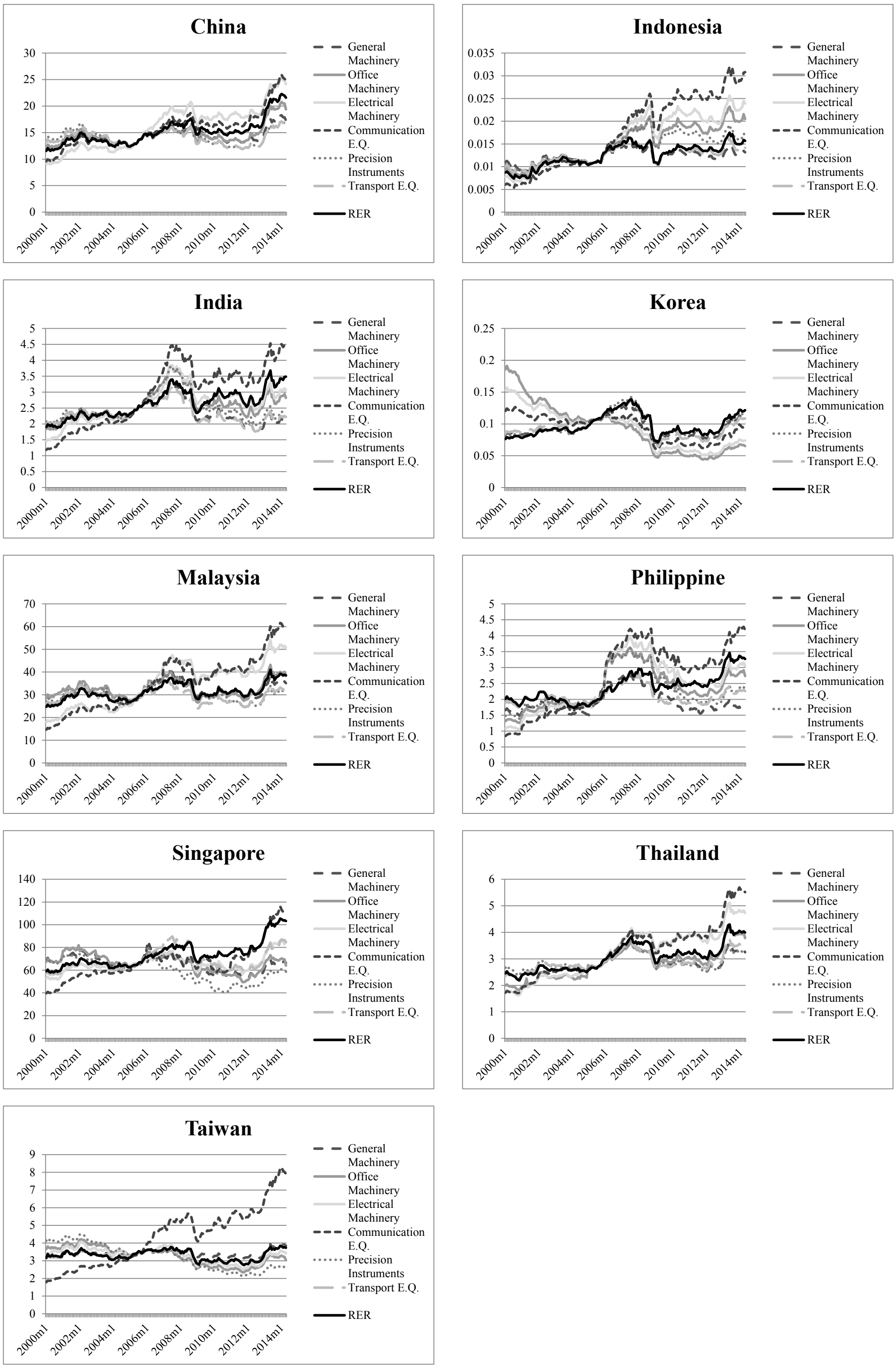
3 The industry-specific REER data for these currencies are available on the website of the Research Institute of Economy, Trade and Industry (RIETI). See the following URL: http://www.rieti.go.jp/users/eeri/en/index.html.

4 See Anderson and van Wincoop (2003) for a formulation of the concept of multilateral resistance, and Rose and van Wincoop (2000) for a related empirical implementation.

5 We include both land border and sea border in the border dummy.

Figure 3: Industry-specific Real Exchange Rate of the Yen vis-à-vis the Asian Currencies: January 2000 through April 2014



Note: Authors' calculation using the monthly producer price index (PPI) listed in Table 1 below.

Source: IMF, *International Financial Statistics*, CD-ROM. See also Appendix Table 8.

differently across industries. We use the industry-specific PPI data for sample countries and construct the dataset of the industry-specific bilateral real exchange rate series for each pair of Asian countries.

Second, we include the "finished goods exports to the world" in our gravity equation to take into consideration the import demand of the countries outside the Asian region for final goods from the Asian countries. As shown in the previous section, intra-Asian trade of intermediate goods is likely to be driven by the world demand for finished goods. Thorbecke (2008) also includes the explanatory variable of finished goods exports to the world. Since placing emphasis on industry differences, we include the industry-specific exports of final goods to the world as an extension of the gravity equation approach.

The baseline gravity equation is shown by:

$$\ln X_{ijt}^{k} = \alpha_0 + \alpha_1 VOL_{ijt}^{k} + \alpha_2 \ln FX_{jwt}^{k} + \alpha_3 Dist_{ij} + \alpha_4 Adja_{ij} + \alpha_5 Lang + \alpha_6 s_{it} + \alpha_7 s_{jt} + \mu_{ijt}^{k}, \quad (1)$$

where t denotes time; k an industry; $\ln X_{ij}$ the natural log of exports of intermediate goods from country i to county j; VOL_{ij} the volatility of the bilateral real exchange rate between country i and country j; $\ln FX_{jw}$ the natural log of final goods exports from country j to the world[6];s_i, s_j and multilateral resistence effects of exporter (country i) and importer (country j), respectively; μ_{ijt} an error term. *Dist*, *Adja* and *Lang* represent a distance, a shared common border and a common language dummy, respectively.

There is no clear consensus as to which proxy variable is the most appropriate for the exchange rate volatility. We employ two measures of the exchange rate volatility. The first measure is the standard deviation of the log difference of the industry-specific bilateral real exchange rate. The second one is the conditional volatility of the industry-specific real exchange rate estimated by the GARCH(1,1) model. Following Clark *et al*. (2004) and Chit *et al*. (2010), the first-difference of the log of monthly exchange rates is assumed to follow a random walk with a drift:

$$\Delta e_{ijt}^{k} = \alpha_0{}^{k} + \alpha_{ijt}^{k} \Delta e_{ijt-1}^{k} + u_{ijt}^{k}, \quad (2)$$

[6] The world represents the countries outside of the Asian region. As will be shown below, "Asia" in this paper is defined as 10 countries: Japan, China, Korea, India, Indonesia, Malaysia, Philippines, Singapore, Thailand and Taiwan.

where $u_{ijt} \sim N(0, h_{ijt})$ and Δe^{k}_{ijt} means the first-difference of the natural log of the bilateral real exchange rate of industry k at t period between countries i and j. The conditional variance is defined as;

$$h^{k}_{ijt} = \beta^{k}_{0} + \beta^{k}_{1} u^{k,2}_{ijt-1} + \beta^{k}_{2} h^{k}_{ijt}, \qquad (3)$$

where $u^{k,2}_{ijt-1}$ denotes the square of residuals, u^{k}_{ijt-1}, estimated by ARCH model at t-1 period. It has one lag of the regressed ARCH model's residual and one lag of the variance itself (1 GARCH term). The estimated standard deviation of each country pair is used as the approximation of the exchange rate volatility.

As discussed in Clark *et al*. (2004) and Thorbecke (2008), when considering the impact of the exchange rate volatility on trade flows, the timing issue is crucial. A number of previous studies use the lagged exchange rate volatility to investigate the impact of the exchange rate changes on trade, since trade contracts tend to be longer and the firms' pricing behavior is unlikely to be changed for a short period. However, exporters may also have more concern about the short-run exchange rate volatility, as longs as their trade contracts are very short, where it is more appropriate to use the volatility of exchange rate in the current year.

The timing issue is also related to the role of "sunk costs". Clark *et al*. (2004) states that firm's trade is less responsive to the short-run volatility of exchange rates, given a large investment of exporting firms in foreign markets to build marketing and distribution networks and/or to set up production facilities. Once production network is established, the relation-specific nature of intermediate goods transactions may also lessen the exchange rate effect on trade in the short-run.

This paper uses four kinds of time windows to allow for timing and uncertainty issues. First is the volatility of the exchange rate in the current year, which is called contemporaneous volatility. The second one is the volatility during the current and the previous year (i.e., the two-year volatility), and the third one is the volatility in the current year and the previous two years (i.e., the three-year volatility). The second and third indicators are for the long-run volatility. The fourth one is the volatility in the previous year, the current year and the next year. Thorbecke (2008) uses this fourth measure to allow for uncertainty of exchange rate changes, since uncertainty is a forward-looking concept.

Table 1: Industry-specific Price Data

<table>
<tr><th>ISIC</th><th>Industry Classification</th><th>CHN</th><th>IDN</th><th>IND</th><th>JPN</th><th>KOR</th><th>MYS</th><th>PHL</th><th>SGP</th><th>THA</th><th>TWN</th></tr>
<tr><td>29</td><td>Machinery and Equipment n.e.c.</td><td>▲</td><td>○</td><td>○</td><td>○</td><td>○</td><td>○</td><td>○</td><td>●</td><td>○</td><td>○</td></tr>
<tr><td>30</td><td>Office,Accounting and Computing Machinery</td><td rowspan="2">○</td><td>X</td><td>X</td><td rowspan="2">○</td><td>X</td><td>○</td><td>X</td><td>○</td><td>○</td><td>○</td></tr>
<tr><td>31</td><td>Electrical Machinery and Apparatus n.e.c.</td><td rowspan="3">○</td><td>●</td><td>○</td><td>○</td><td>○</td><td>○</td><td>○</td><td>○</td></tr>
<tr><td>32</td><td>Communication Equipment and Apparatus</td><td>○</td><td>X</td><td>○</td><td>○</td><td>○</td><td>X</td><td>○</td><td>○</td><td rowspan="2">○</td></tr>
<tr><td>33</td><td>Medical, Precision and Optical Instruments</td><td>○</td><td>X</td><td>○</td><td>○</td><td>○</td><td>X</td><td>●</td><td>○</td></tr>
<tr><td>34</td><td>Motor Vehicles, Trailers and Semi-trailers</td><td rowspan="2">○</td><td rowspan="2">○</td><td rowspan="2">○</td><td rowspan="2">○</td><td rowspan="2">○</td><td>○</td><td rowspan="2">○</td><td rowspan="2">○</td><td rowspan="2">○</td><td>○</td></tr>
<tr><td>35</td><td>Other Transport Equipment</td><td>○</td><td>○</td></tr>
<tr><td colspan="2">Index</td><td>PPI</td><td>WPI</td><td>WPI</td><td>CGPI</td><td>PPI</td><td>PPI</td><td>PPI</td><td>PPI</td><td>PPI</td><td>WPI</td></tr>
</table>

Notes: All countries publish the industry specific price data that follows not ISIC but their own classification, except for Malaysia and Thailand the data of which is based on ISIC.

○ means that the data is available but not exactly corresponds to ISIC.

● means that more detailed data is available, and the industry weight data is also available.

▲ means that more detailed data is available, but the industry weight data is not available.

X means that the data is not available.

Source: See Appendix Table 8.

1.3.2 Industry-specific Exchange Rate

We construct a new dataset of the industry-specific real exchange rate to allow for the difference in price elasticities across industries. We use the 2-digit ISIC Rev.3 for our industrial classification. As pointed out by Kimura *et al*. (2007), the international production and distribution networks in Asia are well developed in the general machinery, electric machinery, transport equipment, and precision instruments industries. Among twenty-three 2-digit sectors of ISIC manufacturing, we focus on seven sectors from ISIC-29 to 33 which are converted into six industries. The details of the industry classification are reported in Appendix Table A2.

We use the following formula to construct the industry-specific exchange rate:

$$RER_{ijt}^{k} = NER_{ijt} \times \frac{P_{jt}^{k}}{P_{it}^{k}}, \tag{4}$$

where t denotes time; k industry; NER_{ij} the bilateral normal exchange rate; P_i and P_j the industry-specific price of home country and partner country, respectively. We use the producer price index (PPI) as the price deflator. The price data are normalized to 100 as of 2005. Table 1 shows the availability of the industry-specific price data. The price data of each ISIC category is not available for all countries. Thus, if it is not available, we use the price data that most likely corresponds to the actual industry.

1.3.3 Data

Japan and emerging Asian 9 economies (China, Korea, India, Indonesia, Malaysia, Philippines, Singapore, Thailand and Taiwan) are analyzed in this study. The sample period for empirical analysis ranges from 2002 to 2012 not only due to the limitation of data availability on the industry-breakdown PPI but also because of the calculation of the exchange rate volatility.

The annual data on exports in terms of US dollars are taken from *OECD STAN Bilateral Trade Database by Industry and End-use (BTDIxE)*. The database presents international trade in goods flows broken down both by industry sector and by end-use categories, allowing for insights into the patterns of trade in intermediate goods between countries to track global production networks and supply chains.[7] The industry classification of this database is ISIC Rev.3. The trade data is deflated by the corresponding industry-specific producer price index.[8] The monthly series of the nominal exchange rate is obtained from the IMF, *International Financial Statistic*, CD-ROM. Most of the monthly series of the industry-breakdown price data are obtained from the official statistics of respective countries and the CEIC Database. The details of the data source are presented in Appendix Table 8 The GDP Data is taken from World Bank, *World Development Indicators* (WDI). The gravity variables are obtained from the World Bank website.

Table 2 presents the summary statistics of the main variables: real exports of intermediate goods and final goods and two types of the industry-specific exchange rate volatility. Among six industries, the level of intraregional intermediate goods exports of the communication equipment is the highest, while that of the precision instruments is the lowest. In exports of final goods, the level of the office machinery is the highest. The degree of the real exchange rate volatility is the highest in the office machinery and the second highest in the precision instruments.

[7] See the URL below for the details:
http://www.oecd-ilibrary.org/science-and-technology/compilation-of-bilateral-trade-database-by-industry-and-end-use-category_5k9h6vx2z07f-en
[8] We also use the aggregated PPI as a price deflator but no significant differences are found in the estimated results.

Table 2: Summary Statistics

	General Machinery	Office Machinery	Electrical Machinery	Communication Equipment	Precision Instruments	Transport Equipment
	Exports of intermediate goods and final goods					
Log of real intermediate goods exports						
Mean	11.62	11.18	11.70	13.15	10.40	11.66
S.D.	1.79	2.46	1.75	2.40	2.18	1.64
Min	6.05	1.45	6.93	5.24	3.48	6.95
Max	16.15	15.31	16.19	17.44	16.44	16.19
Log of real final goods exports						
Mean	15.02	15.30	14.22	15.35	14.29	15.02
S.D.	1.77	1.63	1.31	1.74	1.69	2.18
Min	11.49	11.68	11.27	11.47	11.17	10.65
Max	18.30	18.89	17.42	18.94	17.65	18.78
	Industry-specific real exchange rate volatility: Standard deviation					
Current year (12 months)						
Mean	0.022	0.026	0.024	0.027	0.027	0.020
S.D.	0.011	0.017	0.017	0.017	0.017	0.010
Min	0.004	0.005	0.005	0.004	0.005	0.004
Max	0.071	0.111	0.110	0.110	0.110	0.077
Current year and previous year (24 months)						
Mean	0.023	0.028	0.026	0.029	0.029	0.022
S.D.	0.011	0.016	0.016	0.015	0.016	0.011
Min	0.005	0.006	0.006	0.007	0.006	0.006
Max	0.062	0.086	0.080	0.082	0.089	0.069
Current year and previous two years (36 months)						
Mean	0.024	0.030	0.027	0.030	0.031	0.023
S.D.	0.011	0.015	0.015	0.014	0.015	0.010
Min	0.005	0.007	0.007	0.008	0.007	0.007
Max	0.057	0.073	0.069	0.070	0.078	0.064
Previous year, current year and next year (36 months)						
Mean	0.024	0.028	0.026	0.029	0.029	0.023
S.D.	0.010	0.014	0.014	0.014	0.014	0.009
Min	0.005	0.007	0.007	0.008	0.007	0.007
Max	0.054	0.073	0.069	0.070	0.075	0.059
	Industry-specific real exchange rate volatility: GARCH(1,1) Model					
Current year (12 months)						
Mean	0.024	0.030	0.027	0.030	0.030	0.023
S.D.	0.009	0.013	0.013	0.012	0.013	0.008
Min	0.009	0.006	0.009	0.011	0.006	0.008
Max	0.057	0.089	0.089	0.093	0.090	0.063
Current year and previous year (24 months)						
Mean	0.024	0.030	0.027	0.030	0.030	0.023
S.D.	0.009	0.012	0.013	0.012	0.013	0.008
Min	0.008	0.007	0.009	0.012	0.007	0.008
Max	0.059	0.076	0.075	0.078	0.080	0.061
Current year and previous two years (36 months)						
Mean	0.025	0.030	0.028	0.030	0.031	0.024
S.D.	0.009	0.012	0.012	0.011	0.013	0.008
Min	0.008	0.007	0.010	0.013	0.007	0.008
Max	0.056	0.066	0.066	0.068	0.072	0.058
Previous year, current year and next year (36 months)						
Mean	0.024	0.030	0.027	0.030	0.030	0.023
S.D.	0.008	0.011	0.012	0.011	0.012	0.007
Min	0.009	0.007	0.010	0.013	0.007	0.009
Max	0.050	0.066	0.066	0.068	0.072	0.052
Obs.	989	989	989	989	989	989

Note: Exports of intermediate goods and final goods denote the natural log of the bilateral trade amounts deflated by industry-specific producer price index (PPI).

1.4 Estimation Results

In this section, we report not only the benchmark results but also two additional empirical results for robustness check. While presenting the pooled OLS estimator of our gravity equation (1), we take into account the time-varying country effect to control the effect of multilateral resistance term, as proposed by Anderson and van Wincoop (2003). In this specification, we control not only the time-variant country characteristics but also the time-invariant countrycharacteristics. Thus, we use the within-countrypair-year variation to identify how the exchange rate volatility affects the intra-Asian trade of intermediate goods.

1.4.1 Benchmark Result

Table 3 presents the benchmark result with the industry-specific real exchange rate volatility calculated from the three-year data including the current year and the previous two years. First, our main interest is in possible difference in the impact of exchange rate volatility on intra-regional trade of intermediate goods across industries. While recent studies such as Thorbecke (2008) and Hayakawa and Kimura (2009) found a significantly negative impact of the real exchange rate volatility on machinery trade, Table 3 shows that the exchange rate impact is significantly negative only in two industries: general machinery and electrical machinery. In the other four industries, exchange rate volatility has no significant impact. Second, exports of final goods to the world have significantly positive impact on trade of intermediate goods at the 1 percent significance level for all industries except the electrical machinery where it is at the 5 percent significance level. This result indicates that imports of intermediate goods in a country are driven by its final goods exports. Among the industries, the precision instruments industry is the most sensitive to final goods exports, and the transport equipment industry is the least sensitive. Third, almost all coefficients of the remaining variables are estimated to be significant with expected signs, except for adjacency and ASEAN dummies. While the theoretical foundations of gravity model suggest that two countries sharing a common border will trade more, our result shows that the adjacency dummy is not statistically significant in four out of six industries. In general machinery and electrical machinery, the adjacency dummy is negatively significant at the 5 percent level. Although contrary to our expectation, this result is not surprising, because almost all countries in our sample do not share common borders. Our results also show that the coefficient of the importing country's income variable is larger than that of home country's (export country) income in most cases. This finding is consistent with the theoretical prediction and empirical findings of Feenstra *et al*. (2001), which suggests that a country's exports are more sensitive to the importing country's income than to its own income.

Table 3: Benchmark Results: Industry-specific Exchange Rate Volatility

Variables	*Industries*					
	General Machinery	Office Machinery	Electrical Machinery	Communication Equipment	Precision Instruments	Transport Equipment
Exchange rate volatility	-0.275***	-0.090	-0.262***	0.052	0.058	0.262
(pervious two years and current year)	(0.073)	(0.169)	(0.101)	(0.103)	(0.106)	(0.143)
Final goods exports	0.454***	0.627***	0.249***	0.317***	0.615***	0.333***
	(0.055)	(0.097)	(0.065)	(0.035)	(0.078)	(0.047)
Distance	-0.897***	-0.657***	-1.003***	-0.579***	-0.658***	-0.604***
	(0.052)	(0.132)	(0.059)	(0.055)	(0.078)	(0.069)
Adjacency	-0.415***	-0.241	-0.400***	-0.391***	-0.081	-0.011
	(0.106)	(0.312)	(0.112)	(0.118)	(0.170)	(0.133)
Common Language	0.322***	-0.340**	0.286***	0.045	0.385***	-0.351***
	(0.068)	(0.142)	(0.074)	(0.079)	(0.124)	(0.096)
ASEAN	0.051	0.672***	-0.251**	0.128	1.137***	0.896***
	(0.112)	(0.257)	(0.125)	(0.131)	(0.181)	(0.170)
Constant	11.863***	8.006***	16.537***	13.156***	7.395***	11.074***
	(1.016)	(2.158)	(1.171)	(0.773)	(1.432)	(0.939)
Time-varying exporter effects	yes	yes	yes	yes	yes	yes
Time-varying importer effects	yes	yes	yes	yes	yes	yes
Observations	989	989	989	989	989	989
R-squared	0.927	0.841	0.911	0.950	0.889	0.803

Notes: Robust standard errors are in parentheses. ***, ** and * denote the significance at 1 percent, 5 percent and 10 percent level, respectively.

The industry-specific real exchange rate volatility in three years (i.e., previous two years and the current year) is used for the benchmark estimation.

Why is the impact of exchange rate volatility different across industries? First possible reason is the difference in the degree of product differentiation and, hence, in the firm's pricing behavior and the choice of invoicing currency. Trade of electronic parts and components, for example, is highly competitive and the US dollar invoicing is generally chosen in world markets. While difficult to obtain the data on invoicing currency, several studies present empirical evidence that Japanese firms tend to choose US dollar invoicing in exports of office machinery, communication equipment, and precision instrument industries.[9] Given the US dollar invoicing trade, exporters become a price taker in highly competitive markets, and the volatility of bilateral exchange rates will not have significant impact on the volume of trade. As shown in Appendix Table 9, electronic components are major products of the communication equipment industry where the exchange rate volatility variable has no significant impact on bilateral trade of

[9] Sato (2003), Parsons and Sato (2008) and Ito *et al*. (2010, 2012) empirically show that Japanese firms tend to choose US dollar invoicing in trade of electronics products.

intermediate goods. Personal computers and other electronic devices, which are major products of the office machinery industry, also tend to be traded by invoicing in US dollars.[10]

Second, the impact of the real exchange rate volatility may depend on the difference in trade structures across industries. These two industries with the negative exchange rate impact may be more involved in arm's length (inter-firm) transactions, while the rest of the industries tend to conduct intra-firm transactions. Growing intra-firm trade may play a key role in mitigating the impact of exchange rate volatility on intermediate goods trade. Ito *et al*. (2012) demonstrate that Japanese globally operating firms tend to choose the local currency invoicing in intra-firm trade so that local subsidiaries can avoid taking exchange rate risk. Since US dollar invoicing is dominant in Asia, intra-firm trade is likely to be invoiced in US dollars as well. This is a suggestive evidence for intra-Asian trade of intermediate goods, because Japanese firms are major players in growing regional production network in Asia.

Interestingly, exchange rate volatility has insignificant impact on intermediate goods trade of the transport equipment industry, majority of which is the automobile industry. Automobile parts and components are actively traded within grouped companies, where exchange rate volatility may have little impact on trade volume. In addition, automobile engines are classified into the electrical machinery industry in this paper, since we use the trade data of ISIC revision 3. Engines are differentiated products and Japanese firms tend to export these products by invoicing in the yen, especially in arm's length trade.[11] Since US dollar invoicing is not chosen, the exchange rate volatility may have significantly negative impact on trade of intermediate goods between Asian countries. As discussed in Ito *et al*. (2012), general machinery products tend to be differentiated and the arm's length trade is a prevailing trade pattern in this industry.

1.4.2 Robustness Check

To check the robustness of our benchmark result, we conduct additional empirical examinations. We use three different exchange rates: first, using the aggregate real exchange rate; second, using a various of the industry-specific real exchange rate volatility measurements. For each exchange rate, we calculate the exchange rate

[10] See Ito *et al*. (2010) that estimate the choice of invoice currency in Japanese exports at a disaggregated commodity level.

[11] See Ito *et al*. (2010, 2012).

volatility using four types of time windows to allow for possible different impact of timing and uncertainty: (i) the volatility of the exchange rate in the current year, (ii) the volatility during the current and the previous year (i.e., the two-year volatility), (iii) the volatility in the current year and the previous two years (i.e., the three-year volatility), and (iv) the volatility in the previous year, the current year and the next year. Tables 1.4 and 1.5, respectively, show the results obtained from the aggregate real exchange rates and those from the industry-specific one. In these tables, we report the estimated coefficients for only two variables: the real exchange rate volatility and the final goods exports. Third, to rule out the disturbance caused by the global financial crisis, we re-estimate the equation by suing the data for 2002 to 2008, and the results are presented in Table 6.

Table 4 shows the results of empirical estimation when using the aggregate real exchange rate to calculate the exchange rate volatility. First, in terms of the standard deviation, the exchange rate volatility has no significant impact on intermediate good trade all in all industries except the transport equipment industry. Second, when computing the exchange rate volatility based on the GARCH (1,1) model, we find negative and significant impact of the exchange rate volatility on intermediate goods trade only in the general machinery industry. Third, final goods exports have positive and significant impact on all industries in terms of any types of exchange rate volatility. The above findings are consistent with the presumption that the aggregate real exchange rate is not appropriate for an industry-level analysis.

Table 5 presents the empirical results when using the industry-specific real exchange rate volatility. In all cases, the significantly negative impact of exchange rate volatility is found in the general machinery and the electrical machinery. Final goods exports have significantly positive effect on intermediate goods trade in all cases. These results clearly show that our findings obtained from the benchmark estimation are robust even when we use different measures and time windows of the exchange rate volatility.

Even we use differet sample period, the results are qute robust, as shown in Table 6 Only in General machinery industry when the volatility measured by standard deviation, the significant level of the coeficiants changes from 5 percent level to 10 percent level, the other results are very similar to the findings from the benchmark except for positive effect in two cases in transport equipment industry.

Table 4: Robustness Check by the Aggregate Real Exchange Rate

Variables	*Industries*					
	General Machinery	Office Machinery	Electrical Machinery	Communication Equipment	Precision Instruments	Transport Equipment
Aggregate real exchange rate: Standard deviation						
Current year (12 months)						
Exchange rate volatility	0.020	0.131	0.104*	0.028	0.030	0.121
	(0.055)	(0.113)	(0.062)	(0.070)	(0.089)	(0.094)
Final goods exports	0.348***	0.698***	0.359***	0.311***	0.606***	0.349***
	(0.041)	(0.083)	(0.058)	(0.037)	(0.077)	(0.040)
Previous year and current year (24 months)						
Exchange rate volatility	0.017	0.024	0.057	-0.032	0.043	0.090
	(0.057)	(0.115)	(0.065)	(0.073)	(0.091)	(0.107)
Final goods exports	0.349***	0.689***	0.355***	0.316***	0.606***	0.350***
	(0.034)	(0.084)	(0.058)	(0.027)	(0.077)	(0.040)
Previous two years and current year (36 months)						
Exchange rate volatility	-0.004	0.020	0.033	-0.064	0.036	0.095
	(0.053)	(0.106)	(0.062)	(0.067)	(0.084)	(0.098)
Final goods exports	0.426***	0.651***	0.356***	0.349***	0.498***	0.347***
	(0.056)	(0.094)	(0.058)	(0.052)	(0.073)	(0.040)
previous year, current year, next year (36 months)						
Exchange rate volatility	0.008	0.076	0.056	-0.026	0.100	0.090
	(0.055)	(0.109)	(0.062)	(0.068)	(0.089)	(0.107)
Final goods exports	0.346***	0.706***	0.357***	0.316***	0.447***	0.345***
	(0.035)	(0.087)	(0.058)	(0.027)	(0.064)	(0.041)
Aggregate real exchange rate: GARCH(1,1) Model						
Current year (12 months)						
Exchange rate volatility	-0.020	-0.017	0.026	-0.066	0.039	0.101
	(0.060)	(0.109)	(0.071)	(0.073)	(0.086)	(0.109)
Final goods exports	0.350***	0.684***	0.354***	0.317***	0.500***	0.344***
	(0.034)	(0.085)	(0.058)	(0.027)	(0.074)	(0.041)
Previous year and current year (24 months)						
Exchange rate volatility	-0.043	-0.081	-0.030	-0.121	0.059	0.072
	(0.057)	(0.116)	(0.071)	(0.075)	(0.087)	(0.105)
Final goods exports	0.346***	0.626***	0.287***	0.313***	0.607***	0.345***
	(0.035)	(0.095)	(0.055)	(0.027)	(0.077)	(0.041)
Previous two years and current year (36 months)						
Exchange rate volatility	-0.064	-0.081	-0.068	-0.164**	0.008	0.067
	(0.053)	(0.112)	(0.067)	(0.068)	(0.085)	(0.098)
Final goods exports	0.451***	0.626***	0.908***	0.303***	0.325***	0.345***
	(0.055)	(0.096)	(0.090)	(0.034)	(0.071)	(0.041)
previous year, current year, next year (36 months)						
Exchange rate volatility	-0.030	-0.035	-0.010	-0.121	0.094	0.081
	(0.058)	(0.120)	(0.070)	(0.075)	(0.091)	(0.112)
Final goods exports	0.480***	0.643***	0.353***	0.311***	0.608***	0.343***
	(0.062)	(0.092)	(0.058)	(0.027)	(0.077)	(0.041)
Time-varying exporter effects	yes	yes	yes	yes	yes	yes
Time-varying importer effects	yes	yes	yes	yes	yes	yes
Observations	989	989	989	989	989	989

Notes: Robust standard errors are in parentheses. ***, ** and * denote the significance at 1 percent, 5 percent and 10 percent level, respectively. The estimated coefficients of gravity variables are not reported, since results are very similar in all cases.

Table 5: Robustness Check by the Industry-specific Real Exchange Rate

Variables	*Industries*					
	General Machinery	Office Machinery	Electrical Machinery	Communication Equipment	Precision Instruments	Transport Equipment
Industry-specific real exchange rate: Standard deviation						
Current year (12 months)						
Exchange rate volatility	-0.196**	0.092	-0.216**	0.056	-0.028	0.196
	(0.081)	(0.181)	(0.107)	(0.092)	(0.103)	(0.138)
Final goods exports	0.333***	0.675***	0.244***	0.317***	0.601***	0.349***
	(0.041)	(0.106)	(0.073)	(0.035)	(0.078)	(0.040)
Previous year and current year (24 months)						
Exchange rate volatility	-0.248***	-0.071	-0.235**	0.014	0.004	0.246
	(0.077)	(0.173)	(0.105)	(0.101)	(0.104)	(0.150)
Final goods exports	0.453***	0.690***	0.269***	0.312***	0.607***	0.330***
	(0.055)	(0.111)	(0.063)	(0.034)	(0.078)	(0.044)
previous year, current year, next year (36 months)						
Exchange rate volatility	-0.284***	-0.104	-0.265**	0.043	0.040	0.190
	(0.075)	(0.177)	(0.108)	(0.108)	(0.110)	(0.153)
Final goods exports	0.507***	0.685***	0.227***	0.315***	0.612***	0.315***
	(0.044)	(0.105)	(0.065)	(0.033)	(0.065)	(0.043)
Industry-specific real exchange rate: GARCH(1,1) Model						
Current year (12 months)						
Exchange rate volatility	-0.254***	-0.160	-0.185**	-0.010	0.036	0.039
	(0.061)	(0.112)	(0.087)	(0.069)	(0.075)	(0.116)
Final goods exports	0.281***	0.605***	0.225***	0.308***	0.499***	0.336***
	(0.042)	(0.092)	(0.075)	(0.038)	(0.073)	(0.042)
Previous year and current year (24 months)						
Exchange rate volatility	-0.291***	-0.127	-0.270***	-0.041	0.035	0.073
	(0.064)	(0.127)	(0.098)	(0.077)	(0.080)	(0.119)
Final goods exports	0.412***	0.616***	0.219***	0.335***	0.499***	0.362***
	(0.055)	(0.092)	(0.076)	(0.058)	(0.073)	(0.046)
Previous two years and current year (36 months)						
Exchange rate volatility	-0.323***	-0.087	-0.344***	-0.074	0.013	0.101
	(0.066)	(0.138)	(0.100)	(0.084)	(0.083)	(0.122)
Final goods exports	0.404***	0.624***	0.146*	0.310***	0.498***	0.349***
	(0.055)	(0.094)	(0.083)	(0.050)	(0.074)	(0.041)
previous year, current year, next year (36 months)						
Exchange rate volatility	-0.331***	-0.251*	-0.295***	-0.056	0.060	0.057
	(0.068)	(0.143)	(0.108)	(0.086)	(0.088)	(0.135)
Final goods exports	0.259***	0.580***	0.206***	0.330***	0.501***	0.334***
	(0.042)	(0.093)	(0.077)	(0.060)	(0.074)	(0.042)
Time-varying exporter effects	yes	yes	yes	yes	yes	yes
Time-varying importer effects	yes	yes	yes	yes	yes	yes
Observations	989	989	989	989	989	989

Notes: Robust standard errors are in parentheses. ***, ** and * denote the significance at 1 percent, 5 percent and 10 percent level, respectively. The estimated coefficients of gravity variables are not reported, since results are very similar in all cases.

Table 6: Robustness Check by Sub-period: 2002-2008

Variables	*Industries*					
	General Machinery	Office Machinery	Electrical Machinery	Communication Equipment	Precision Instruments	Transport Equipment
Volatility Based on Standard deviation						
Current year (12 months)						
Exchange rate volatility	-0.232**	0.080	-0.284**	0.038	-0.055	0.217
	(0.098)	(0.231)	(0.119)	(0.108)	(0.133)	(0.180)
Final goods exports	0.479***	0.649***	0.317***	0.302***	0.527***	0.347***
	(0.056)	(0.118)	(0.060)	(0.036)	(0.098)	(0.040)
Previous year and current year (24 months)						
Exchange rate volatility	-0.260**	-0.078	-0.271**	0.019	-0.032	0.353
	(0.107)	(0.234)	(0.127)	(0.123)	(0.141)	(0.218)
Final goods exports	0.448***	0.656***	0.137	0.299***	0.567***	0.354***
	(0.056)	(0.089)	(0.119)	(0.034)	(0.093)	(0.041)
Previous two years and current year (36 months)						
Exchange rate volatility	-0.270**	-0.235	-0.268**	0.035	0.036	0.408*
	(0.108)	(0.236)	(0.122)	(0.124)	(0.154)	(0.215)
Final goods exports	0.447***	0.505***	0.121	0.301***	0.548***	0.354***
	(0.056)	(0.098)	(0.095)	(0.035)	(0.094)	(0.041)
previous year, current year, next year (36 months)						
Exchange rate volatility	-0.310***	-0.120	-0.295**	0.063	0.025	0.309
	(0.096)	(0.224)	(0.128)	(0.130)	(0.143)	(0.197)
Final goods exports	0.292***	0.509***	0.131	0.302***	0.572***	0.298***
	(0.043)	(0.085)	(0.120)	(0.035)	(0.096)	(0.045)
Volatility Based on GARCH(1,1) Model						
Current year (12 months)						
Exchange rate volatility	-0.361***	0.029	-0.204**	0.037	-0.014	0.077
	(0.085)	(0.129)	(0.100)	(0.078)	(0.104)	(0.177)
Final goods exports	0.437***	0.630***	0.227**	0.306***	0.540***	0.328***
	(0.056)	(0.096)	(0.089)	(0.038)	(0.093)	(0.045)
Previous year and current year (24 months)						
Exchange rate volatility	-0.373***	0.153	-0.269**	0.024	-0.029	0.191
	(0.101)	(0.153)	(0.112)	(0.088)	(0.118)	(0.163)
Final goods exports	0.401***	0.696***	0.306***	0.303***	0.538***	0.346***
	(0.055)	(0.091)	(0.069)	(0.040)	(0.093)	(0.041)
Previous two years and current year (36 months)						
Exchange rate volatility	-0.367***	0.231	-0.346***	0.020	-0.038	0.190
	(0.102)	(0.167)	(0.112)	(0.092)	(0.122)	(0.156)
Final goods exports	0.412***	0.512***	0.161*	0.305***	0.536***	0.331***
	(0.057)	(0.093)	(0.089)	(0.047)	(0.092)	(0.042)
previous year, current year, next year (36 months)						
Exchange rate volatility	-0.425***	0.087	-0.355***	-0.002	-0.019	0.132
	(0.094)	(0.175)	(0.124)	(0.100)	(0.127)	(0.167)
Final goods exports	0.259***	0.685***	0.109	0.302***	0.539***	0.327***
	(0.044)	(0.093)	(0.108)	(0.048)	(0.092)	(0.042)
Time-varying exporter effects	yes	yes	yes	yes	yes	yes
Time-varying importer effects	yes	yes	yes	yes	yes	yes
Observations	629	629	629	629	629	629

Notes: Robust standard errors are in parentheses. ***, ** and * denote the significance at 1 percent, 5 percent and 10 percent level, respectively. The estimated coefficients of gravity variables are not reported, since results are very similar in all cases.

1.5 Concluding Remarks

The international production and distribution network is well developed in Asia, which results in a remarkable expansion of intermediate goods trade characterized as a vertical intra-industry trade. Since finished goods produced in the network are exported to the markets throughout the world, the demand for final goods is likely to promote the intra-Asian trade of intermediate goods. Meanwhile, the intra-regional exchange rate volatility has increased substantially among Asian countries. The exchange rate volatility, by increasing uncertainty, reduces the locational benefits of cross-border fragmentation and is likely to increase the service link cost. Consequently, it may harm the intermediate goods trade or cross-border fragmentation.

In this paper we have empirically investigated the impact of exchange rate volatility on intermediate goods exports for general machinery, office machinery, electrical machinery, communication equipment, precision instruments and transport equipment in which the networks are qualitatively and quantitatively most important. Since the price elasticity is quite different across industries, we construct a new dataset of industry-specific real exchange rates and deflate the trade values by industry-breakdown producer price index.

It is found that, in contrast to the recent studies, the exchange rate impact on intra-regional trade differs across industries. The exchange rate volatility has negative and significant effect only on the general machinery industry and a part of the electric machinery industry with more differentiated products, even when taking into account the world's demand for the final processed exports. These findings are supported by various kinds of the exchange rate volatility in the short- and long-run. Our empirical results suggest that the different impact of the exchange rate volatility across industries has to do not only with the characteristics of traded goods in respective industries, but also with an increase in intra-firm trade where exchange rate risk is well managed by the parent company. Given that the growing cross-border fragmentation and processing trade are driven by intra-firm trade, the real exchange rate volatility will have weaker impact on regional trade of intermediate goods along the production chain. This evidence has important policy implications for the recent debate on possible regional exchange rate arrangements in Asia against the background of deepening economic integration.

Chapter 2: Industry-specific Real Effective Exchange Rates and Export Price Competitiveness: The Case of Japan, China and Korea

2.1 Introduction

It has been repeatedly pointed out that the nominal appreciation of the Japanese yen vis-à-vis the US dollar deteriorates export price competitiveness of Japanese firms. After the collapse of Lehman Brothers in September 2008, for instance, the yen appreciated sharply in nominal terms vis-à-vis all currencies, which resulted in a large decline of Japanese exports. The yen kept appreciating since then and stayed around 80 yen vis-à-vis the US dollar from July 2011, while the yen started to depreciate from the end of 2012. Exchange rates of the yen vis-à-vis Asian currencies need to be considered as well in analyzing Japanese exporter's price competitiveness. For example, the yen and the Korean won have moved in opposite directions vis-à-vis the US dollar for the last ten years. As the yen appreciated sharply in nominal terms vis-à-vis the won, Japanese firms were exposed to increasingly severe competition with Korean counterparts.

To consider the impact of exchange rate changes on export performance in the world market, however, it is not the bilateral exchange rate but the effective exchange rate that provides a better measurement of exporting firms' price competitiveness. The Bank for International Settlements (BIS) publishes effective exchange rates of 61 countries in both nominal and real terms. While covering a large number of countries, the BIS effective exchange rates do not provide any information on possible differences in price competitiveness across industries. Even if the nominal exchange rate is common to all industries in a country, the real exchange rate on both bilateral and effective basis can differ across industries. Each industry may face a different competitive environment from others, because the relative movements of the domestic industry-specific price to the corresponding foreign prices are likely to differ, with the result that some industries may lose and others may gain export price competitiveness in the country.

There have been a few studies that analyze the effective exchange rate at an industry level. Goldberg (2004), for example, constructs the US real effective exchange rates (REERs) by industry and demonstrates the effectiveness of industry-specific indices by analyzing the relationship between US producer profits and the industry-specific exchange rate indices. By making both aggregate and sector-specific exchange rate indices for the Portuguese economy, Alexandre, *et al*. (2009) find that the sector-specific exchange rates are more informative than aggregate exchange rates in explaining changes in domestic employment. But, these studies basically calculate the effective exchange rate by using the industry-specific trade share and fail to utilize the industry-specific price data for all trading partner countries, which results in an inaccurate calculation of REER by industry.[12]

The innovative feature of this paper is three folds. First, we construct the industry-specific real effective exchange rate (henceforth, I-REER) for Japan, China and Korea as a new measure of exporting firms' price competitiveness across industries. We have constructed a new data set of industry-specific producer price indices (PPIs) for twenty-seven countries with thirteen industry classifications from January 2001 to February 2013, which is a significant advance from the existing studies. In this paper, we present the monthly series of I-REER of the four selected industries (Metal, General Machinery, Electrical Machinery, and Transport Equipment) for Japan, China and Korea.[13] Moreover, we disaggregate the Electrical Machinery industry into three sub-sectors, Office Machinery, Electrical Apparatus and Communication Equipment, for further comparison of export price competitiveness between Japan and Korea.

Second, it is well known that Korean electronics firms such as Samsung and LG electronics became profitable, while Japanese firms such as Sharp and Panasonic worsened business performance. By conducting factor decomposition analysis of I-REER series, we demonstrate why Korean firms enjoy far better export performance than Japanese ones by investigating cost competitiveness. It is shown that a substantial fall of domestic PPIs during the won appreciation period has enhanced Korean firms' export competitiveness compared to the Japanese one especially in the electric machinery industry. In contrast, Japanese automobile firms do not lose export competitiveness with respect to the Korean counterparts, due to the relative decline of domestic production costs.

Third, we apply the structural vector autoregression (VAR) technique to the relationship between I-REER and export performance (real exports). By decomposing I-REER into domestic and foreign prices as well as the industry-specific nominal effective exchange rate (henceforth, I-NEER), we also conduct the 5-variable structural near-VAR analysis to reveal how real exports respond to various shocks. The results of

[12] Recently, Benkovskis and Wörz (2012) attempt to analyze the non-price factor of competitiveness by constructing industry-specific annual price data set from import unit-values at H.S. 6-digit level.
[13] We have so far published a daily series of I-REER for Japan, China and Korea from January 2005 on the website of the Research Institute of Economy, Trade and Industry (RIETI) (http://www.rieti.go.jp/users/eeri/en/index.html). See also Sato, *et al*. (2012) and (2013) for the daily series of I-REER of thirteen industries for Japan, China and Korea.

impulse response function analysis show that the relative cost reduction of Korean electronics firms as well as the nominal depreciation of the won has significant impact on real exports, which supports the conclusion of the factor decomposition analysis.

The remainder of this paper is organized as follows. Section 2 describes the method of constructing the I-REER and presents the monthly series of I-REER of selected industries for Japan, China and Korea. Section 3 discusses the export price competitiveness by investigating the relative price movements. Section 4 conducts a structural VAR analysis to show the relationship between I-REER and real exports. Finally, Section 5 concludes.

2.2 I-REER for Japan, China and Korea

2.2.1 Method of Calculation

To calculate the effective exchange rates, we use the following formula that is typically used in the literature:

$$EER_{it} = \prod_{j=1}^{n} \left(ER_{it}^{j} \right)^{\alpha_i^j}, \qquad (1)$$

where *EER* denotes the effective exchange rate; *ER* the bilateral nominal or real exchange rate of country *j*'s currency vis-à-vis the home currency; α_i^j the share of home country's exports of industry *i* to country *j* in the home country's total exports. If *ER* is the bilateral real (nominal) exchange rate, we construct the industry-specific real (nominal) effective exchange rates.

The novelty of this study is to construct a new data set of industry-breakdown PPI for twenty-seven countries from January 2001 to the present.[14] In calculating the effective exchange rates, we use this data set assuming one home country and twenty-six trading partner (export destination) countries.[15] The aggregate REER series

[14] In this paper, our sample period ranges from January 2001 to February 2013. The details of the new PPI data set are presented in Sato, *et al.* (2013). The twenty-seven countries include Japan, nine Asian countries (China, Korea, Indonesia, India, Malaysia, the Philippines, Singapore, Thailand and Taiwan), eleven European countries (Belgium, Ireland, Italy, France, Germany, Greece, Netherlands, Norway, Spain, Sweden and UK), Australia, Canada, Russia, South Africa, Turkey and the United States.

[15] Trade weight for each industry is calculated by dividing the export amounts to each destination by the total amount of exports to twenty-six destination countries. We use a three-year average of the trade share for calculation of I-REER to smooth out the annual change in trade share. See Sato, *et al.* (2013) for further details.

Table 7: Industry Classification and Industry Share

Industry Classification			Industry Share (percent)		
Code	ISIC	Industry Name	Japan	China	Korea
1	15-16	Food	0.6	2.4	1.1
2	17-19	Textile	1.2	**20.3**	3.8
3	20	Wood	0.0	0.8	0.0
4	21-22	Paper	0.6	0.9	0.9
5	23	Petroleum	0.1	0.4	0.3
6	24	Chemical	**11.3**	6.2	**13.1**
7	25	Rubber	3.7	3.0	2.6
8	26	Non-Metal	1.5	2.1	0.5
9	27-28	Metal	**10.2**	**10.3**	**11.2**
10	29	General Machinery	**17.5**	10.0	**10.0**
11	30-32	Electrical Machinery	**16.0**	**33.4**	**20.5**
12	33	Optical Instruments	6.0	4.1	8.9
13	34-35	Transport Equipment	**31.2**	6.0	**27.0**

Note: Industry classification is based on ISIC Revision 3. The details of industry classification are presented in Sato, *et al*. (2013). The share of each industry in Japan, China and Korea is calculated by dividing each industry's exports in total exports as of 2010. Bold figures painted in grey show that the share of an industry in question is 10 percent or more in all industries.

Source: Authors' calculation from the UN Comtrade Database.

published by BIS is constructed using consumer price index (CPI) as a domestic price index[16] However, it is better to use PPI to measure export competitiveness in terms of cost of production.[17] We calculate the I-REER for thirteen industries based on the 2-digit International Standard Industrial Classification (ISIC) Rev.3.[18] The details are presented in Table 7.

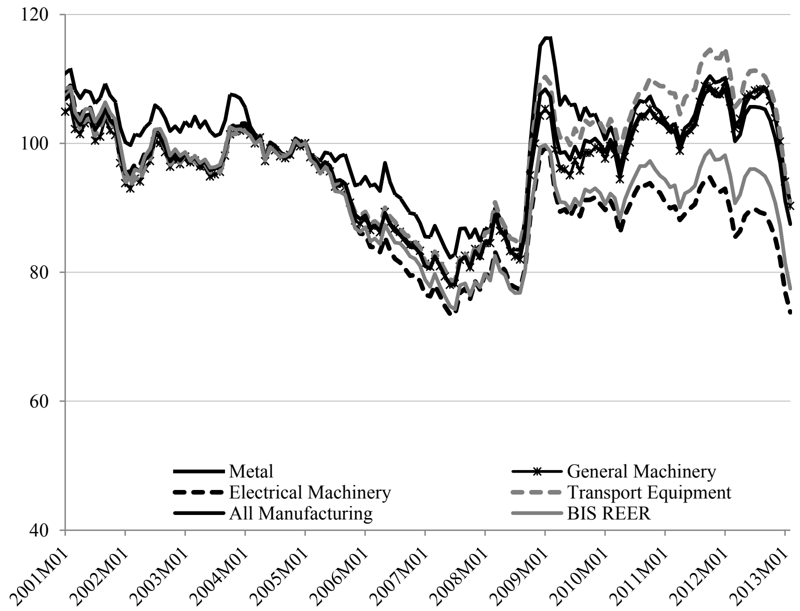
2.2.2 I-REER of Selected Industries

[16] International Monetary Fund (IMF) also publishes the REER based on unit labor cost (ULC), but the industry breakdown data on ULC based REER is not available.

[17] In constructing the PPI data set, we attempted to check whether Hedonic method is used in making the PPI series of each sample country to allow for the quality change of the products. Japanese PPI is constructed by using the Hedonic method, but it is very hard to collect information on whether the quality change is controlled in PPI of other countries. This issue is important in making an international comparison of competitiveness using the I-REER series, and we need to make further effort to obtain this information in our future research. We would like to thank referees for this insightful suggestion.

[18] We aggregate twenty-two ISIC manufacturing industries into thirteen industries. The availability of the data is reported in Sato, *et al*. (2013).

Figure 4: I-REER for Japan



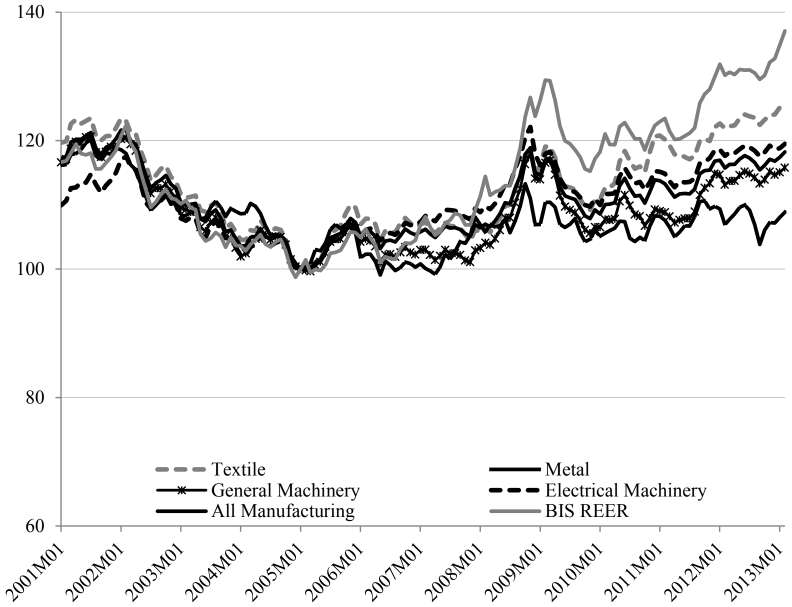
Note: Monthly series (2005=100) ranging from January 2001 to February 2013. By definition, an increase (decline) means appreciation (depreciation) of I-REER. "All Manufacturing" denotes the I-REER of all thirteen industries. "BIS REER" represents the BIS effective exchange rate indices (broad indices) comprising 61 economies.

Source: Authors' calculation and the BIS website (http://www.bis.org/statistics/eer/index.htm).

Figures 4 through 6 show the monthly series of I-REER for Japan, China and Korea, respectively, from January 2001 to February 2013, the base year of which is 2005.[19] For space limitation, we show I-REER of four selected industries, i.e., Metal, General Machinery, Electrical Machinery, and Transport Equipment, the choice of which is based on the industry share in each country (Table 7). Since the share of China's Transport Equipment is very small, we report I-REER of Textile for China instead of Transport Equipment. In addition to the four selected industries, we add two series of "aggregate" REER, i.e., "All Manufacturing" that stands for the weighted average of I-REERs of all thirteen industries and "BIS REER" that BIS publishes as the CPI-based broad indices comprising sixty-one economies, so that we can make a comparison between the BIS REER calculation and our I-REER approach.

[19] We tried different base years, for example, assuming 2001-year data is equal to 100. But, the conclusion to be discussed below will not change. As China renounced the US dollar peg policy in 2005, it is better to choose the year 2005 as the base year so that we can check the difference in I-REER movements between the US dollar-peg regime and more flexible exchange rate period.

Figure 5: I-REER for China

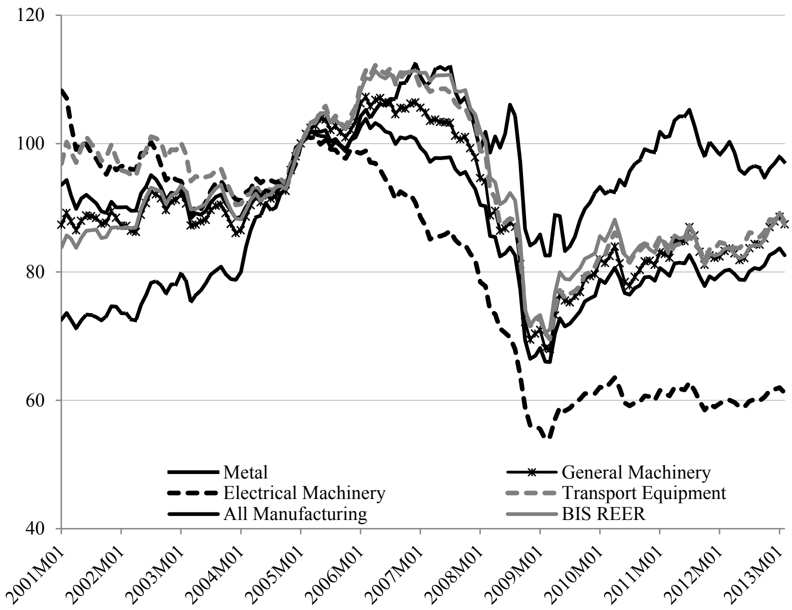


Note: See Figure 4.

Figure 4 shows the monthly series of I-REER for Japan from January 2001 to February 2013. First, there is a large difference in the level of I-REERs across industries. While the difference was small up to the early 2005, the extent of the difference started to widen after then and became much larger after the collapse of Lehman Brothers in September 2008. Such different movements of I-REERs cannot be captured by the BIS's aggregate REER series. Second, the Electrical Machinery I-REER stays at the lowest level after the sharp appreciation of the yen from September 2008, while the Transport Equipment I-REER fluctuates at the highest level. A direct interpretation of this result is that Japan's Electrical Machinery industry enjoys stronger price competitiveness than other industries like Transport Equipment. However, Japan's Electrical Machinery firms compete not with Transport Equipment firms but with foreign firms of the same industry. Thus, it is necessary to investigate I-REER for other countries such as Korea. Finally, the level of the BIS's aggregate REER is much lower than that of All Manufacturing I-REER, likely because BIS uses not PPI but CPI to calculate the REER series.

In Figure 5, the China's I-REER exhibits a clear upward trend from around 2005, likely because the Chinese government has started to adopt managed floating system since July 2005 and the Chinese renminbi has been gradually appreciating in nominal terms vis-à-vis the US dollar. In contrast, during the US dollar peg period from

Figure 6: I-REER for Korea

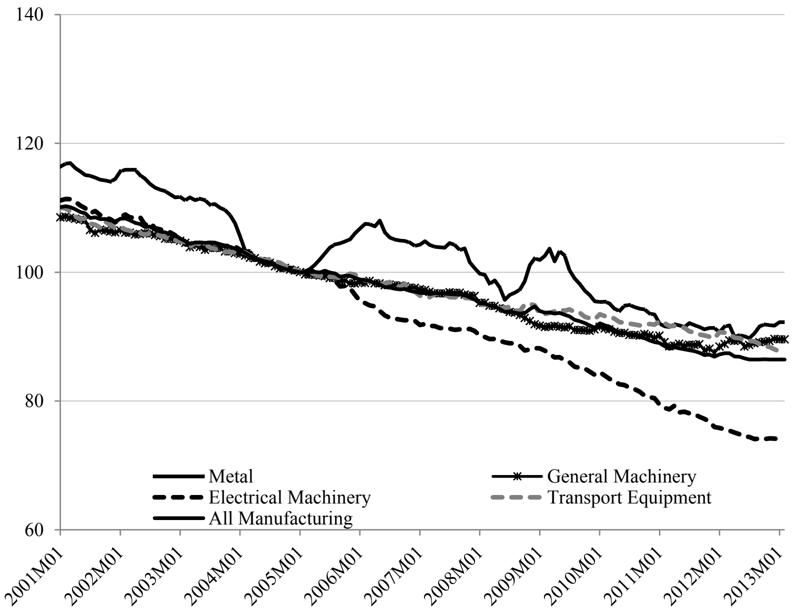


Note: See Figure 4.

2001 to 2005, the China's I-REER shows a downward trend. In addition, the difference in the level of I-REERs started to increase from around 2010. The Electrical Machinery I-REER in China fluctuates above the All Manufacturing I-REER, which differs from the corresponding relationship of I-REERs in Japan. It is interesting to note that China's BIS REER is far above the I-REERs and exhibits a sharp appreciation from the mid-2011. This is because the BIS REER is calculated based on CPI. Since CPI has broader coverage of domestic prices than PPI, the BIS REER tends to reflect a rise in domestic price inflation in China.

The Korea's I-REERs in Figure 6 show strikingly large swings over the sample period. First, most I-REERs started to depreciate from the late 2007 and substantially from September 2008. Second, only the Electrical Machinery I-REER started to depreciate much earlier, i.e., from 2006, while the nominal exchange rate of the won vis-à-vis the US dollar continued to appreciate from 2002 to the end of 2007. Moreover, the extent of depreciation is by far the largest in the Electrical Machinery I-REER. Third, after reaching the bottom in early 2009, Korea's I-REERs appreciated by 20 or so. But, it is only the Electrical Machinery I-REER that stays at around the same level as in early 2009. Such a marked difference in I-REER movements between Electrical Machinery and other industries clearly shows far stronger price competitiveness of the Electrical Machinery industry in Korea.

Figure 7: Relative Price Changes for Japan



Note: The relative price is defined as the domestic price relative to the weighted average of foreign prices in an industry in question.

Source: Authors' calculation.

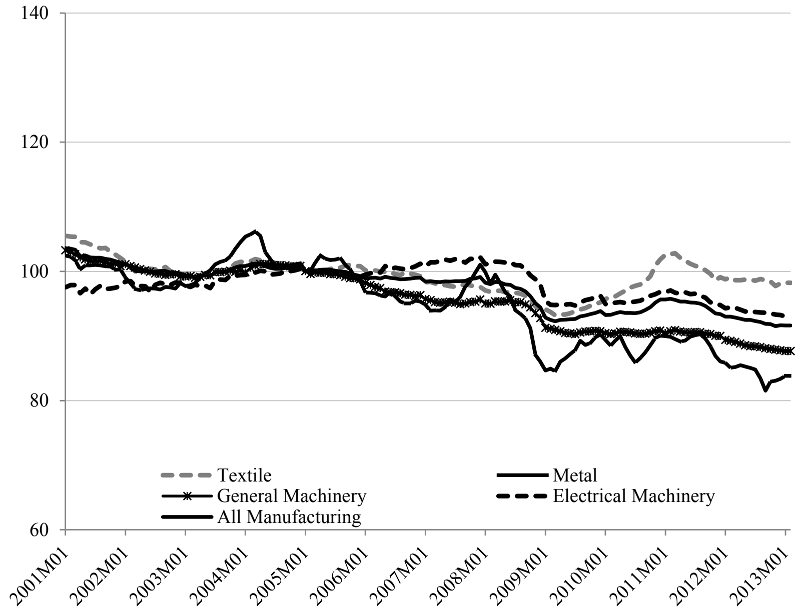
Comparison of the Electrical Machinery I-REER between Japan and Korea is particularly interesting. Japan's Electrical Machinery I-REER also started to show a larger decline than other I-REERs after a sharp increase from September 2008 to February 2009 (Figure 1). But, the degree of decline in I-REER is far smaller in Japan's Electrical Machinery than in the Korean counterpart. Moreover, although the Korean won started to appreciate in nominal terms vis-à-vis the US dollar from April 2009, the Korea's Electrical Machinery I-REER has not shown a clear upward movement since then. Even though the yen started to depreciate sharply in nominal terms from the end of 2012, the level of the Japan's Electrical Machinery I-REER is around 74 as of February 2013, which is much higher than that of the Korean counterpart (around 61). Still the level of Korea's I-REER is far lower than that of Japan.

2.3 I-REER and Export Competitiveness

2.3.1 Relative Price and Cost Competitiveness

We have so far observed the movements of I-REERs for Japan, China and

Figure 8: Relative Price Changes for China



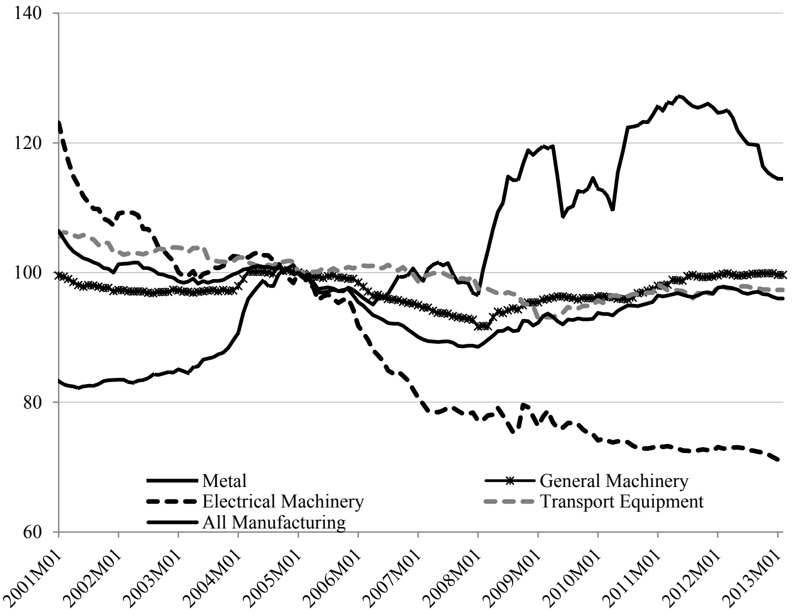
Note: See Figure 7.

Korea. The graphical analysis shows that even though the level of I-REERs varies across industries, the short-run changes of I-REERs are very similar in a country, which indicates that the short-run fluctuations of I-REERs are mainly driven by the common factor, i.e., the nominal exchange rate changes.

The impact of nominal exchange rate changes on export price and competitiveness is discussed in the literature on exchange rate pass-through and the choice of invoice currency. Specifically, exporting firms typically determine the degree of exchange rate pass-through and/or the choice of invoice currency in response to the nominal exchange rate changes. Exporting firms may choose to stabilize the export price in the importer's currency by squeezing profit margins, which is called pricing-to-market (PTM) in the literature. Sato, *et al*. (2013) shows that Korean export prices are almost stable in contract currency terms because US dollar invoicing is dominant in Korean trade, which results in large exchange gains of Korean exporters during the won depreciation period from September 2008 to the end of 2012. It is also revealed that Japanese export price is quite stable even though the yen appreciated substantially from September 2008, which suggests that Japanese firms took exchange losses and squeezed profit margins during the yen appreciation period.[20]

[20] See Parsons and Sato (2008), Ceglowski (2010), Yoshida (2010) and Shioji (2012) for the recent studies on exchange rate pass-through of Japanese trade. See also Ito, *et al*. (2012) for an empirical

Figure 9: Relative Price Changes for Korea



Note: See Figure 7.

This paper does not directly consider the exchange rate pass-through and the adjustment of profit margins in firms' export pricing. Rather, the I-REER provides us with information on export price competitiveness from a different aspect, i.e., the cost competitiveness. To advance our analysis of export price competitiveness, let us decompose the I-REER series into two components: I-NEER and the relative price. Equation (1) can be reformulated as:

$$\begin{aligned} REER_{it} &= \prod_{j=1}^{n}\left(RER_{it}^{j}\right)^{\alpha_{it}^{j}} = \prod_{j=1}^{n}\left(NER_{t}^{j}\cdot\left(\frac{P_{it}}{P_{it}^{j}}\right)\right)^{\alpha_{it}^{j}} \\ &= \prod_{j=1}^{n}\left(NER_{t}^{j}\right)^{\alpha_{it}^{j}}\cdot\prod_{j=1}^{n}\left(\frac{P_{it}}{P_{it}^{j}}\right)^{\alpha_{it}^{j}} = NEER_{it}\cdot RP_{it} \end{aligned} \quad (2)$$

where $REER_i$ denotes the I-REER of industry i; RER_i^j and NER_i^j the industry i's bilateral real and nominal exchange rate of the partner country j's currency vis-à-vis the domestic currency, respectively; P_i and P_i^j the domestic and foreign country j's price, respectively; α_i^j the weight of industry i's exports to country j; n the number of trading partner countries; and t the time period. $NEER_i$ stands for I-NEER; and RP_i the relative domestic price to the weighted average of foreign ones.

study of the choice of invoice currency in Japanese exports.

Figures 7 through 9 show the relative price movements obtained from I-REERs for Japan, China and Korea, respectively. In Figure 7, all relative prices exhibit a clear downward trend over the sample period, which indicates that Japanese PPI has declined substantially compared to the weighted average of foreign PPIs.[21] The degree of decline is the largest in the Electrical Machinery industry. China's relative price also shows a downward trend, but to a lesser extent than the case of Japan (Figure 8). Taking into account such movements of relative prices, the steady increase in China's I-REERs from 2005 to 2013 (Figure 5) can be ascribed to an appreciation of the China's I-NEER. The Korea's relative price movements are much more interesting, in that the relative price movement of Electrical Machinery is far different from that of other industries. In Figure 9, the relative price of all Korean industries except Electrical Machinery increased steadily from 2008, which corresponds to the won depreciation period starting from the mid-2008. In marked contrast, the relative price of Electrical Machinery fell sharply from 2005 to the early 2007 and continued to decline steadily even from 2008 to the present. Thus, the industry-specific price movements can explain the strong price competitiveness of Electrical Machinery in Korea and Japan.

In contrast, the relative price of the Korea's Transport Equipment industry increased from 2009, while the corresponding Japan's relative price kept declining over the sample period. It is well known that Korean automobile firms became a strong competitor for Japanese firms, increasing their market share in the United States especially during the nominal won depreciation period. Taking into consideration the relative price movements, however, the Korean automobile firms' export competitiveness is likely due to the won depreciation in nominal terms.

For an additional analysis of cost competitiveness, we investigate the unit labor cost (ULC) focusing on two major industries: Electrical Machinery and Transport Equipment (Figure 10).[22] We calculate annual series of Industry-specific ULCs from

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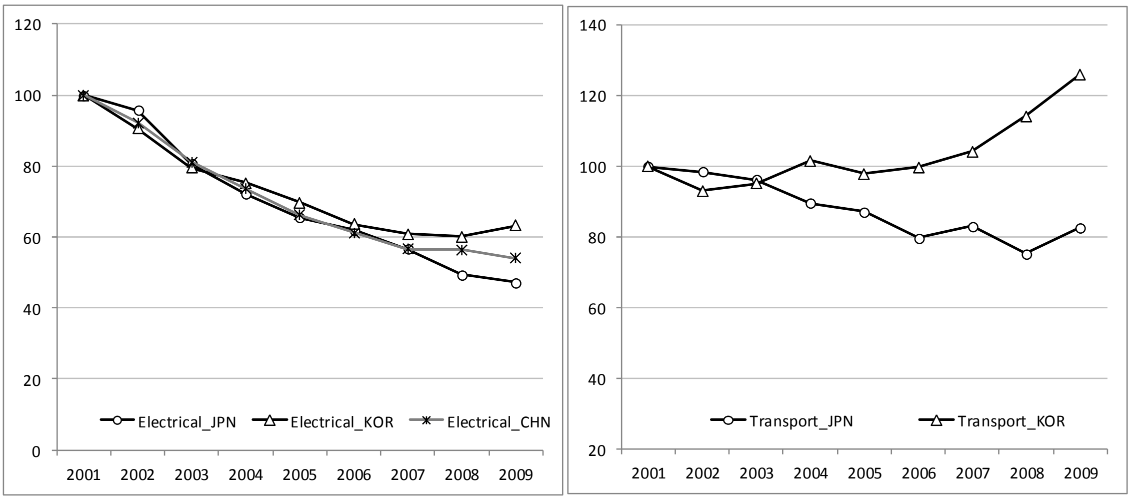
[21] It may be interesting to investigate whether Japanese firms' competitiveness is affected by an increase in the electricity prices caused by the 11 March 2011 Fukushima accident (see Koyama (2013) for the detailed discussion). We observed the movements of electricity price that is obtained from the corporate goods price index database published by the Bank of Japan (downloaded as of June 2, 2013 from: http://www.stat-search.boj.or.jp/index_en.html), and found that the electricity price kept rising from October 2009 to April 2013. However, as shown in Figure 4, Japanese relative prices exhibit a clear downward trend during the same period, which implies that the impact of the electricity price increase is relatively small.

[22] ULC is defined as a ratio of total labor compensation (in nominal terms) to real output. Ito and Shimizu (2013) calculate ULC for each industry using the data obtained from the World Input-Output Database (WIOD). We follow the Ito and Shimizu's (2013) calculation method and reproduce the ULC of Electrical Machinery and Transport Equipment in Figure 10.

Figure 10: Unit Labor Cost for Japan, China and Korea

(10a) Electrical Machinery (10b) Transport Equipment



Note: Annual data (2001=100) from 2001 to 2009 for Japan (JPN), China (CHN) and Korea (KOR). Unit labor cost (ULC) is calculated by the following formula:

$$ULC_t = \frac{w_t L_t}{Y_t} = \frac{w_t}{Y_t / L_t},$$

where w denotes the nominal labor compensation per worker; L the number of workers; Y real output; and t the time subscript.

Source: Authors' calculation. The data is taken from the World Input-Output Database (WIOD).

2001 to 2009 for Japan, China and Korea by using the World Input-Output Database (WIOD).[23] In the Electrical Machinery industry, ULC of all three countries exhibit a clear downward trend, indicating the improvement of cost competitiveness (Figure 10a). However, in the case of the Transport Equipment industry, Korea's ULC rises from 2006, while Japan's ULC keeps falling over the sample period, which implies that Korea's Transport Equipment industry may deteriorate its cost competitiveness (Figure 10b).

2.3.2 Simulation Analysis: Factor Decomposition of I-REER

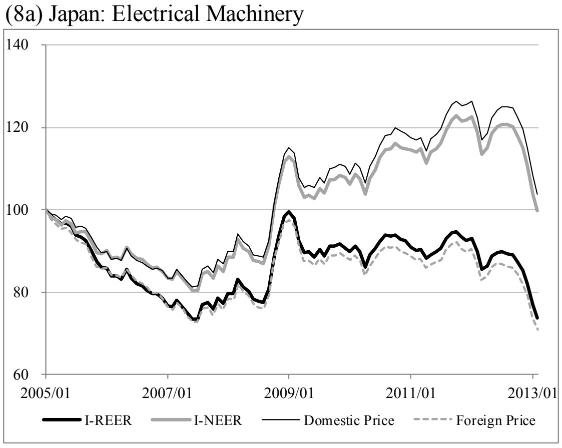
We have so far observed the relative price changes, but have not yet considered which price, domestic or foreign one, drives the changes in relative prices. To investigate the relative importance of prices, we conduct factor decomposition of

[23] Since the latest data provided by WIOD is 2009, we show the movements of UCLs from 2001 to 2009 in Figure 10.

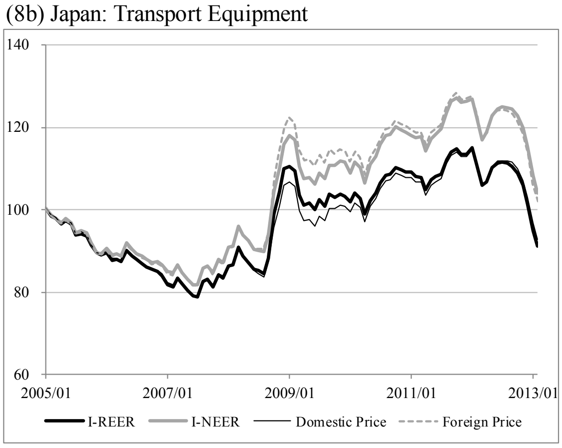
I-REER series by simulating the hypothetical I-REER series (henceforth, simulated I-REER) with an assumption that one of the price components of I-REER is constant at the initial observation in the series. If the component is an important factor, the simulated I-REER will show different movements from the actual I-REER. If the component is not important, the simulated I-REER will fluctuate very closely to the

Figure 11: Factor Decomposition of I-REER Fluctuations: Japan and Korea

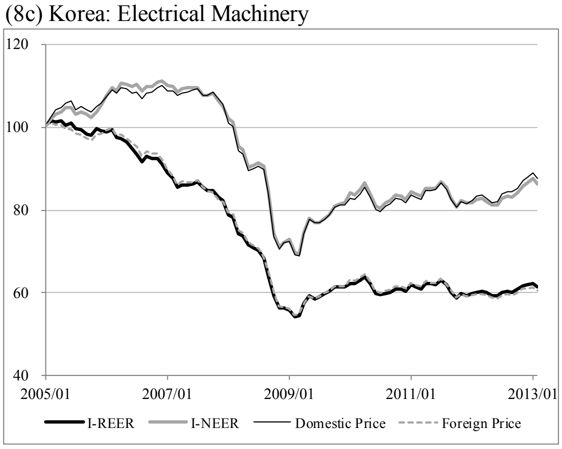
(8a) Japan: Electrical Machinery



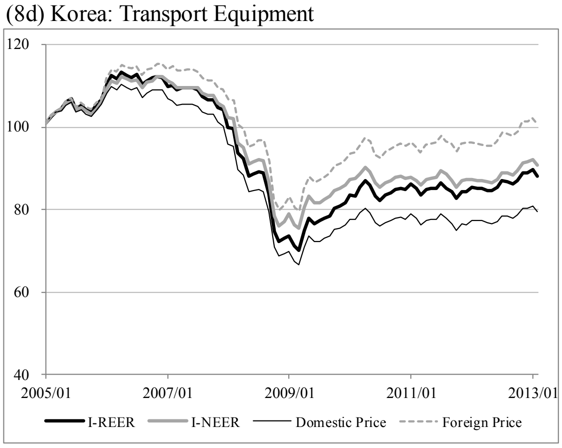
(8b) Japan: Transport Equipment



(8c) Korea: Electrical Machinery



(8d) Korea: Transport Equipment



Note: Results for two industries are presented. "I-REER" and "I-NEER" stands for the industry-specific REER and NEER, respectively. Other line graphs are simulated by the following assumption.

1. "Domestic_Price" represents the simulated I-REER if the domestic price (producer price) is assumed to be constant (i.e., 100) from January 2005 to February 2013.

2. "Foreign_Price represents the simulated I-REER if the weighted average of partner country's domestic price (producer price) is assumed to be constant (i.e., 100) from January 2005 to February 2013.

actual I-REER. For this simulation analysis, we use the following two components, i.e., domestic PPI and a weighted average of trading partner's PPIs, with a focus on Electrical Machinery and Transport Equipment industries. To highlight the recent changes of I-REERs, our simulation starts from January 2005 that is regarded as the base period.

Figure 11 presents the results of both I-REER and I-NEER, which provides us with useful information on the relative price changes at each industry. For instance, I-NEER is far above the I-REER in the Japanese Electrical Machinery industry with a gap widening between the two (Figure 11a). This result indicates that the Japanese relative price against foreign prices has been declining, which conforms to the finding of Japanese relative price changes in Figure 7. A question is which factor, domestic price or foreign (weighted average) price, has driven the relative price decline in Japanese Electrical Machinery industry. Figure 11a shows that the simulated I-REER with an assumption of constant domestic price is far above the actual I-REER, and even higher than the actual I-NEER, while the simulated I-REER with an assumption of constant foreign price is somewhat below the actual I-REER. This evidence indicates that the recent movements of the Electrical Machinery I-REER are mainly driven by the domestic price decline. While the I-NEER kept appreciating from the late 2008 to the end of 2012, the I-REER stayed around 90, likely due to the efforts of cost reduction by Japanese firms. From the end of 2012, both I-NEER and I-REER of Electrical Machinery depreciated sharply, suggesting that Japanese Electrical Machinery firms have rapidly improved their export price competitiveness in response to the nominal yen depreciation.

Korea's Electrical Machinery I-REER exhibits a remarkable decline (Figure 11c). The movement of the simulated I-REER with an assumption of constant domestic price is almost the same as that of I-NEER, and the gap between the simulated and actual I-REER started to widen substantially especially from 2006 when the won kept appreciating in nominal terms. As the actual I-REER is far lower than the simulated I-REER as well as I-NEER, we may say that Korean electrical machinery firms made considerable efforts to reduce the production costs during the won appreciation period.

Figure 11 also presents the factor decomposition results for the Transport Equipment industry. The Korea's actual I-REER of Transport Equipment exhibits an upward trend and the difference in level between I-REER and I-NEER of Transport Equipment is very small (Figure 11d). Moreover, the simulated I-REER with an assumption of constant domestic price is lower than the actual I-REER, which indicates that the Korean Transport Equipment industry has deteriorated export price competitiveness as the domestic production cost actually increased, which corresponds to the increase in ULC in Figure 10.

Turning to the Japanese Transport Equipment industry, I-NEER is higher in level than the actual I-REER, although the simulated I-REER with constant domestic price moves very closely to the actual I-REER (Figure 11b). On the other hand, the simulated I-REER with constant foreign prices is above the actual I-REER, especially after the sharp appreciation of the yen in nominal terms from September 2008. As shown in Figure 4, Japan's relative price declined, which is likely due to the increase in foreign production costs over the sample period. Taking into account the sharp fall of Japan's I-REER from the end of 2012, Japanese Transport Equipment firms have improved their export competitiveness against the Korean counterparts, due not only to the relative decline of domestic production costs but also to the nominal depreciation.

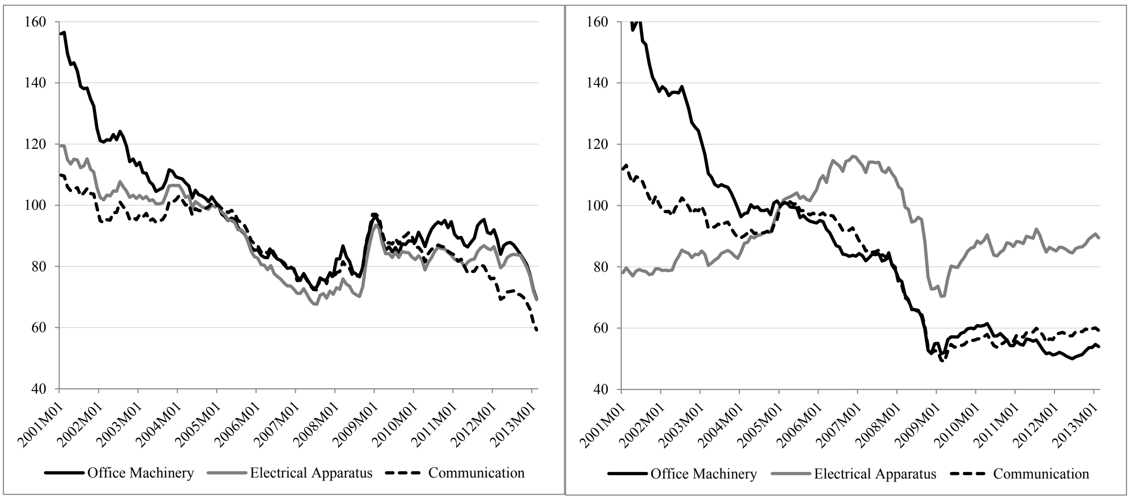
2.3.3 I-REER and Export Performance of Electrical Machinery Firms

The above factor decomposition analysis can explain why Korean electronics firms became far more profitable than Japanese firms. As shown in Figure 11c, Korean electronics firms started to reduce costs of production rapidly and substantially, even when the NEER of the won kept appreciating. At that time, Japanese electronics firms enjoyed depreciation of the yen both in nominal and real effective terms, and made a large plant and equipment investment. In 2007, for example, Sharp Corporation constructed the world's largest liquid crystal display (LCD) panel plant for the production of LCD TVs in Sakai, Osaka Prefecture. At that time, Japanese electronics firms pursued the business strategy of selling high value-added and high-priced TVs in the markets of advanced countries, although the world price of flat-screen TVs including LCD TVs continued to decline substantially. In contrast, Korean electronics firms, Samsung and LG electronics, succeeded in expanding market share in emerging economies by improving the cost competitiveness.

Figure 9 clearly shows that Korean electronics firms substantially reduce the production cost from the late 2005 to the early 2007, and Figure 6 also indicates that the export competitiveness in terms of I-REER improved much further from 2007 to 2008 thanks to a sharp nominal depreciation of the won. In Figure 12, we disaggregate the Electrical Machinery I-REER into three sub-sectors' I-REER. Communication Equipment includes flat-screen TVs, mobile devices, semiconductors and integrated circuits that are main products of Samsung and LG electronics. Korea's Communication

Figure 12: I-REER for Japan and Korea: Three Electrical Machinery Industries

(12a) Japan (2005=100) (12b) Korea (2005=100)



Note: Monthly series (2005=100) ranging from January 2001 to February 2013. Electrical Machinery is disaggregated into the following three sub-industries the classification of which is based on ISIC Revision 3. "Office Machinery" stands for "Manufacture of office, accounting and computing machinery" (ISIC code 30); "Electrical Apparatus" denotes "Manufacture of electrical machinery and apparatus n.e.c." (ISIC code 31); and "Communication Equipment" represents "Manufacture of radio, television and communication equipment and apparatus" (ISIC code 32).

Source: Authors' calculation.

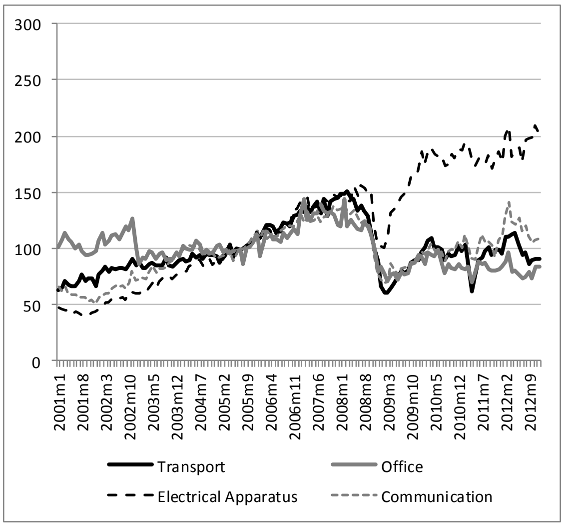
equipment I-REER in Figure 12b shows similar movements of Korea's Electrical Machinery I-REER in Figure 6.

In making a comparison of I-REER movements between Japan and Korea (Figure 12), it is clear that the level of I-REER is almost the same between Japanese electronics firms and Korean counterparts especially in the Communication Equipment industry. However, it is unlikely that Japanese firms did realize they were not in a better position than Korean counterparts. As shown in Figures 4 and 6, the BIS REER suggests that the won kept appreciating from 2005 to 2007, while the yen continued to depreciate during the same period. I-REER provides us with a better measurement of the industry-level export competitiveness.

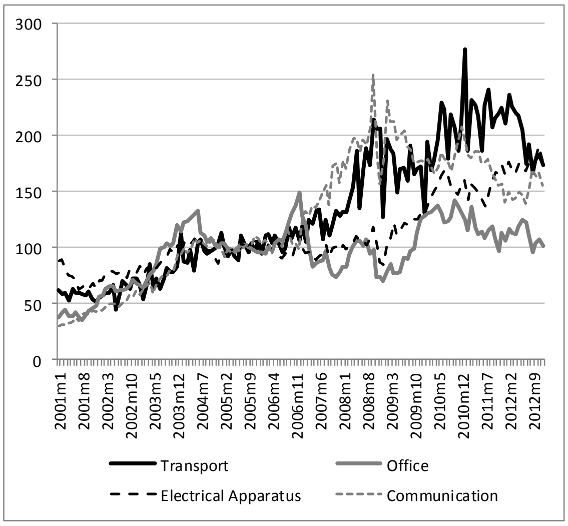
After the large plant and equipment investment, the global financial crisis happened in the wake of the Lehman Brothers collapse in September 2008. Japanese electronics firms suffered from excessive production capacity caused by shrinking demand of US and European markets as well as the sharp appreciation of the yen. The

Figure 13: Real Exports of Japan and Korea (2005=100)

(13a) Japan's Real Exports



(13b) Korea's Real Exports



Note: Real export index (2005=100). Monthly series from January 2001 to December 2012. Export amounts are deflated by industry-specific price data. See also the note of Figure 12.

Source: CEIC Database.

large plant investment was undoubtedly a misjudgment of the part of management.

Figure 13 presents the real exports of Transport Equipment and three Electrical Machinery industries in Japan and Korea. From September 2008, Japan's real exports fell sharply due to the global financial crisis as well as the sharp nominal appreciation of the yen. The level of real exports has not yet recovered to the pre-crisis level except for the Electrical Apparatus industry. In contrast, even after September 2008, Korea's real exports did not decline likely due not only to the reduction of production costs but also to the sharp nominal depreciation of the won. To empirically analyze this possible impact of these factors on real exports, we conduct structural VAR analysis in the next section.

2.4 VAR Analysis of I-REER and Exports

2.4.1 Empirical Strategy of VAR Analysis

This section empirically investigates how the changes in I-REER affect real exports of Japan and Korea focusing on Transport Equipment and three Electrical Machinery industries. To allow for possible lagged effects of I-REER on exports, we use a VAR model by including the following variables. First, we use the industry-breakdown data of real export index to examine the impact of I-REER. Second, we include the weighted average of trading partner country's industrial production index (IPI) by industry as a proxy for world outputs. Although the industry-specific IPI is not available for all sample countries, we calculate the weighted average IPI by industry using the industry-specific export share. Third, instead of including the I-REER variable, we decompose I-REER into three components: I-NEER, industry-specific domestic PPI, and the industry-specific foreign PPI (weighted average). These three variables are included in the VAR model to investigate which factor has more influences on the Japanese and Korean real exports by industry. All variables are in natural logarithm. In the case of world output, we use the cyclical component of IPI that is obtained by applying the Hodrick-Prescott filter to the IPI series.

In order to allow for the effects of above variables on real exports, we employ the following near-VAR model with block exogeneity:[24]

$$\sum_{s=0}^{p}\begin{bmatrix} A_{11}(s) & A_{12}(s) \\ A_{21}(s) & A_{22}(s) \end{bmatrix}\begin{bmatrix} y_{1,t-s} \\ y_{2,t-s} \end{bmatrix} = \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{bmatrix}, \qquad (4)$$

where $A_{12}(s) = 0$ for each s = 0, 1,…, p , $y_{1,t}$ is a vector of variables external to the domestic country, and $y_{2,t}$ is a vector of variables in the domestic country. A vector of structural shocks, $\varepsilon_t = [\varepsilon_{1,t} \quad \varepsilon_{2,t}]'$, is uncorrelated with past y_{t-s} for $s > 0$, and satisfies $E[\varepsilon_t \varepsilon_t' \mid y_{t-s}, s > 0] = I$ and $E[\varepsilon_t \mid y_{t-s}, s > 0] = 0$, where $\varepsilon_{1,t}$ is a vector of structural shocks of external origin and $\varepsilon_{2,t}$ is a vector of structural shocks of domestic origin. The model is formulated separately for each industry. We impose the block exogeneity restriction, $A_{12}(s) = 0$ for each s = 0, 1…p, which indicates that domestic shocks, $\varepsilon_{2,t}$, have neither contemporaneous nor lagged effects on the external variables, $y_{1,t}$.

[24] See Cushaman and Zha (1997), Zha (1999), and Maćkowiak (2007) for an analysis using the near-VAR model with block exogeneity.

A foreign block, $y_{1,t}$, includes two variables, namely the world real output (the weighted average of trading partner's IPI) and the world price (the weighted average of trading partner's PPI). In the foreign block, we impose the long-run zero restrictions, as in Blanchard and Quah (1989), where (i) only a shock to the first variable (i.e., world real output shock) affects the second variable (world price) in the long run; and (ii) both the world real output shock and a shock to the world price (i.e., world price shock) affect world inflation in the long run.

A country-specific block, $y_{2,t}$, includes three variables, namely the domestic price (PPI), I-NEER, and real export index. In the country-specific block, we impose the contemporaneous zero restrictions. The domestic price is contemporaneously affected only by a shock to the domestic price (i.e., the domestic price shock). Both the domestic price shock and a shock to I-NEER (i.e., NEER shock) affect I-NEER contemporaneously, but a shock to real export index (i.e., the export shock) does not affect domestic price and I-NEER contemporaneously. The real export index is contemporaneously affected by the all three shocks.

The SUR estimation is used with the above block exogeneity assumption to identify structural shocks by imposing both contemporaneous and long-run restrictions. Our near-VAR structure is just-identified by combining both short- and long-run restrictions as well as the block exogenous restrictions.[25] In this near-VAR estimation, the monthly series of data is used. The number of lag is chosen for the near-VAR system using AIC.[26]

It is necessary to check the time-series properties of each endogenous variable for the near-VAR estimation. Although not reported in this paper, the result of unit-root tests shows that the endogenous variables are not stationary in level, but stationary in first-differences, even in the case of the cyclical component of the IPI series. Thus, we took the first-difference of each log transformed variable for the SUR estimation of the near-VAR model to ensure the stationarity of variables.

2.4.2 Data

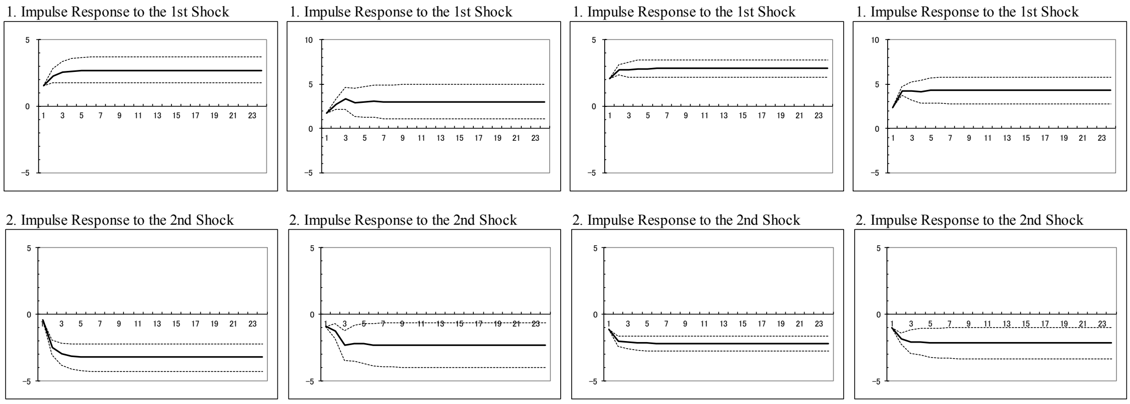
As a proxy for the world real output, we calculate the weighted average of industrial production index (IPI) of twenty-six trading partner countries for each

[25] The RATS 8.0 econometric software program is used for estimation.
[26] The lag order varies across industries ranging from one to four.

Figure 14: Impulse Responses of Japanese and Korean Exports to Structural Shocks

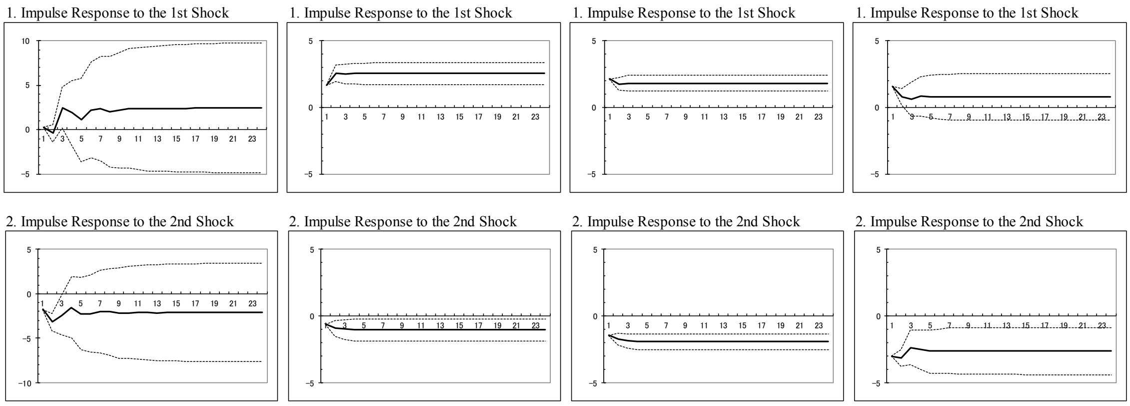
14a: Japanese Exports

(1) Transport Equip. (2) Office Machinery (3) Electrical Apparatus (4) Communication



14b: Korean Exports

(1) Transport Equip. (2) Office Machinery (3) Electrical Apparatus (4) Communication



Note: The results of impulse responses of real exports to each structural shock obtained from 3-variable near-VAR model are reported. The 1st shock represents the world output shock, and the 2nd shock the REER shock. For space limitation, the impulse response to the 3rd shock (export shock) is not reported. The thick line denotes the impulse response, and the dotted line stands for the percentile bands of the 16 per cent and 84 per cent fractiles.

industry. The monthly series of the industry-specific IPI is taken from CEIC Database and IMF, *International Financial Statistics*, CD-ROM. Since only the quarterly series of data is available for Australia, we assume that IPI is the same in three months of respective quarters. Real exports are obtained by dividing the export amounts by industry-specific price data. All data are monthly, expressed in natural logarithms. Seasonality is adjusted using the Census X12 method.

2.4.3 Empirical Results

As a preliminary investigation, we first conducted 3-variable near-VAR estimation including the world IPI, I-REER and real export index, where only the world IPI is included in the foreign block and assumed to be strictly exogenous. The remaining two variables are included in the country-specific block, where contemporaneous zero restriction is imposed assuming that I-REER is not contemporaneously affected by the export shock. The results of impulse response function analysis are presented in Figure 14. Due to space limitation, we report the impulse response of real export index to word output shock and REER shock only. The solid line indicates the impulse response, while the dotted line shows percentile bands of the 16 per cent and 84 per cent fractiles.[27] Figure 14 shows that the response of real export index is significantly negative to REER shock in all industries, while the response is significantly positive to world output shock, which indicates that I-REER can explain the industry-specific real export movements even if allowing for the world real output changes.

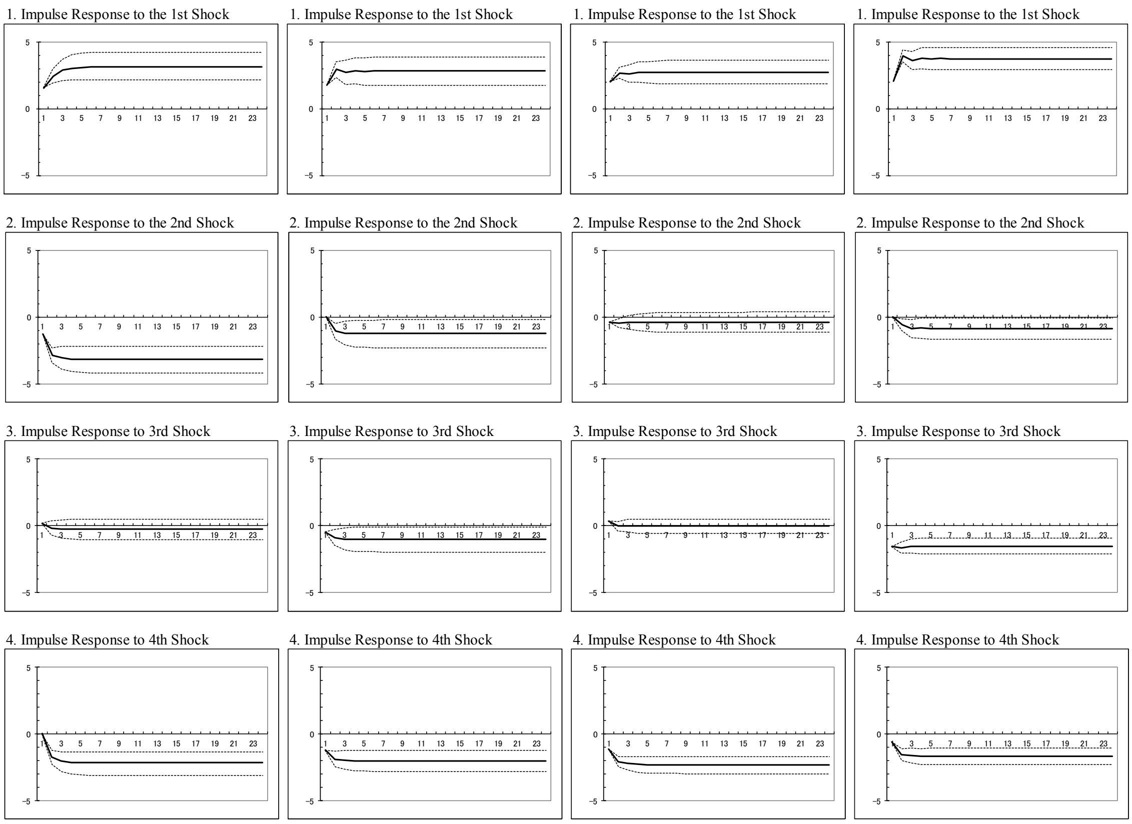
Figure 15 shows the results of 5-variable near-VAR estimation for Japan. First, the impulse response of real exports to NEER shock is significantly negative over the twenty-four month time horizons in Japanese Transport Equipment and three Electrical Machinery industries, suggesting that the nominal yen appreciation from September 2008 significantly affects real exports. Second, the response of real export index to world output is significantly positive over the twenty-four time horizons. Although world output variable is constructed by IPI that does not necessarily capture demand factors, it is shown that Japanese exports are affected by world demand. Third, the impulse response of real export index to two price variables is ambiguous. Only in Office Machinery and Communication Equipment, the response of real export index to domestic price changes is significantly negative. The response of real exports to foreign price changes is negative in most cases, which is contrary to what we expected. By taking into account the result of Figure 14, we may say that Japanese real exports are mainly driven by the nominal exchange rate changes as well as the world demand.

Figure 16 present the results of 5-variable near-VAR estimation for Korea. First, in Communication Equipment that is the major industry in Korea, impulse responses of real exports is significantly negative to NEER shock and domestic price shock, and significantly positive to foreign price shock and world output shock. In other

Figure 15: Impulse Responses of Japanese Exports to Structural Shocks

[27] This follows Sims and Zha (1999) and conducts the Monte Carlo integration of 2,500 replications.

(1) Transport Equip. (2) Office Machinery (3) Electrical Apparatus (4) Communication



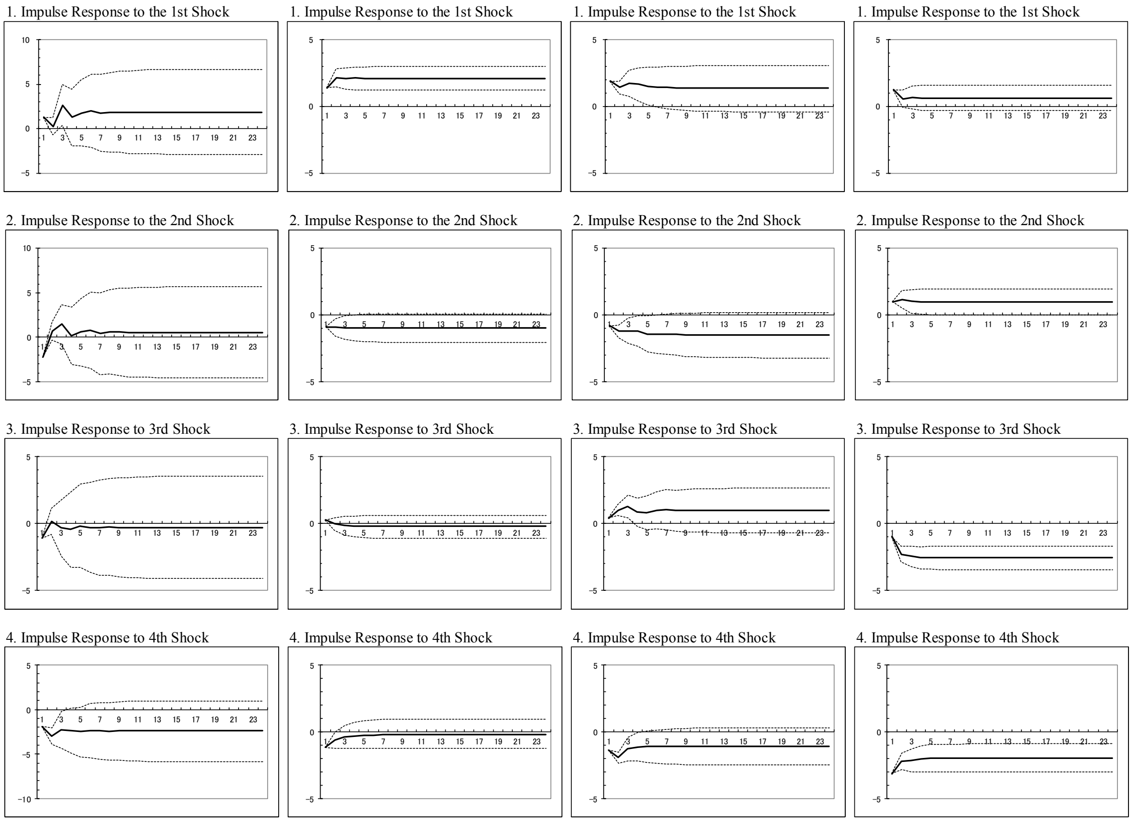
Note: The results of impulse responses of real exports to each structural shock obtained from 5-variable near VAR model are reported. The 1st shock represents the world output shock, the 2nd shock the foreign price shock, the 3rd shock the domestic price shock, and the 4th shock NEER shock. For space limitation, the impulse response to the 5th shock (export shock) is not reported. The thick line denotes the impulse response, and the dotted line stands for the percentile bands of the 16 per cent and 84 per cent fractiles.

Electrical Machinery and Transport Equipment industries, the impulse response of real export index to the world output changes is significantly positive at least for the first several periods, while the impulse response to NEER shock is significantly negative for the first few periods. Like the case of Japan, the impulse response of real export price to two prices is ambiguous.

Thus, the results of near-VAR estimation support the findings of the previous sections. Korean electronics firms categorized in Communication Equipment have enjoyed strong cost competitiveness, which is supported by the results of impulse response function analysis in Figure 16. The NEER changes also have significantly

Figure 16: Impulse Responses of Korean Exports to Structural Shocks

(1) Transport Equip. (2) Office Machinery (3) Electrical Apparatus (4) Communication



Note: See note of Figure 15.

negative impact on real exports, which suggests that the sharp nominal depreciation of the won improved the export performance. On the other hand, the exports of Japanese electronics firms are mainly driven by the world demand and the nominal exchange rate changes. While Japanese electronics firms have improved the cost competitiveness, the results of impulse response function analysis reveal that the impact of relative price decline is not very clear. Although there is room for further investigation, this result can explain the Korean electronics firms' stronger export competitiveness than the corresponding Japanese firms.

2.5 Concluding Remarks

The main contribution of this paper is to construct the new dataset of I-REER for Japan, China and Korea as a useful measure to consider the empirical importance of the exchange rate on the exporting firms' competitiveness and performance across industries. The monthly series of I-REER for selected four industries is presented with the sample period ranging from January 2001 to February 2013, which shows a large difference in a level of I-REER not only between three countries but also across industries. By conducting simulation analysis and structural VAR estimation, we have found that Korean electronics firms substantially improved cost competitiveness by lowering the production cost during the won appreciation period, while Japanese electronics firms' large plant investment caused by misjudgment of the management led to excessive production capacity, which resulted in the deterioration of Japanese export competitiveness.

Our empirical results provide us with the following implications. First, it is useful for exporting firms to monitor I-REER in comparison with competitor's I-REER changes. Aggregate REER will not give us any information on industry difference of export price competitiveness. Second, our empirical results clearly show that the nominal exchange rate changes have significant influences on export performance and competitiveness. The prolonged nominal appreciation of the yen have seriously negative impact on export performance and even firms' business performance, especially when foreign competitors enjoy the nominal depreciation of their currency. Third, it may be necessary to stabilize the regional exchange rate volatility to avoid regional trade imbalances. The yen and won moved in an opposite direction after the Lehman Brothers collapse in September 2008, which caused large difference in export competitiveness. Since exchange rate appreciation has negative impact on export performance, regional exchange rate stability will help to prevent beggar-thy-neighbor policy and facilitate further intra-regional trade.

Our new data set of I-REER is constructed based on the conventional REER formula. However, recent studies such as Klau and Fung (2006) propose to take into account the third market effect to calculate REER indices. It will be necessary to develop the method of constructing I-REER for future research.

Chapter 3: Industry-specific Exchange Rate Fluctuations, Japanese Exports and Financial Constraints: Evidence from Panel VAR Analysis

3.1 Introduction

Financial constraints can play a non-trivial role in firms' export performance, but there have been only a few studies that investigate how financial constraints affect the impact of exchange rate fluctuations on exports.[28] Dekle and Ryoo (2002) build a theoretical model and present empirical results by using the Japanese firm-level data from 1982 to 1997. Given inadequate data on financial constraints, they conduct two empirical schemes to investigate the role of that on exchange rate elasticities of exports. Firstly, they compare the export elasticities of *non-keiretsu* firms with *Keiretsu* firms which can be characterized as less financial constraints due to the stronge relationships with banks. Then, they compare the actual export elasticities with the hypothetical export elasticities under the assumption that the firm hedges completely.[29] They find that *keiretsu* firms are less responsive to exchange rate fluctuations than non-*keiretsu* firms and the hypothetical elasticites are much lower than the actual elasticities for most industries, which suggest that firms or industries that are less financially constrained tend to have lower exchange rate elasticities of exports. Strasser (2013) empirically investigates the role of financial constraints on the firm's export and pricing behavior by using the German firm-level survey data for the period from January 2003 to August 2010. It is found that the degree of exchange rate pass-through for financially constrained firms is almost twice as high as that for unconstrained firms. Moreover, the export volume of firms with financial constraints is about twice as sensitive to exchange rate fluctuations as that of firms without financial constraints. Although interesting findings, these studies basically focus on the banks' lending attitude that is characterized as external financial constraints. In the context of Japanese exporting firms, however, it is more important to take into account internal constraints as well as external constraints.

Figure 17 shows how the two types of financial constraints have changed from 2001 to 2013: one is the lending attitude of Japanese financial institutions (a measure of external financial constraints) and the other is the liquidity ratio of Japanese firms (a

[28] See, Amiti and Weinstein (2011), Manova(2012) among others.

[29] On their theoretical work, they assume that firms can offset the impact of the external financial constraints by hedging. One prediction of their model is that *firms or industries with extensive hedging will tend to have a smaller impact of the exchange rate on exports, than firms or industries with little hedging.*

measure of internal financial constraints). In Japan, the lending attitude exhibits large fluctuations from 2002 to 2003 and from 2009 to 2010 when Japanese firms faced severe external financial constraints. During the same period, the liquidity ratio was very high, which indicates that Japanese firms on average had ample internal funds. The degree of both external and internal financial constraints may differ across industries (Appendix Figure 24). Thus, it is interesting to examine how and to what extent financial constraints influence the response of Japanese exports to exchange rate shock and whether the response varies over the level of financial constraints.

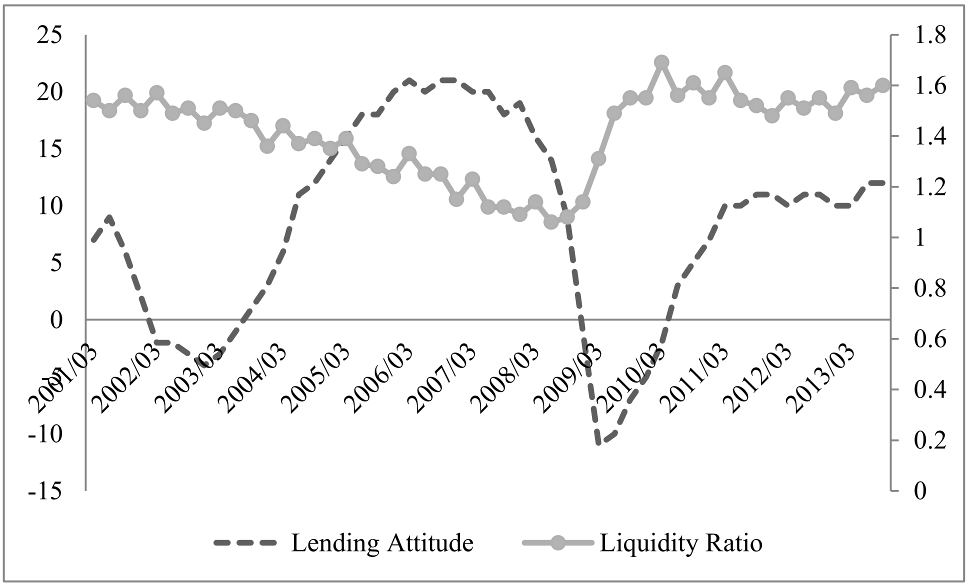
This paper differs from the existing studies in three respects. First, in contrast to the previous studies, the effect of both external and internal financial constraints is empirically investigated for the first time. By fully utilizing the financial data from Bank of Japan, *Tankan* (*Short-Term Economic Survey of Enterprises in Japan*) *Database*, the effect of external financial constraints and internal financial constraints on the relationship between exchange rate fluctuations and Japanese exports are separately and jointly estimated to compare the difference in the response of Japanese exports to exchange rate shock across different level of financial constraints. Second, it takes a different approach by focusing on the difference in the short-run effect of exchange rate shock on exports when exporters facing different level of financial constraints both internally and externally, while the existing studies investigate to what extent the financial constraints can affect the impact of exchange rate fluctuation on exports (Dekle and Ryoo, 2007; Stress, 2013). Third, the industry-specific real effective exchange rate of the yen developed by Sato et al. (2012) is employed to take account of the heterogeneity in exchange rate movements across industries as shown in Figure 2. As pointed out by Byrne et al. (2008), the estimates from sectoral studies may be biased by using aggregated exchange rate. It is industry-specific exchange rate which can eliminate this bias.

Following the approach in Loayza and Raddatz (2007) and Towbin and Weber (2013), the present paper estimates a Panel VAR and augments it with interaction terms that allow the VAR coefficients to vary with financial constraints (internal and external). This technique enables us to directly analyze how the responses of exports to exchange rate shocks vary with internal financial constraints and external financial constraints. While the literature typically uses interaction terms in single equation regression, only a few studies employ interaction terms in a VAR model. The use of interaction terms in Panel VARs is a simple way to allow for deterministically varying coefficients across time and industries.

There are three main findings in this paper: firstly, Japanese exports negatively and significantly respond to exchange rate shock. Second, financial constraints (internal financial constraints and external financial constraints) have significant influences on Japanese exports in response to the exchange rate changes. Japanese exporters with either lower internal or external financial constraints are less affected by exchange rate shocks. Third, lowering external financial constraints can help exporters with relatively higher internal financial constraints less affected by exchange rate shocks. This result suggests that accommodative financial environment can help Japanese exporters alleviate the impact of yen appreciation on their exports, when they are facing some difficulties to finance internally.

The rest of the paper is organized as follows: Section 2 surveys theoretical mechanisms underlying my approach. Section 3 provides the data description. Section 4 explains the estimation methodology. Section 5 discusses the main results, and section 6 concludes.

Figure 17: Lending Attitude of Financial Institution and Liquidity Ratio for All Manufacturing Sector



Source: Bank of Japan, Tankan (Short-Term Economic Survey of Enterprises in Japan), 2001Q1-2013Q3.

3.2 Exchange Rate Fluctuations, Financial Constraints and Exports

After the collapse of the Bretton Woods agreements, the exchange rate fluctuation has been a central concern for policymakers and academic circles. However,

Table 8 Correlations between Changes in Exchange Rate and Current Profits

Industry	Description	Nominal Effective Exchange Rate	Real Effective Exchange rate
All	Including From Industry 1 to Industry 13	-0.227	-0.233
1	Food, Beverage, Tobacco	-0.030	-0.022
2	Textiles, Textile Products, Leather and Footwear	-0.162	-0.222
3	Wood Products(excl. furniture)	-0.260	-0.006
4	Paper, Paper Products, Printing and Publishing	-0.135	-0.202
5	Coke, Refined Petroleum Products, Nuclear Fuel	0.017	-0.134
6	Chemicals and Chemical Products	-0.247	-0.337
8	Non-metallic Mineral Products	-0.419	-0.390
9	Basic Metals and Fabricated Metal Products	-0.291	-0.418
10	Machinery and Equipment n.e.c.	-0.364	-0.359
11	Electrical Industry	-0.344	-0.324
12	Optical Instruments	0.088	0.074
13	Transport Equipment	-0.268	-0.289

Note: All variables entered in the first difference of log terms. Current profit is half yearly data from *Tankan Database*, Bank of Japan. (2001h1-2013h1)

there is no consensus on the impact exchange rate fluctuations may have on exports, though a large number of academic literature emergence regarding this issue. The traditional view of the impact the exchange rate fluctuation may have on exports is that a change in exchange rate fluctuations may affect the relative price between domestic and foreign price, which results in expenditures shift between domestic and foreign goods (Obstfeld, 2002). Thus, appreciation in exchange rate may reduce exports by increasing the price of export goods faced by consumers in the export market. However, as shown in Figure 25, despite large fluctuations in the nominal effective exchange rate of the yen, the export price index in contract currency basis is quite stable, which suggests that Japanese export firms tend to stabilize the export price in the local currency.[30] In other words, Japanese exporters pursue the pricing to market behavior. Given such incomplete exchange rate pass-through, Japanese exports might not be affected by exchange rate fluctuations.[31]

Then, how can financial constraints affect the relationship between exchange rate fluctuations and exports, when the incomplete exchange rate pass-through exists? One mechanism can think of that exchange rate movements may create fluctuations in profits of exporters, which may lead to a fluctuation in working capital. For example, following an appreciation of the Japanese Yen, Japanese exporters don’t completely pass through the exchange rate change to the price of export goods probably because of competitive pressure from the export market. Even through tthe price of export products

[30] This pricing behavior is empirically investigated by Shimizu and Sato (2015).

[31] Existing studies have mainly explored three channels leading to incomplete pass-through, that is, pricing to market (Dornbusch, 1987; Atkeson and Burstein, 2008), local currency pricing (Engel, 2003) and Local distribution margin (Campa and Goldberg, 2010).

faced by the consumers in export market will not change the appreciation can still cause the current earnings of the exporter decline. Because the price of export goods denominated in the Yen decreased though the export demand may not change duo to the inflexible price, certeris paribus. As shown in Table 8, most of the industries have a negative correlation between the changes in exchange rate and current profits, which supports the expectation. If exporters are financially constrained either internally or externally, in other words, they face difficulties to finance internally or borrow from external financial markets to produce export goods, the reduction in current earnings will cause working capital decrease. Consequently, exporters are likely to be unable to produce more just due to the reduction in working capital. Therefore, easing firms' access to external finance should alleviate the impact of exchange rate on exports. This mechanism is empirically and theoretically examined by Dekle and Ryoo (2007). In the paper, they build a simultaneous structural model with external financing costs and estimate the model by using Japanese firm-level. They report that less financially constrained firms tend to have lower exchange rate elasticity of exports. This mechanism is also rationalized by Aghion et al. (2009). They assume that the borrowing ability of firms is proportional to their current earnings, with a higher multiplier implying a better developed financial market in the economy. When the export price is inflexible, firms' current earnings denominated in domestic currency will reduce following an exchange rate appreciation. This will reduce their ability to borrow in order to survive idiosyncratic liquidity shock and thereby innovate in longer term. Therefore, relaxing external financial constraints can weaken the negative effect of an appreciation on their excess to external finance and thereby exports.

3.3 Data Description

The data used in this paper is Japanese industry-breakdown quarterly data from 2001 quarter 1 to 2013 quarter 4. The industry classification is following *International Standard Industry Classification Revision 3* (*ISIC, Rev.3*) and then 21 2digit maufacturing sectors are aggregated into 13 industries as that in Sato *et al.* (2013). The selection of industries is limited by exchange rate data. See the Table 11 in Appendix.

The data used to measure the financial constraints is from *Tankan* (*Short-Term Economic Survey of Enterprises in Japan*), which is widely used in Japan.[32] *Tankan* database is a statistical survey by the Bank of Japan, which is performed to provide an accurate picture of business trends of enterprises in Japan. The survey is carried out

[32] The detail of the Tankan statistic: https://www.boj.or.jp/en/statistics/outline/exp/tk/extk03.htm/#p01

quarterly in March, June, September, and December. Sample enterprises are selected from a population (approximately 210 thousand private enterprises excluding financial institutions) based on the Ministry of Internal Affairs and Communications' "Establishment and Enterprise Census of Japan" (conducted in October 2006) with at least 20 million yen in capital. Manufacturing and nonmanufacturing are split into 17 and 14 categories, respectively. Since *Tankan* database does not provide financial data for rubber and plastics industry, it will be excluded in the analysis. This paper only focuses on manufacturing sector and 17 categories are aggregated into 13 industries as described above.

The proxy for internal financial constraints is the ratio of liquidity, which is defined as the ratio of quarter-end balance of cash, deposits, and securities listed as liquid assets to monthly average sales during the fiscal year. The higher value means the more internal finance the firm can access, which can be characterized as lower internal finance constraints. Then, the external financial constraints is measured by the lending attitude of financial institutions, which is a diffusion index from "Judgment Survey". In the survey, the responding enterprises are asked to choose one from three answers: 1) Accommodative, 2) Not so severe, 3) Severe, to descripte the lending attitude of financial institutions towards them. Then these responses are conducted into Diffusion Index (DI) by industry as follows:

DI (percent points) = Percentage share of enterprises responding Answer One minus Percentage share of enterprises responding Answer Three.

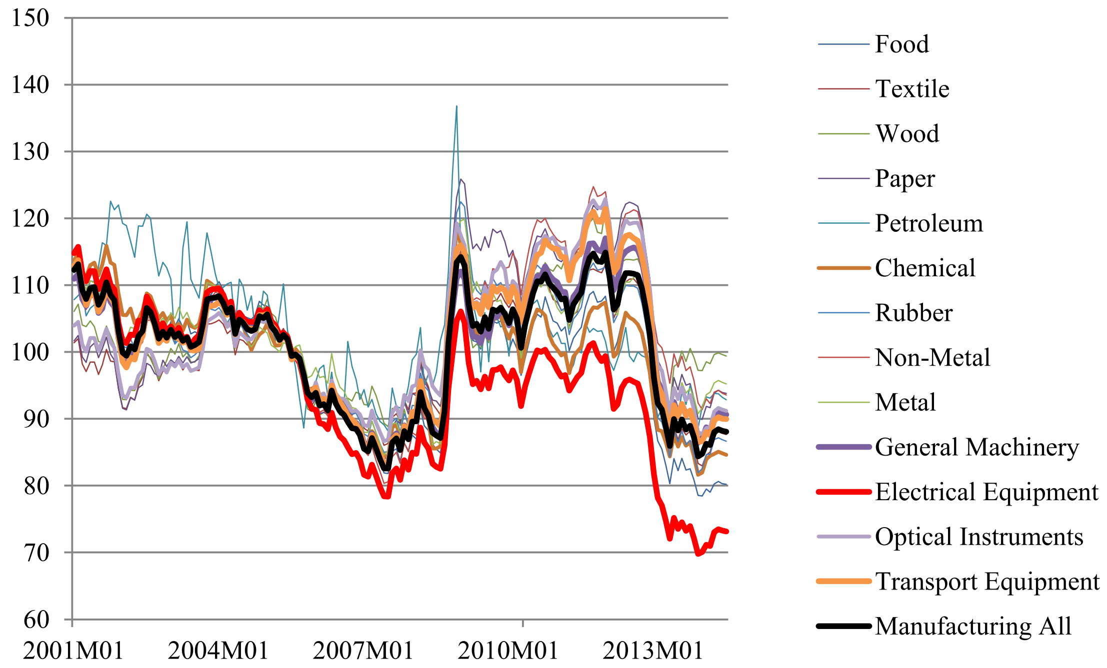
Therefore, this is a direct measurement of external financial constraints, the higher value of which means the more accommodative lending attitude of financial institution in Japan which can be characterized as lower external financial constraints. As shown in Figure 24 in Appendix, there is a big difference in the movements of the liquidity ratio and the lending attitude of financial institutions across industries. These sectoral variations can be exploited to identify the effect of the exchange rate on Japanese export for different levels of financial constraints both internally and externally.

As for exchange rate data, this paper use the industry-specific real effective exchange rate of the yen developed by Sato et al. (2012), which captures the difference in exchange rate fluctuations across industries. An increase in the exchange rate means appreciation. As showed in Figure 18, the most striking feature is the large difference in the level of I-REER across industries especially after the sharp appreciation in the Lehman Brothers collapse in September 2008. If we ignore this heterogeneity in the movements across industries by using aggregated REER which is widely used by the existing studies, the results will be biased as suggested by Byrne et al. (2008).

The world real income is proxied by the trade-weighted average of the partners' real GDP for each industry. Following Sato *et al.* (2013), 28 trading partners of Japan are included in the calculation as showed in Table A2 in the appendix. The GDP data is obtained from *International Financial Statistics (IFS)-IMF*. The export data used to calculate the industry-breakdown export weight of each partner is from *STAN Bilateral Trade in Goods by Industry and End-use (BTDIxE), ISIC Rev.3, OECD*.

The Japanese export data is from *Trade Statistics of Japan Ministry of Finance*, which is monthly data based on 9 digit HS classification.. Then, the export data is converted into ISIC rev.3 2 digit industries by using the concordance code from *World Integrated Trade Solution* (*WITS*) and further transformed into quarterly data of 13 industries.

Figure 18: Industry-specific Real Effective Exchange Rate in Japan



Source: Research Institute of Economy, Trade & Industry, IAA (RIETI), January 2001 to July 2014.

3.4 Empirical methodology

3.4.1 Model

Several authors (Stress, 2013; Dekle and Ryoo, 2007) have argued that there is a negative relationship between financial constraints and the response of exporters to exchange rate shock. However, most of these studies focus on to what extent the financial constraints can affect the impact of exchange rate fluctuation on exports. By contrast, this paper tries to investigate the short run effect of exchange rate shock at a different level of financial constraints. In addition, different from existing studies, this paper focuses not only on the external financial constraints but also on internal financial constraints. The joint effect of the two types of constraints on the response of Japanese exports to exchange rate shock is empirically investigated for the first time.[33]

This paper employs a structural Panel Vector Auto-regression (Panel-VAR) model augmented by adding interaction terms with financial constraints. The standard Panel VAR is as following:

$$A_0 Y_{i,t} = \sum_{l=1}^{q} A_l Y_{i,t-l} + \lambda D_i + e_{i,t} \ , \qquad (1)$$

where i denotes industry, and t represents time, and q stands for the number of lags. $Y_{i,t}$ is a vector that contains three variables: The weighted average of trading partner's GDPs comes first as a proxy for world real income (external variable), and Japanese export volumes (real export) and I-REER are included as the second and the third variables, respectively. D_i is industry-specific effects. In order to allow the coefficients to vary with the level of both internal and external financial constraints, the interaction terms with financial variables (F_{it}) including both internal and external financial constraints are added into the Panel-VAR model:

$$A_0 Y_{i,t} + B_0 F_{i,t} * Y_{i,t} = \sum_{l=1}^{q} A_l Y_{i,t-l} + \sum_{l=1}^{q} B_l F_{i.t} * Y_{i,t-l} + \gamma F_{i,t} + \lambda D_i + v_{i,t} \ , \qquad (2)$$

which can be rewritten into a more compact form:

---

[33] The financial constraints defined in existing papers can be characterized as external financial constraints. For example, the financial constraints variable defined in Strasser (2013) is a judgment of credit provided by banks with three answers "accommodating", "neutral", and "restrictive", which is quite similar as the proxy for external financial constraints in this paper.

$$\Phi_{i,t,0}Y_{i,t} = \sum_{l=1}^{q}\Phi_{i,t,l}Y_{i,t-l} + \Gamma X_{i,t} + \varepsilon_{i,t}\,, \qquad (3)$$

where $X_{i,t}$ is a vector of industry-specific effect (D_i) and single terms of financial variables (F_{it}), which contains internal financial constraints (InF_{it}), external financial constraints (ExF_{it}) and interaction terms of internal and external financial constraints ($InF_{it} * ExF_{it}$). The matrices $\Phi_{i,t,g}$ ($g = 0,1,\ldots q$) with time *t* and industry subscript *i* contain time varying coefficients defined as $\phi_{i,t,g}^{jk}$, which are combinations of A_g and $B_g F_{i,t}$, $g = 0,1,\ldots q$. Thus, each of these coefficients is a function of financial constraints for different lags including contemporaneous. $\varepsilon_{i,t}$'s are the structural errors, which are i.i.d. with zero means and a diagonal variance-covariance matrix Σ.

The identification assumption used in the paper is a combination of strict exogenous and contemporaneous zero restrictions. First, the world real income is restricted to be exogenous with respect to two domestic variables, Japanese export volume and I-REER. Therefore, the domestic shocks have neither contemporaneous nor lagged effects on the world real income. Second, the contemporaneous zero restrictions are imposed on two domestic variables: export volume cannot be contemporaneously affected by a shock of I-REER, but the I-REER can be contemporaneously affected by export volume. This assumption is motivated by the fact proposed in Clark *et al.* (2004) that exporters are unlikely to response immediately to exchange rate changes but will rather take a "wait and see" approach. These assumptions are equivalent to imposing the following structures in the $\Phi_{i,t,0}$ and $\Phi_{i,t,l}$ matrices:

$$\Phi_{i,t,0} = \begin{bmatrix} 1 & 0 & 0 \\ \phi_{i,t,0}^{21} & 1 & 0 \\ \phi_{i,t,0}^{31} & \phi_{i,t,0}^{32} & 1 \end{bmatrix};\quad \Phi_{i,t,l} = \begin{bmatrix} \phi_{l}^{11} & 0 & 0 \\ \phi_{i,t,l}^{21} & \phi_{i,t,l}^{22} & \phi_{i,t,l}^{23} \\ \phi_{i,t,l}^{31} & \phi_{i,t,l}^{32} & \phi_{i,t,l}^{33} \end{bmatrix},\quad l = 1,2,\ldots,p \qquad (4)$$

While the exogenous restriction of the world real income should be rational in the studies for small economies, it might be a little controversial in the studies of countries with a relatively large economy scale, such as Japan. In fact, a standard Granger causality test cannot reject the hypothesis that I-REERs and export volume cannot Granger cause the world real income, which rationalizes the assumption for the world real income.

The formula of the coefficients $\phi_{i,t,g}^{jk}$ in the matrices $\Phi_{i,t,g}$ is given by:

$$\phi_{i,t,g}^{jk} = \alpha_g^{jk} + \beta_{g,1}^{jk} InF_{it} + \beta_{g,2}^{jk} ExF_{it} + \beta_{g,3}^{jk} InF_{it} * ExF_{it} , \quad (5)$$

where internal financial constraints (InF_{it}) is proxied by liquidity Ratio and external financial constraints (ExF_{it}) proxied by the lending attitude of financial institutions. With this structure, we can allow Japanese exports response to exchange rate shock differently for different level of financial constraints. To control for the endogenous problem of the financial constraints that the current value of them may be dependent on the exports, all financial variables enter the estimation with one lag of the time period.

For the comparison from the existing studies, the first step is to look at the dynamic effects of exchange rate shock conditional on internal financial constraints and external financial constraints separately by setting either $\beta_{g,2}^{jk} = \beta_{g,3}^{jk} = 0$ or $\beta_{g,1}^{jk} = \beta_{g,3}^{jk} = 0$. Then, it proceeds to examine the most general case in which all coefficients are unrestricted. While the domestic variables, export volume and I-REERs, are allowed to dependent on financial constraints (internal and external), the external variable of the world real income is restricted to be independent of domestic financial constraints. Note that ϕ_l^{11} in $\Phi_{i,t,l}$, $l = 1,2,\ldots,p$, is without time t and industry subscript *i*.

The use of Panel VARs allowing heterogeneity in coefficients by including interaction terms, with the corresponding restrictions on the parameters, is common in the recent literature that estimates the impact of exogenous shocks on different macroeconomic variables (Loayza and Raddatz, 2007; Towbin and Weber, 2013). One advantage of this approach is that it can test how country or industry characteristics affect the response of the economy to external shocks.

3.4.2 Implementation

Under the identification assumptions described above, error terms are assumed to be uncorrelated across equations. Thus the Panel VAR in (3) can be efficiently estimated equation by equation using OLS and the dummy of finance crisis is included in each equation to control for the disturbance caused by the Lehman's collapse. All variables enter the Panel VAR model in terms of the first differences of the logarithmic form. The number of lags is chosen following Schwartz information criterion, and the optimal number of lag is two. The confidence intervals for the impulse response function (IRF) are estimated by non-parametric bootstrapping following the procedure mentioned in Towbin and Weber (2013).

To test whether the response of Japanese exports to exchange rate shock affected by financial constraints (internal and external), three different Wald tests are applied. The first one is to test for the joint significance of all interaction and triple terms. The null hypothesis is that the internal financial constraints and external financial constraints cannot explain the heterogeneity in the response of Japanese exports:

$$H_0 : \beta_{g,1}^{jk} = \beta_{g,2}^{jk} = \beta_{g,3}^{jk} = 0, g = 0,1,2$$

The second one is to test for the significant role of internal financial constraints. The null hypothesis is that the internal financial constraints cannot improve the overall explanatory power:

$$H_0 : \beta_{g,1}^{jk} = \beta_{g,3}^{jk} = 0, g = 0,1,2 .$$

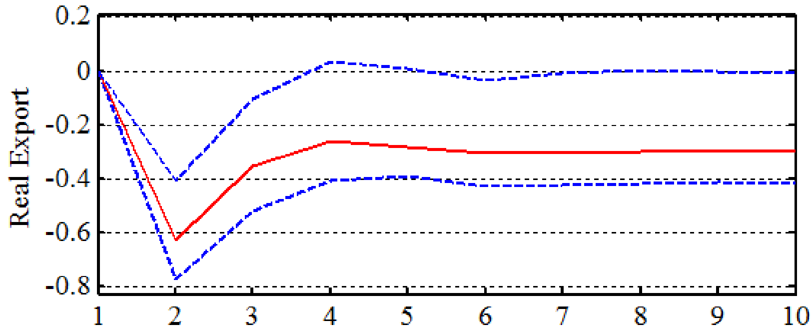
The last test is for the significant role of external financial constraints. The null hypothesis is that the external financial constraints cannot improve the overall explanatory power:

$$H_0 : \beta_{g,2}^{jk} = \beta_{g,3}^{jk} = 0, l = 0,1,2 .$$

As shown in Table 2, the Wald statistics of these three tests are 4.89, 4.88 and 4.50, respectively, which indicates that the financial constraints (internal and external) play a role in explaining the relationship between exchange rate fluctuations and exports.

The response of Japanese exports to exchange rate shock is allowed to vary with internal financial constraints and external financial constraints, which are captured by $\phi_{i,t,g}^{jk}$. Although these coefficients are time-varying, we can evaluate them with specific value of financial constraints (internal and external). The strategy to analyze the

Figure 19: Response To Exchange Rate Shock Without Interactions



Note: Bands are 90 percent confidence intervals computed by bootstrapping.

effect of financial constraints in this paper is to compare the cumulative impact of exchange rate shock on Japanese exports at different level of financial constraints. Specifically, two levels of financial constraints are specified, that is, a relatively higher level of financial constraints measured at the 25th percentile value and relatively lower level of financial constraints measured at 75th percentile value[34]. Comparing the impact of a given shock at these different levels provides a clear picture on how much financial constraints contributes to amplify or dampen the impact of exchange rate shock.

3.5 Empirical Results

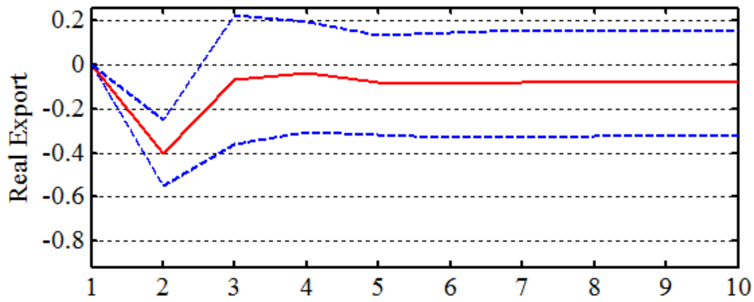
3.5.1 Response to exchange rate shock without interactions

For comparison purpose, three-variable Panel-VAR is first estimated, which includes the world real income, Japanese export volume and I-REERs without any interaction terms. Figure 19 shows the cumulative effect of a one unit shock in terms of exchange rate (appreciation) on Japanese export volume. The dotted lines in the picture show their 10% and 90% confidence bands estimated by non-parametric bootstrapping. Figure 19 shows that the response of Japanese export volume to an exchange rate shock is significantly negative, which indicates an appreciation of the yen will reduce its export volume. This result differs from the existing evidences that support the idea that the exchange rate fluctuations generally have an insignificant impact on exports for developed countries (Hooper and Kohlhagen (1978); Grier and Smallwood, 2007).

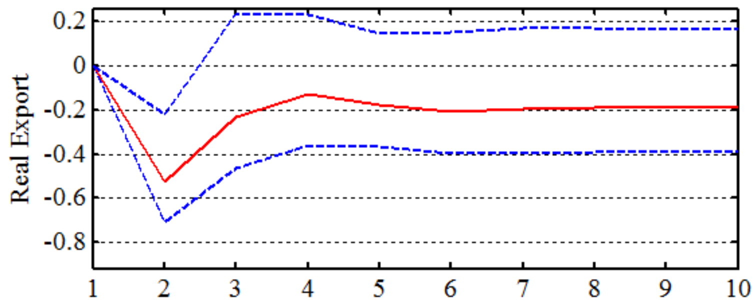
[34] The higher level of the measurement of financial constraints (internal and external) means the lower financial constraints are, see section 3.1.

Figure 20: Response to Exchange Rate Shock Conditional On External Financial Constraints

Low External Financial Constraints



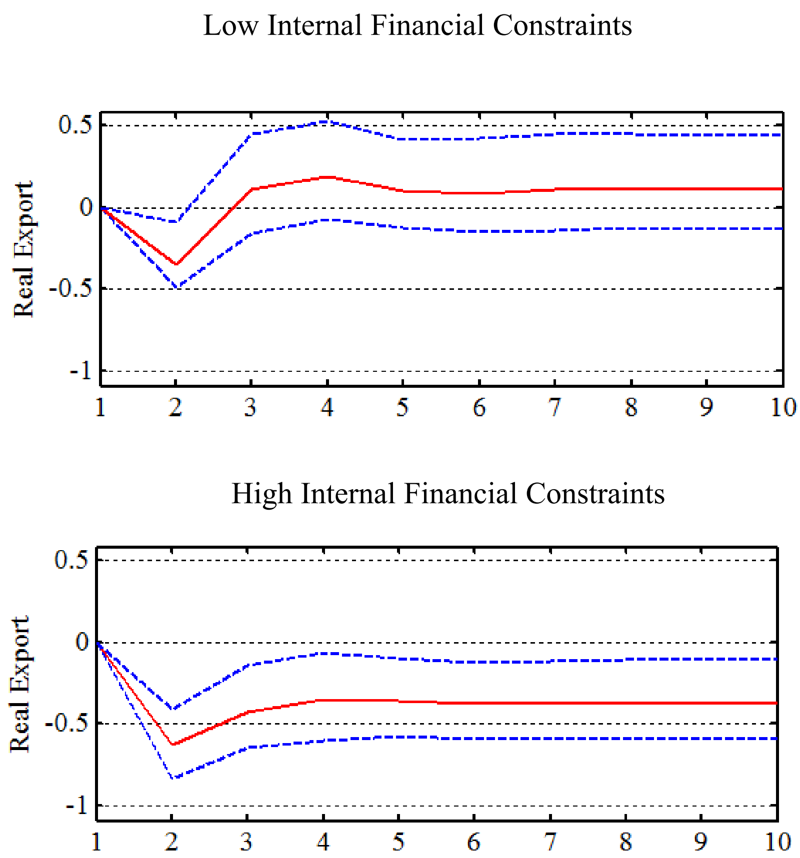
High External Financial Constraints



Note: Bands are 90 percent confidence intervals computed by bootstrapping.

However, previous studies used aggregated exchange rate, which may lead to some bias on the estimates as pointed out by Byrne *et al.* (2008). Another explanation proposed by Dekle and Ryoo (2007) is that the negative impact of exchange rate fluctuations can be attributed to the changes in financing constraints that are correlated with exchange rate fluctuations. In the working paper version of Dekle and Ryoo (2007), they show that exchange rate depreciation is on average related to a relaxation of financing constraints in 10 out of 14 industries. In addition, Table 8 shows the appreciation of the yen is negatively correlated with current profit in most industries. When the exchange rate appreciates, the exporter with tightened financial constraints cannot produce more for export even when foreign prices are inflexible. Consequently, exchange rate appreciation has a negative impact on exports.

Figure 21: Response to exchange rate shock conditional on internal financial constraints

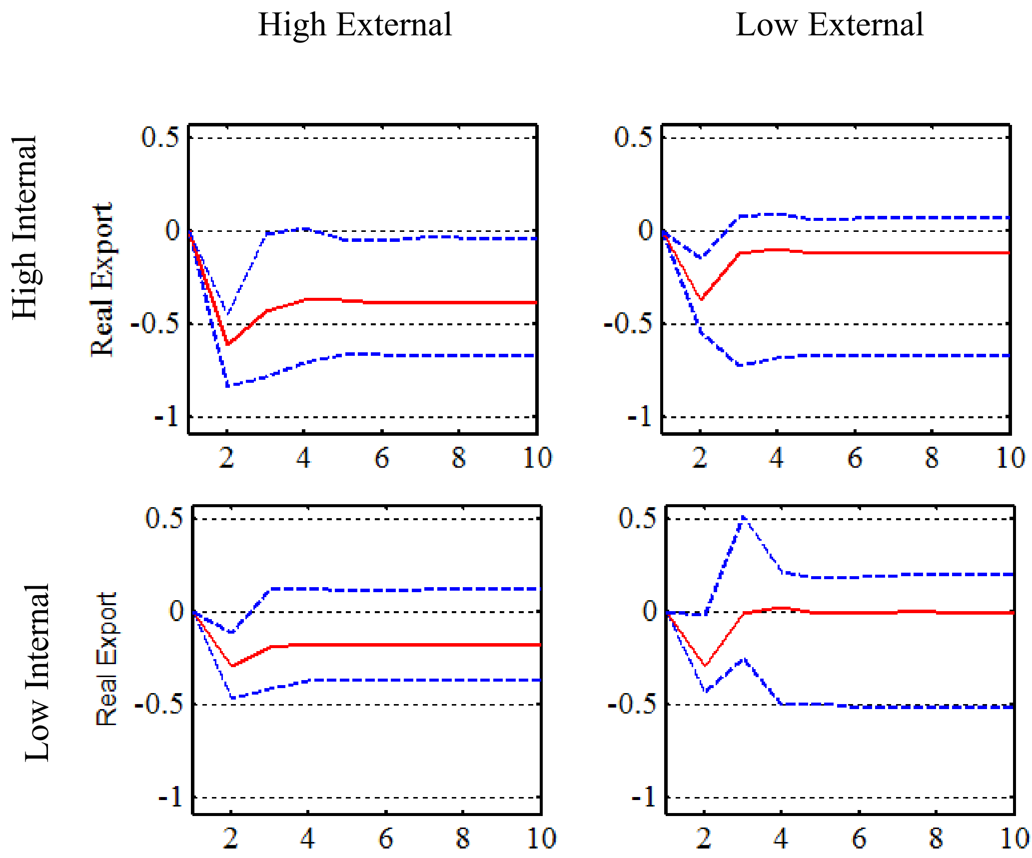


Note: Bands are 90 percent confidence intervals computed by bootstrapping.

3.5.2 Response to exchange rate shock conditional on external financial constraints

Then the external financial constraints is added to Panel VAR model. Figure 20 shows the response of Japanese exports to exchange rate shock conditional on different level of external financial constraints, which is proxied by the lending attitude of financial institutions. The relatively lower financial constraints measured by 75 percentile point (relatively accommodative lending attitude of financial institutions) and the relatively higher financial constraints measured by 25 percentile point (relatively severe lending attitude of financial institutions). We can observe the different response of Japanese export volumes to the exchange rate shock across the two levels of external financial constraints: the exporters show less response to exchange rate shock when facing relatively low external financial constraints. This result is consistent with the

Figure 22:Response to Exchange Rate Shock Conditional on Both Internal Financial Constraints and External Constraints



Note: Bands are 90 percent confidence intervals computed by bootstrapping.

existing studies (Dekle and Ryoo, 2007; Stress, 2013) that support the view that financially constrained exporters are more sensitive to exchange rate fluctuations. However, it is surprising that the difference is negligible.

3.5.3 Response to exchange rate shock conditional on internal financial constraints

Figure 21 shows that the cumulative impact of exchange rate conditional on different level of internal financial constraints, which is proxied by liquidity ratio. Similarly, relatively low internal financial constraints are measured by 75 percentile point (higher liquidity ratio) and relatively high internal financial constraints are measured by 25 percentile (lower liquidity ratio). It is very striking that, comparing to external financial constraints, the difference in the response of Japanese export volumes to exchange rate shock across the two levels of internal financial constraints is quite large. The impact of exchange rate shock on exports is quite large and continues for a long period under relatively higher internal financial constraints, while the impact is almost insignificant at relatively lower internal financial constraints. This may suggest that the internal financial constraints do appear to play a significant role in affecting the impact of exchange rate shock on exports.

3.5.4 Response to exchange rate shock conditional on both internal financial constraints and external constraints

The main interest of this paper is in the triple term between exchange rate fluctuations, internal financial constraints and external financial constraints. Figure 7 shows the impulse response of export volumes to exchange rate shock facing four combinations of internal financial constraints and external financial constraints, i.e. low internal financial constraint (high liquidity ratio) and low external financial constraints (accommodative lending attitude); low internal financial constraints and high external financial constraints (severe lending attitude); high internal financial constraints (low liquidity ratio) and low external financial constraints; high internal financial constraint and high external financial constraints. As shown in Figure 7, the exchange rate shock has no significant effect on Japanese exports when both internal and external financial constraints are relatively low. By contrast, when the internal and external financial constraints are relatively high, the impact of exchange rate shock on Japanese exports is quite large. We can also observe that easing either internal financial constraints or external financial constraints does appear to mitigate the impact of exchange rate shock. When external financial constraint is relatively high, the negative impact of exchange rate shock on Japanese exports becomes insignificant by easing internal financial constraints (relatively lower internal financial constraints). This result may imply that increasing the liquidity ratio can help firms alleviate the negative impact of exchange rate fluctuations. However, excessively high liquidity ratio is not good for capital efficiency. As showed as at the upper part of Figure 7, even when the internal financial constraints is relatively high, easing external financial constraints leads to a smaller response of Japanese exports to exchange rate shock. This suggests that accommodative financial environment can help firms with high internal financial constraints alleviate the impact of yen appreciation on their exports.

3.6 Conclusion

This paper is motivated by the fact that Japanese firms are facing a quite different financial environment from the period before the Lehman's collapse. The lending attitude of financial institutions in Japan becomes relative sever and the liquidity ratio becomes relatively higher after the collapse. It is empirically investigated whether and how internal and external financial constraints influence the response of Japanese exports to the exchange rate shock by employing a Panel-VAR approach. The internal financial constraint is proxied by liquidity ratio, and external financial constraint is proxied by lending attitude of financial institutions. All industry-breakdown data of financial constraints is obtained from *Bank of Japan, Tankan (Short-Term Economic Survey of Enterprises in Japan)*. To take a consideration of the bias that may be caused by using aggregated exchanger rate, this paper employs the industry-specific real effective exchange rate data developed by Sato *et al*. (2013) to allow for the different movements of real effective exchange rates across industries.

It is concluded that first, Japanese exports negatively and significantly respond to exchange rate shock. Under the existence of the incomplete pass-through, one explanation for this result proposed by Dekle and Ryoo (2007) is that the responsiveness of Japanese exports to exchange rate fluctuations can be attributed to a tightening of balance sheet constraints. Second, financial constraints (internal financial constraints and external financial constraints) have significant influences on the response of Japanese exports to the exchange rate shock. Japanese exporters with lower either internal or external financial constraints are less affected by the exchange rate shock. Finally, accommodative financial environment can help firms with higher internal financial constraints alleviate the impact of yen appreciation on its exports.

Although our finding suggests that increasing the liquidity ratio can help firms absorb the impact of the exchange rate shock, this is not good for capital efficiency, if the liquidity ratio becomes excessively high. As pointed out by Sher (2014), large cash holdings may be a potential obstacle to the success of Abenomics by impeding growth in wages, investment and dividend payments. It is also shown that financial constraints is one of the factors that contribute to the positive cash accumulation of Japanese nonfinancial firms. Therefore, a policy that improves firms' access to market-based financing (external finance) can help firms mitigate the negative impact of exchange rate shock and also encourage them to use their cash holdings.

Conclusion

The exchange rate fluctuation is widely considered to have a negative impact on emerging Asia countries. Given a rapid progress of economic integration through trade and investment, a good understanding of the impact of exchange rate fluctuations is good for regional cooperation. This thesis empirically examines the impact of exchange rate fluctuations on exports of East Asia region, by using industry-specific exchange rate, which can capture the heterogeneity in the movements of exchange rate across industry, to eliminate the bias caused by aggregated exchange rate.

The overall of this thesis to the existing empirical literature is to provide new evidence on the relationship between exchange rate fluctuations and exports by using industry-specific exchange rate. Understanding the degree to what extent the impact exchange rate fluctuations may have on exports of Asia countries is an important issue for regional integration and export promotion policies. These evidences provided by this study improve this understanding, and therefore, fills an important gap in the existing studies.

In addition, this is the first study that jointly examines the role of internal and external financial factor on the trade effects of exchange rate fluctuations. The empirical results suggest that financial sector is an important factor in determining the impact of exchange rate may have on exports. A important application of my results is that improving financial environment can help firm alleviate the negative impact of exchange rate shock.

Appendix

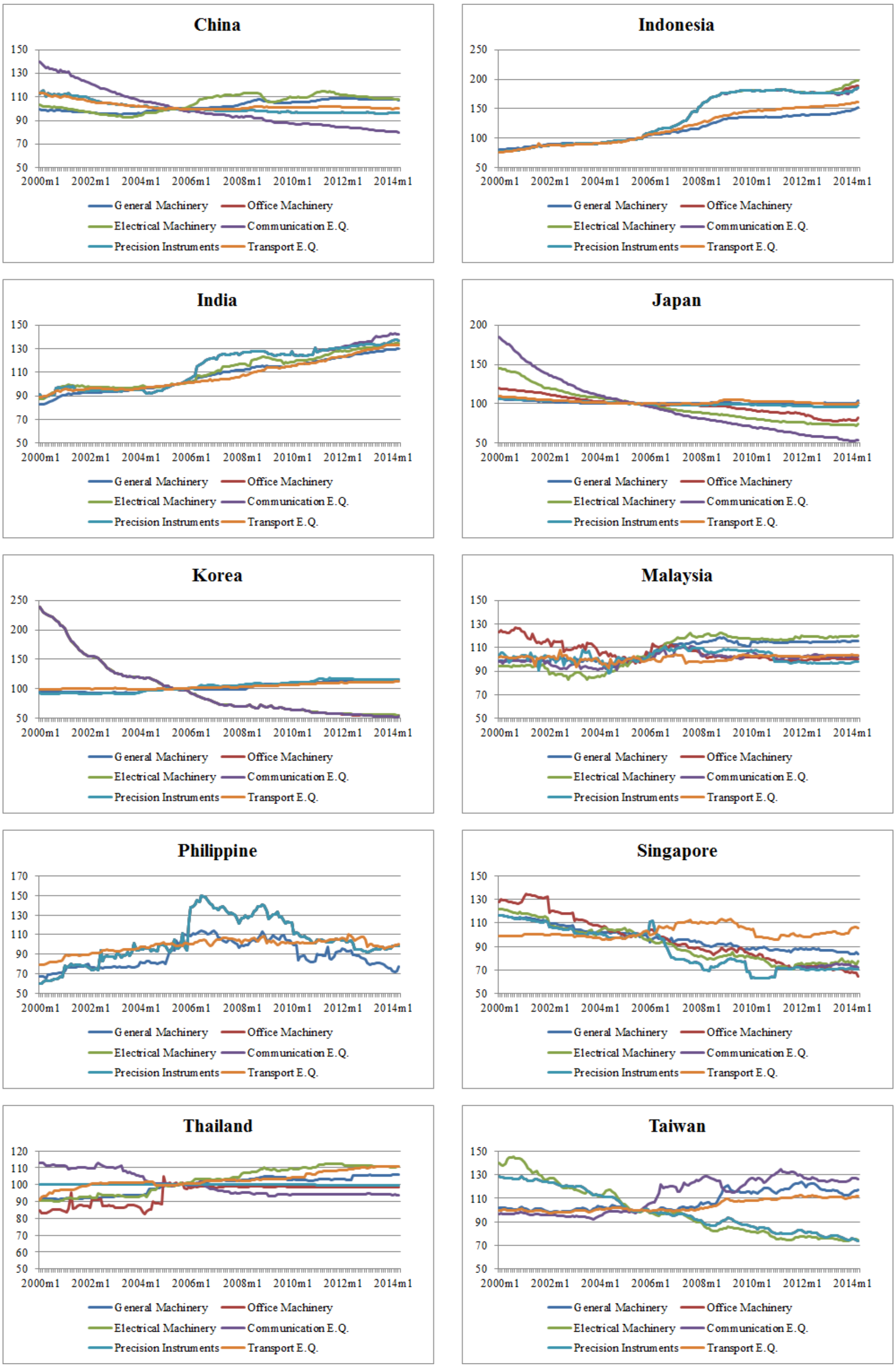
Table 9: Data Source

Country	Datasource	Link
China	1. CEIC	
	2. *China Statistical Yearbook*	
India	Office of Economic Adviser to Government of India	http://eaindustry.nic.in/
Indonesia	1. BPS, *Indikator Ekonomi* (*Economic Indicators*)	
	2. CEIC	
Japan	Bank of Japan	http://www.boj.or.jp/
Korea	The Bank of Korea	http://eng.bok.or.kr/eng/engMain.action
Malaysia	CEIC	
Philippines	1. Republic of Philippines National Statistics Office	http://www.census.gov.ph
	2. *Philippine Yearbook*	
Singapore	CEIC	
	Statistics Singapore	http://www.singstat.gov.sg/
Thailand	CEIC	
Taiwan	CEIC(include output data)	
Grivity Data	World Bank	
GDP Data	World Bank (WDI)	http://data.worldbank.org/data-catalog
Trade Data	OECD STAN Database	http://stats.oecd.org/

Table 10: Details of the Industries

ISIC 4-digit	*Industry*
	General Machinery (*Machinery and Equipment n.e.c.*)
2911	Engines and turbines, except aircraft, vehicle and cycle engines
2912	Pumps, compressors, taps and valves
2913	Bearings, gears, gearing and driving elements
2914	Ovens, furnaces and furnace burners
2915	Lifting and handling equipment
2919	Other general purpose machinery
2921	Agricultural and forestry machinery
2922	Machine-tools
2923	Machinery for metallurgy
2924	Machinery for mining, quarrying and construction
2925	Machinery for food, beverage and tobacco processing
2926	Machinery for textile, apparel and leather production
2927	Weapons and ammunition
2929	Other special purpose machinery
2930	Domestic appliances n.e.c.
	Office Machinery (*Office, Accounting and Computing Machinery*)
3000	Office, accounting and computing machinery
	Electrical Machinery (*Electrical Machinery and Apparatus n.e.c.*)
3110	Electric motors, generators and transformers
3120	Electricity distribution and control apparatus
3130	Insulated wire and cable
3140	Accumulators, primary cells and primary batteries
3150	Electric lamps and lighting equipment
3190	Other electrical equipment n.e.c.
	Communication Equipment (*Communication Equipment and Apparatus*)
3210	Electronic valves and tubes and other electronic components
3220	Television and radio transmitters and apparatus for line telephony and line telegraphy
3230	Television and radio receivers, sound or video recording or reproducing apparatus, and associated goods
	Precision Instruments (*Medical, Precision and Optical Instruments*)
3311	Medical and surgical equipment and orthopedic appliances
3312	Instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment
3313	Industrial process control equipment
3320	Optical instruments and photographic equipment
3330	Watches and clocks
	Transport Equipment (*Motor Vehicles, Trailers and Semi-trailers*)
3410	Motor vehicles
3420	Bodies (coachwork) for motor vehicles; trailers and semi-trailers
3430	Parts and accessories for motor vehicles and their engines

Figure 23: Producer Price Index by Industry in Asia Countries



Notes: **The base year is 2005. The details of the data source is shown in Appendix**

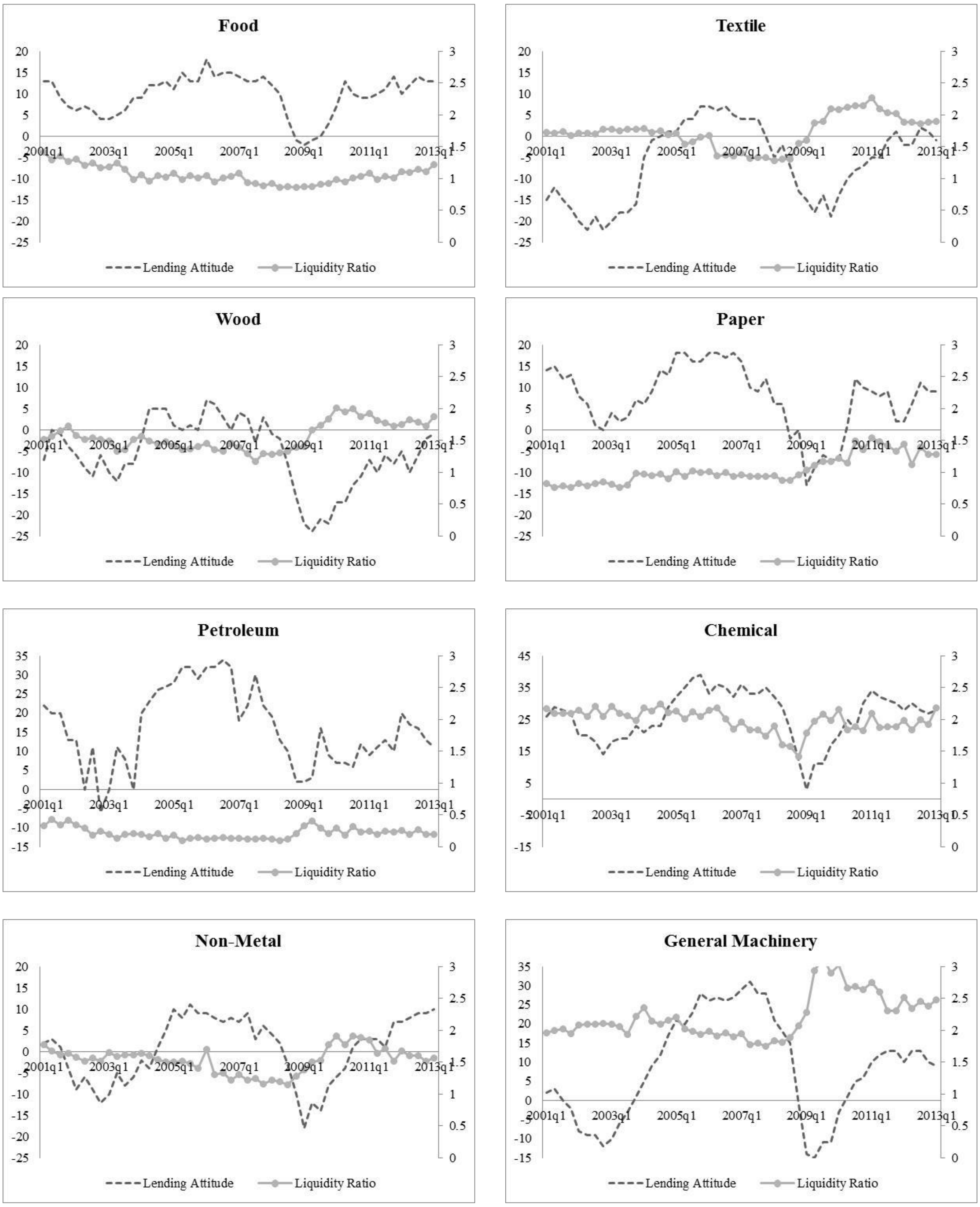
Table 11: Industry Classification

Code	ISIC.rev3	Industry Name	Description
1	15-16	Food	Food, Beverage, Tobabcoo
2	17-19	Textile	Textiles, Textile Products, Leather and Footwear
3	20	Wood	Wood Products(excl. furniture)
4	21-22	Paper	Paper, Paper Products, Printing and Publishing
5	23	Petroleum	Coke, Refined Petroleum Products,Nuclear Fuel
6	24	Chemical	Chemicals and Chemical Products
7	25	Rubber	Rubber and Plastics Products
8	26	Non-Metal	Non-metallic Mineral Products
9	27-28	Metal	Basic Metals and Fabricated Metal Products
10	29	General Machinery	Machinery and Equipment n.e.c.
11	30-32	Electric Machinery	Electrical Machinery and Apparatus n.e.c.
12	33	Optical Instruments	
13	34-35	Transport Equipment	Transport Equipment

Table 12: Partner Countries

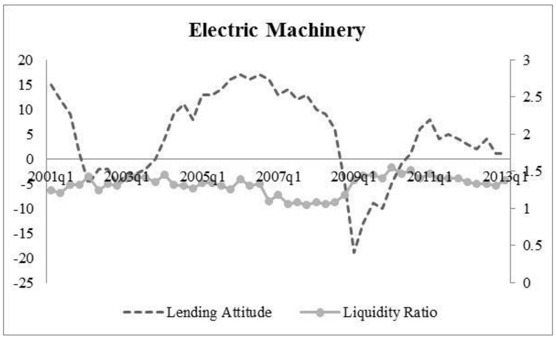
Asia	8. Taiwan	15. German	23. Sweden
1. China	9. Thailand	16. Greece	24. Switzerland
2. India	***Europe***	17. Ireland	25. UK
3. Indonesia	10. Belgium	18. Italy	***Other***
4. Korea	11. Canada	19. Netherlands	26. Australia
5. Malaysia	12. Denmark	20. Norway	27. New Zealan
6. Philippine	13. Finland	21. Russia	28. USA
7. Singapore	14. France	22. Spain	

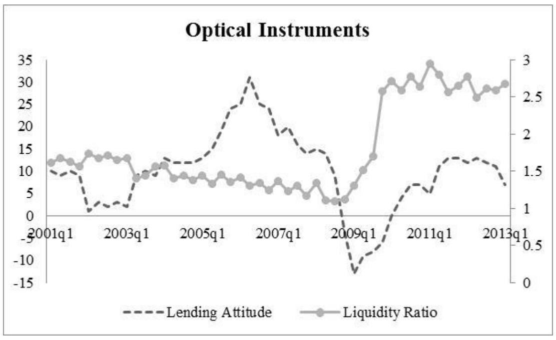
Figure 24: Lending Attitude of Financial Institution and Liquidity Ratio for Each Sector

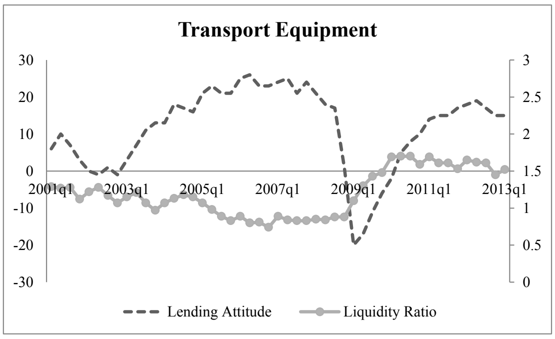


Data source: Bank of Japan, Tankan (Short-Term Economic Survey of Enterprises in Japan), 2001Q1-2013Q3.

Figure 24: Lending Attitude of Financial Institution and Liquidity Ratio for Each Sector(Continued)







Data source: Bank of Japan, Tankan (Short-Term Economic Survey of Enterprises in Japan), 2001Q1-2013Q3.

Figure 25: Export Price Index for All Industries

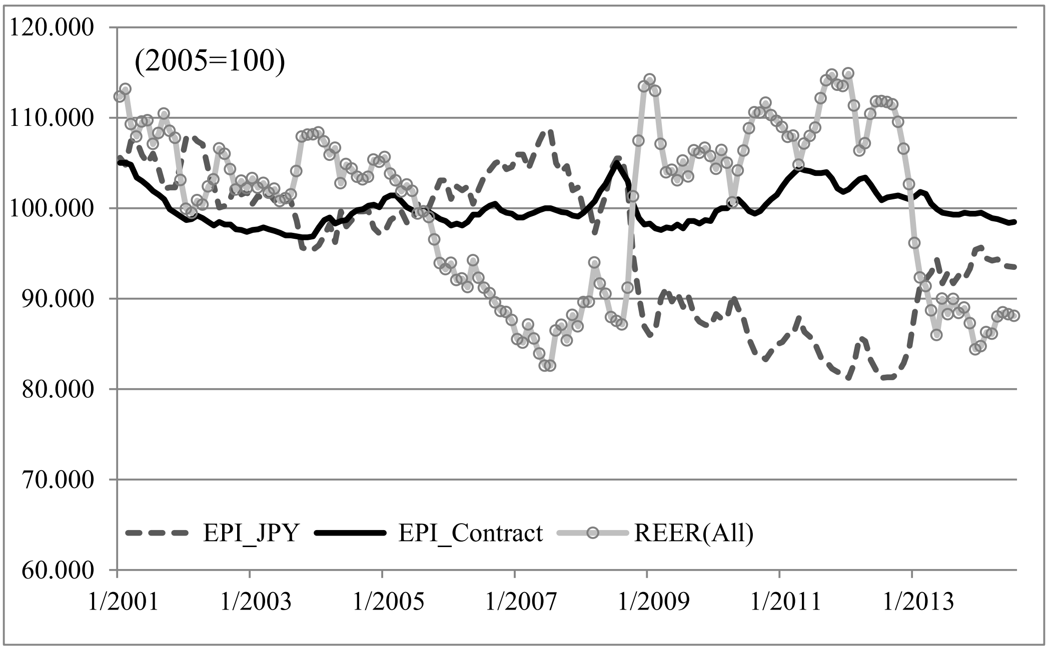
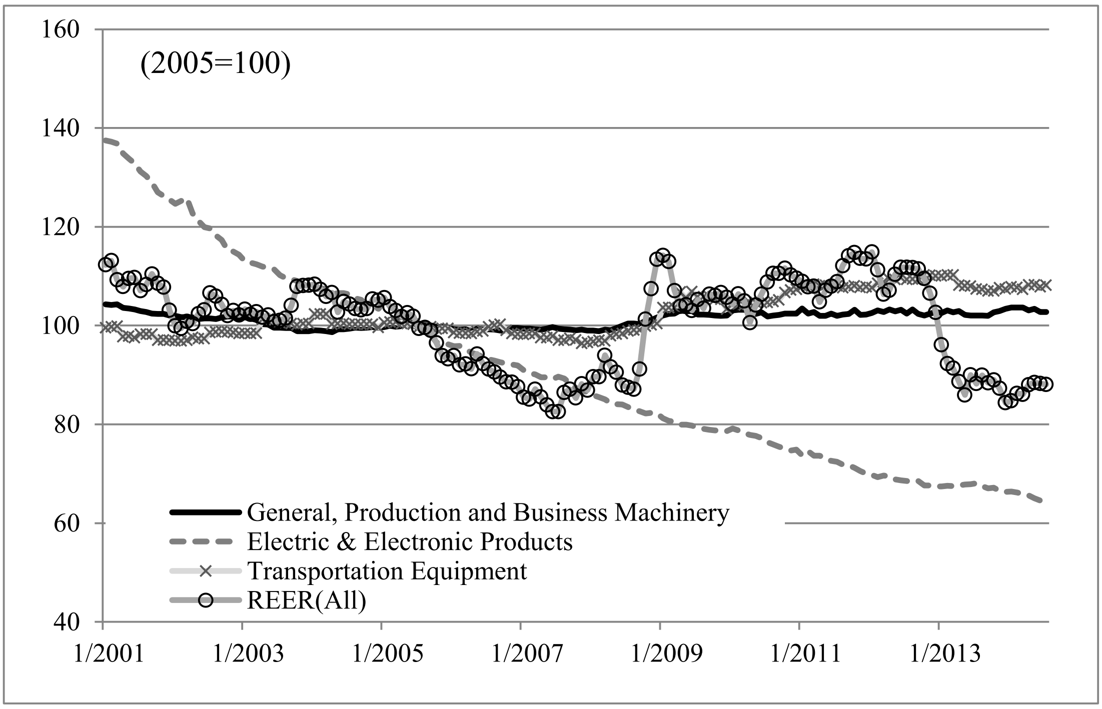


Figure 26: Export Price Index for Selected Main Industries



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