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The Impact of Exchange Rate Volatility on Korea-Japan Trade Flows: An Industry Level Analysis*

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Abstract

The existing literature, in both theoretical and empirical viewpoints, indicates that there is no consensus regarding the effects of exchange rate volatility on bilateral trade flows. It can show the different effects across countries and industries. This article examines impact of volatility of exchange rate on 57 importing and 69 exporting industries of Korea vis-à-vis Japan. The study is conducted by employing disaggregated trade data (3-digit level of SITC product) to avoid the aggregation bias problem. The autoregressive distributed lag (ARDL) cointegration model is adopted in the empirical estimation, using annual data during 1970 to 2016. The findings indicate that the exchange rate volatility affects bilateral trade flows between Korea and Japan in both short run and long run. Nevertheless, the majority of industries are unaffected in the long run. The number of negatively affected industries are remarkably higher than the positively affected ones in both exporting and importing products. The machinery and transport equipment (SITC7) are the most negatively affected commodities of both importing and exporting products. While the effects of income on bilateral trade flows are in line with the theoretical prediction, the majority of industries are not affected by the real exchange rate in the long run.

Keywords: Autoregressive Distributed Lag (ARDL) Model, Bilateral Trade, Exchange Rate Volatility, Industry Level Analysis

JEL Classifications: C50, F14, F31

Ⅰ. Introduction

Korea economy has been strongly driven by export-oriented trade policy since 1960. The economy has depended heavily on international trade since then. <Table 1> presents the top 10 major trade partners of Korea during 1970 to 2016. The cumulative import values indicate that Japan is Korea's largest import partner. Japan alone accounts for 16.40 per cent of Korea's total imports. In addition, Japan is also the important export partner of Korea. The cumulative export values exhibit that Japan holds 8.31 per cent of Korea's total

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exports.

Accordingly, Japan represents 12.22 per cent of Korea's total trade values since 1970 to 2016. This makes Japan is the third largest trade partner of Korea, after China (16.98 per cent) and the United States of America or USA (13.95 per cent). Therefore, study on the effects of exchange rate volatility on bilateral trade flows between Korea and Japan is crucial for Korea, provided that there is no general agreement on the impact of exchange rate volatility on bilateral trade in both theoretical and empirical perspectives.

The relationship between exchange rate volatility and bilateral trade flows between Korea and Japan during 1970 to 2016 is presented in <Fig. 1>. It depicts the patterns of exchange rate volatility between Korean Won (KRW) against Japanese Yen (JPY) and changes in exports and imports of Korea vis-à-vis Japan of SITC (Standard International Trade Classification) products at 1-digit and 3-digit code. The graphs imply that there is a high degree of reactivity between exchange rate volatility and the exports and imports of 3-digit code products, SITC671 (pig iron and spiegeleisen) and SITC282 (iron and steel scrap), rather than between the volatility and the exports and imports of 1-digit code products, SITC6 (manufactured goods classified chiefly by material) and SITC2 (crude material, inedible except fuels). The existing literature argues that study on the impact of exchange rate volatility on bilateral trade flows at aggregate level of industry can subject to aggregation bias in general. Therefore, the second type of research is conducted by using disaggregated level data (industry level data) such as 3-digit level data of SITC product in the study.

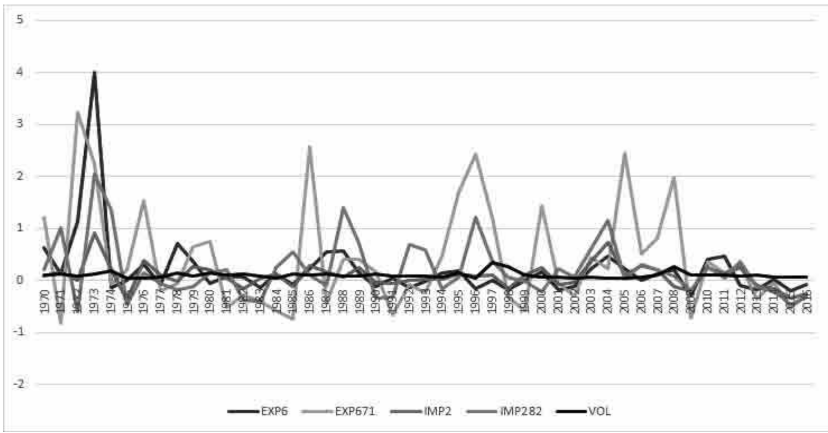
To the best of the our knowledge, the only study regarding the effects of exchange rate volatility on bilateral trade flows of certain product groups between Korea and Japan is Baek Jung-Ho (2013). Nevertheless, his study was conducted at 1-digit level of SITC industry.

Table 1. Korea's Major Trade Partners (1970-2016)

Imports		Exports		Total trade	
Partner	Percent	Partner	Percent	Partner	Percent
Japan	16.40	China	19.77	China	16.98
China	13.99	United States	15.12	United States	13.95
United States	12.71	Japan	8.31	Japan	12.22
Saudi Arabia	6.02	Hong Kong, China	5.65	Saudi Arabia	3.58
Australia	3.85	Singapore	3.29	Hong Kong, China	3.17
Germany	3.81	Vietnam	2.45	Germany	3.10
United Arab Emirates	2.78	Germany	2.43	Australia	2.64
Indonesia	2.73	Indonesia	1.88	Singapore	2.60
Qatar	2.71	India	1.84	Indonesia	2.29
Kuwait	2.39	United Kingdom	1.68	United Arab Emirates	1.93
	67.38		62.43		62.46
Row	32.62	Row	37.57	Row	37.54
Total	100.00	Total	100.00	Total	100.00

Source: Author's calculations based on data from WITS (2017).

Fig. 1. Exchange Rate Volatility and Changes in Trade Flows between Korea and Japan



Notes: 1. EXP6=Changes in Korea's exports of SITC6, EXP671=Changes in Korea's exports of SITC671
IMP2=Changes in Korea's import of SITC2, IMP282=Changes in Korea's import of SITC282
VOL=Volatility of bilateral exchange rate.
2. $Change\ of\ x = (x_t - x_{t-1})/x_{t-1}$

Source: Author's calculations based on data from WITS (2017) and OECD (2017).

The impact of volatility on trade flows at industry level needs further investigation. Consequently, this paper aims to examine the effects of exchange rate volatility between KRW against JPY on exports and imports of Korea vis-à-vis Japan. We contribute to the existing researches in that our works are conducted at 3-digit level of SITC industry. Therefore, the aggregation bias problem is alleviated in our study. Moreover, the empirical findings provide more specific and detailed evidences of the affected industries in the case of Korea and Japan. Since our studied variables are mixed between integrated of order zero or I(0) and one or I(1) variables, therefore, the autoregressive distributed lag (ARDL) cointegration model or the bounds testing cointegration approach is employed in our study. We examine 69 Korean exporting industries (which account for 94.65 per cent of total exports from Korea to Japan) and 57 importing industries (96.02 per cent of total imports of Korea from Japan) by using the annual data between 1970 and 2016.

The rest of the paper is organized as follows. Chapter Ⅱ reviews the literature pertaining to the effects of exchange rate volatility on bilateral trade flows. Chapter Ⅲ describes the research methodology. The empirical results are reported in Chapter Ⅳ. Chapter Ⅴ is a research conclusion.

Ⅱ. Literature Review

1. Review of Theory

Generally, the exchange rate volatility is viewed as uncertainty to the firm's profit. Thus, increase in volatility may decrease the international trade transaction of the firm due to the lower expected profit. Nonetheless, there is no certain agreement for the impact of exchange rate volatility on international trade from the theoretical point of view. The existing trade theories indicate that the volatility may have positive, negative or no effect on international trade.

Kawai and Zilcha (1986) suggested that if the firm receives the payment after finishing trade transaction at the future spot exchange rate, the exchange rate risk will raise the uncertainty of the expected profit. Therefore, the risk-neutral and risk-averse firm may reduce the international trade transaction in response to the exchange rate volatility. However, Varian (1992) established that the expected profits from international trade of firm are positively related to the degree of uncertainty, whereas the higher uncertainty reduces its utility. As a result, the impact of exchange rate volatility on firm's trade could be positive, negative or no impact. It is determined by the degree of firm's risk aversion. De Gauwe (1988) demonstrated that the risk-averse firm may increase trade in response to uncertainty from the volatility of exchange rate. This is because the volatility creates both substitution effect and income effect to the risk-averse firm. The substitution effect discourages firm's trade to avoid the profit loss from the volatility of exchange rate. In contrast, since the increase in uncertainty lowers the total expected utility of firm, the income effect will induce the firm to increase volume of trade in order to compensate the decrease in utility. In the case of extreme risk aversion, the income effect may dominate the substitution effect. Consequently, the volatility of exchange rate may raise the international trade level. In the other way, some trade theories explained the effect of exchange rate volatility by not employing the assumption of risk aversion. According to Gros (1987), if firm has capacity to adjust its production in response to exchange rate movement, the exchange rate volatility can increase international trade. In addition, Krugman (1988) showed that in the presence of sunk costs, the exchange rate fluctuation can lead risk-neutral firm decides to increase or decrease international trade which is not reversed when the exchange rate returns back to its normal level.

2. Review of Empirical Studies

2.1. Studies in General Cases

Studies using aggregate data were conducted in several cases. Choudhry, Hassan and Papadimitriou (2014) and Choudhry and Hassan (2015) found that the United Kingdom's imports from Germany were negatively affected by the volatility of bilateral exchange rate. The similar evidence was detected on Japan's imports from China. In contrast, there was no impact from volatility on China's imports from Japan (Nishimura and Hirayama, 2013). However, the volatility affected the bilateral trade flows both negatively and positively across 13 studied countries (Baum and Caglayan, 2010). The same patterns exhibited in bilateral trade flows between USA and its 13 trading partners (Caglayan and Di, 2010). Nonetheless, Vieira and MacDonald (2016) proclaimed that only the negative impact was detected among their 106 studied countries.

There is an important argument that the results from the studies at aggregate level of industry may not reliable due to the aggregation of data, the so-called aggregation bias problem. Therefore, the second type of research conducts the study at disaggregated level of industry (or industry level), as follows. The positive effects of volatility on bilateral trade flows were apparent between USA and Brazil in various industries (Bahmani-Oskooee, Harvey and Hegerty, 2013). Likewise, the favourable effects of exchange rate volatility were also found on trade flows among the countries in South Asia (Tang, 2014). Nonetheless, while the positive impact of volatility presented on trade of machinery and transport equipment between Japan and USA, it showed mixed results on chemicals products and miscellaneous manufactured articles (Bahmani-Oskooee and Hegerty, 2008). Sato et al. (2016) added that the impact of volatility depends on the characteristics of the trading goods. For instance, the volatility negatively affected trade in general machinery, whereas it had no impact of trade of intermediate goods for the intra-Asia trade. The mixed effects of exchange rate volatility on bilateral trade flows were reported in numerous studies, mostly between USA and its trade partners. The 22 and 23 exporting industries of Italy vis-à-vis USA were positively and negatively influenced by the volatility, whereas they were 13 and 23 for the importing industries, respectively (Bahmani-Oskooee, Harvey and Hegerty, 2015). In addition, the mixed effects of volatility displayed on bilateral trade flows between USA and Spain (Bahmani-Oskooee, Harvey and Hegerty, 2014), USA and Eurozone countries (Verheyen, 2012), USA and Malaysia (Bahmani-Oskooee and Harvey, 2011) and USA and Singapore (Bahmani-Oskooee and Harvey, 2015). In contrast, not many industries were affected by exchange rate volatility on trade flows between Pakistan and Japan (Bahmani-Oskooee, Iqbal and Salam, 2016).

2.2. Studies in Case of Korea

Study at the aggregate level of industry was conducted by Kim Chang-Beom (2011a). He claimed that increase of exchange rate volatility had negative impact on total exports from Korea to the world. Nevertheless, Lee Jae-Hwa (2011a) argued that the adverse effect of exchange rate volatility on exports from Korea to the world existed only in the long run. In contrast, Pino, Tas and Sharma (2016) asserted that the exchange rate volatility had a significant impact on export flows in the short run as well as in the long run during 1974 to 2011. On the import side, Kim Chang-Beom (2011b) found that volatility had a significant negative effect on the imports of Korea from four economic blocks (APEC, ASEAN, EU, NAFTA) during 1999 to 2009. The negative impact of the volatility on bilateral trade flows between Korea and USA was detected by Choi Kyong-Wook (2010) and Chun Sun-Eae (2013). For the case of Korea-Japan, Baak, Al-Mahmood and Vixathep (2007) found that exchange rate volatility had negative impact on exports from Korea to Japan in both the short run and the long run during 1981 to 2004. This argument was in line with Kim Chong-Sun (2014). Nonetheless, Lee Jae-Hwa (2011b) argued that the adverse effect of exchange rate volatility on exports from Korea to Japan existed only in the short run during 1980 to 2009.

Concerning the study at industry level, Lee Sang-Ho (2011) posited that exchange rate volatility reduced the exports of manufacturing products from Korea to the world. This argument was supported by Jung Moon-Hyun (2016) who found that exchange rate volatility had negative effect on the exports of automotive industry from Korea to 28 major trading partners during 2001 to 2014. However, Bahmani-Oskooee, Hegerty and Zhang (2014) examined 148 exporting products and 144 importing commodities of Korea vis-à-vis the rest of the world. The empirical results indicated that the volatility showed both negative and positive effects on 20 and 12 exporting products, respectively. In addition, 8 and 14 importing commodities exhibited negative and positive impact from the volatility, respectively. Nonetheless, Lee Min-Hwan and Kim Young-Jae (2012) claimed that the effects of the exchange rate volatility on international trade became relatively weaker compared with the past. The case between Korea and USA was investigated at 1-digit level of SITC industry by Baek Jung-Ho (2014). The positive effects of volatility on exporting products revealed in manufactured goods (SITC6), whereas the negative ones exhibited in machinery and transport equipment (SITC7). As for the importing commodities, the positive effects were recorded in beverage and tobacco (SITC1), while the negative impacts disclosed in 3 industries. Nonetheless, there was no impact of volatility on imports of the other 6 products. Furthermore, Bahmani-Oskooee, Harvey and Hegerty (2012) conducted a study at 3-digit level of SITC industry and claimed that 16 (out of 96) importing industries and 7 (out of 29) exporting industries of Korea vis-à-vis USA were influenced by exchange rate volatility differently. Lastly, Baek Jung-Ho (2013) examined the case of Korea-Japan at 1-digit level of SITC industry during 1991 to 2010. The results revealed that the exports of manufactured goods classified chiefly by material (SITC6) from Korea to Japan were negatively affected by the exchange rate volatility in both short run and long run. While the impact of volatility on imports of Korea from Japan was negative on machinery and transport equipment (SITC7), the positive impact was found on chemicals and related products (SITC5), in the short run. In the long run, both SITC5 and SITC7 products received the negative effects from the exchange rate volatility.

In summary, according to the existing literature, three points are worth mentioning. First, based on the theoretical perspective, there is no consensus regarding the impact of exchange rate volatility on the volume of trade. It can have positive, negative or no impact. Second, due to the issue of aggregation bias problem, the second type of empirical work has been studied at the industry level. However, the empirical evidences reveal that the impact of exchange rate volatility on bilateral trade at industry level is inconclusive. It depends on a specific industry and a specific country. Third, there is only one study (Baek Jung-Ho, 2013) with regard to the impact of exchange rate volatility on bilateral trade at industry level between Korea and Japan. Nonetheless, the study was conducted at 1-digit level of SITC industry. Accordingly, we contribute to the previous researches by studying the impact of exchange rate volatility on bilateral trade between Korea and Japan at 3-digit level of SITC industry. Our study is different from the existing literature regarding the impact of exchange rate volatility on bilateral trade flows between Korea and Japan in twofold. First the study is conducted at the disaggregated level of industry. Therefore, the aggregation bias problem can be avoided. Second, the study covers all categories of bilateral trade flows between two countries. Hence, the study provides the specific and comprehensive results for the impact of volatility on certain products.

Ⅲ. Methodology

1. Model Specification

The framework of our study rests on the import and export demand model. The import demand means the demand by domestic residents for foreign goods whereby the export demand refers to the demand by foreign countries for commodities produced domestically. According to Dornbusch (1988), the export demand is primarily determined by two main factors. They are foreign income, which represents the purchasing power of the buyer and the relative price variable for the terms of trade. The same concept can be applied for the import demand in that the demand for imports is a function of domestic income and relative price variable. Cushman (1987/1990) and Haynes, Hutchison and Mikesell (1996) used the export and import values as the proxies of trade flows in their estimations.

However, Bahmani-Oskooee and Goswami (2004) and Bahmani-Oskooee and Ardalani (2006) argued that when the bilateral trade flows are studied, the data of import and export prices are not available on bilateral basis to be employed in the export and import demand functions. They proposed that the relative price variable should be substituted by the real bilateral exchange rate. This suggestion is in line with Kenen and Rodrik (1986) which argued that the real exchange rate is a good proxy of price. Consequently, the important determinants of imports and exports are income level and the real exchange rate. We follow their arguments. Furthermore, the exchange rate volatility is added into the demand model in order to examine the effect of volatility on bilateral trade between Korea and Japan. Based on Korea's perspective, the Japan's demand for Korea's exports can be presented in log linear form as equation (1).

$$\ln XKR_{it} = a + b\ln YJP_t + c\ln REX_t + d\ln VOL_t + \varepsilon_t \qquad (1)$$

Equation (1) indicates that the volume of exports of product i from Korea (XKR_{it}) is determined by three major factors. First, Japan's income level (YJP_t), since the increase in Japanese income generally raises the demand for imports (exports from Korea), thus the expected sign of coefficient b is positive. Second, real bilateral exchange rate (REX_t) between KRW and JPY, the real depreciation of KRW improves the export competitiveness of Korean products, therefore the sign of coefficient c should be positive. Third, the volatility of the real bilateral exchange rate (VOL_t), according to the existing literature, the expected sign of coefficient d is uncertain. It can be either negative or positive value or no impact.

Equation (1) and its coefficients represent the long run relationship among the variables. The short run perspective can be incorporated into equation (1) by converting it into the form of autoregressive distributed lag (ARDL) cointegration model (Pesaran, Shin and Smith, 2001). For simplicity matter, let the lowercase denotes the natural logarithm of the uppercase: $xkr_{it} = \ln XKR_{it}$. As a result, a conditional ARDL-error correction model of equation (1) is obtained, as follows.

$$\Delta xkr_{it} = \pi + \sum_{j=1}^{n1}\gamma_j \Delta xkr_{it-j} + \sum_{j=0}^{n2}\delta_j \Delta yjp_{t-j} + \sum_{j=0}^{n3}\rho_j \Delta rex_{t-j} + \sum_{j=0}^{n4}\lambda_j \Delta vol_{t-j} + \alpha_1 xkr_{it-1} + \alpha_2 yjp_{t-1} + \alpha_3 rex_{t-1} + \alpha_4 vol_{t-1} + \mu_t \quad (2)$$

where $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ are the long run multipliers and $\triangle$ is the first difference operator which represent the short run dimension of the model. The n_1, n_2, n_3, n_4 are the optimal lag lengths which are chosen by minimizing the Akaike Information Criterion (AIC).

The long run relationship among the studied variables can be tested by conducting a cointegration test, based on equation (2). The joint significance of the long run multipliers is examined by applying an F-test on the null hypothesis of nonexistence of cointegration ($Ho: \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$) against an alternative hypothesis, $H1: \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq 0$.

Equation (2) can also be used to estimate the long run coefficients by imposing the condition that remove the short run dynamics from the equation. It can be accomplished by substituting all first difference terms with zero ($\triangle xkr = \triangle yjp = \triangle rex = \triangle vol = 0$). We will obtain equation (3).

$$xkr_{it} = \Omega_0 + \Omega_1 yjp_t + \Omega_2 rex_t + \Omega_3 vol_t + v_t \quad (3)$$

where,

$$\Omega_0 = -\pi/\alpha_1, \Omega_1 = -\alpha_2/\alpha_1, \Omega_2 = -\alpha_3/\alpha_1, \Omega_3 = -\alpha_4/\alpha_1$$

and v_t is error term.

Therefore, the long run coefficients can be estimated by using equation (3). The short run coefficients and the error correction term can be estimated by using an error correction model associated with equation (3), as stated in equation (4).

$$\Delta xkr_{it} = \pi + \sum_{j=1}^{n1}\gamma_j \Delta xkr_{it-j} + \sum_{j=0}^{n2}\delta_j \Delta yjp_{t-j} + \sum_{j=0}^{n3}\rho_j \Delta rex_{t-j} + \sum_{j=0}^{n4}\lambda_j \Delta vol_{t-j} + \vartheta ECT_{t-1} + \mu_t \quad (4)$$

where ECT_{t-1} is the one period lagged error correction term of equation (3). The $\gamma_j, \delta_j, \rho_j, \lambda_j$ are the short run coefficients and ϑ is the speed of adjustment to the long run equilibrium of the model.

Likewise, the Korea's import demand equation can be stated as equation (5).

$$\ln MKR_{it} = g + h\ln YKR_t + j\ln REX_t + k\ln VOL_t + \nu_t \quad (5)$$

The demand for imports of Korea from Japan of commodity i at period t (MKR_{it}) is also determined by three factors: Korea's income (YKR_t), the bilateral real exchange rate (REX_t) and the real exchange rate volatility (VOL_t). Consequently, the sign of h, j and k is expected to be positive, negative and unpredictable, respectively.

The conditional ARDL-error correction model of the import demand is specified as equation (6).

$$\Delta mkr_{it} = \chi + \sum_{j=1}^{n5}\zeta_j \Delta mkr_{it-j} + \sum_{j=0}^{n6}\phi_j \Delta ykr_{t-j} + \sum_{j=0}^{n7}\psi_j \Delta rex_{t-j} + \sum_{j=0}^{n8}\Omega_j \Delta vol_{t-j} + \beta_1 mkr_{it-1} + \beta_2 ykr_{t-1} + \beta_3 rex_{t-1} + \beta_4 vol_{t-1} + \eta_t \quad (6)$$

By substituting the first difference terms with zero into equation (6), the associated conditional long run model of demand for imports of Korea is presented as equation (7).

$$mkr_{it} = \omega_0 + \omega_1 ykr_t + \omega_2 rex_t + \omega_3 vol_t + v_t \qquad (7)$$

where,

$$\omega_0 = -\chi/\beta_1, \omega_1 = -\beta_2/\beta_1, \omega_2 = -\beta_3/\beta_1, \omega_3 = -\beta_4/\beta_1$$

and v_t is error term.

An error correction model associated with equation (7) of import demand can be expressed as equation (8).

$$\Delta mkr_{it} = \chi + \sum_{j=1}^{n5} \zeta_j \Delta mkr_{it-j} + \sum_{j=0}^{n6} \phi_j \Delta ykr_{t-j} + \sum_{j=0}^{n7} \psi_j \Delta rex_{t-j} + \sum_{j=0}^{n8} \Omega_j \Delta vol_{t-j} + \Psi ECT_{t-1} + \eta_t \qquad (8)$$

The $\zeta_j, \phi_j, \psi_j, \Omega_j$ are the short run coefficients and Ψ is the error correction term.

In summary, the cointegration test will be performed by using equation (2) and (6). In addition, the long run coefficients will be estimated under equation (3) and (7), whereas the short run coefficients and the error correction terms can be obtained by estimating equation (4) and (8), for exports and imports of Korea, respectively.

2. Data

This study employs annual time series data during 1970 to 2016. To avoid the aggregation bias problem, our study conducts at 3-digit level of SITC (Rev.1) industry. The 69 exporting and 57 importing commodities of Korea are analysed. They account for 94.65 and 96.02 per cent of total exports and imports of Korea vis-à-vis Japan, respectively. The details of commodities are presented in <Table 5> and <Table 8>. The export values (xkr_i) and import values (mkr_i) for each commodity, in U.S. dollars, are collected from the World Integrated Trade Solution (WITS) databases. We use the real value of exports (imports) in the estimation which is calculated by deflating each industry's export (import) value by the Korean export (import) prices index of all items (2010=100), due to the unavailability of annual price of each product. The data of export (import) price index are acquired from Bank of Korea. The income level of Korea (ykr) and Japan (yjp) are proxied by real gross domestic product (real GDP, 2010 U.S. dollars) which are obtained from IFS-IMF (International Financial Statistics of the International Monetary Fund). The real bilateral exchange rate between KRW and JPY (rex) is defined as $REX = E.P^{JP}/P^{KR}$ where E is nominal bilateral exchange rate as the number of KRW per one JPY (KRW/JPY), P^{JP} is consumer price index (CPI) of Japan and P^{KR} is CPI of Korea. As a result, increase in rex represents the real depreciation of the KRW against JPY which should induce higher exports from Korea to Japan and vice versa for appreciation. The series of nominal exchange rates (period-average) and CPI (all items index, 2010=100) are extracted from OECD.Stat databases (The Organisation for Economic Co-operation and Development). With regard to the real bilateral exchange rate volatility (vol), we follow Bahmani-Oskooee and Hegerty (2009) in that the volatility for each year is defined as standard deviation of the 12 monthly real exchange rate (rex) observations within that year. There is no general agreement on the best methodology to generate the volatility, provided that various methods are available.

Ⅳ. Estimation Results

1. Unit Root Test

One of the advantages of the ARDL approach is that it can be used to estimate the coefficients and perform the cointegtarion test simultaneously. Moreover, it allows the combination of I(0) and I(1) variables in the model, whereas the Engle and Granger (1987) and Johansen (1988/1995) methods of cointegration require that all variables have to be I(1). Given that the macroeconomic variables generally are either I(0) or I(1). Consequently, it does not really need to perform the unit root test for the studied variables. Nevertheless, we apply the Augmented Dickey-Fuller (ADF) tests to all studied variables to ensure that there is no I(2) variable in our data. <Table 2> summarizes the results of ADF tests.

The results from the ADF tests indicate that both the real bilateral exchange rate volatility (vol) and the real bilateral exchange rate (rex) are I(0) variables since they are stationary at level form, whereby the income of both countries (ykr, yjp) are I(1) variables. The exports (xkr) and imports (mkr) are either I(0) or I(1), as displayed in the <Table 2>. We also include total exports (tex) and total imports (tim) in our analysis in order to observe the aggregation bias problem. The ADF tests reveal that there is no I(2) variable in our study. This confirms that the ARDL model is justifiable in our study.

2. Bounds Test for Cointegration

Since our study scrutinizes the effects of exchange rate volatility on bilateral trade in both short run and long run, therefore, it is necessary that the studied variables have to be cointegrated in the long run. Thus, the

Table 2. Summary of the Augmented Dickey-Fuller (ADF) Tests

	Variable		
Integrated order	xkr	mkr	Other
I(0)	031, 048, 054, 099, 282, 284, 332, 513, 521, 541, 553, 581, 599, 629, 641, 642, 651, 653, 655, 656, 661, 664, 681, 682, 695, 698, 711, 714, 715, 719, 722, 723, 724, 732, 821, 841, 861, 893, 894, 931, **tex**	231, 512, 514, 533, 581, 611, 671, 698, 719, 732, 892	vol, rex
I(1)	032, 053, 055, 112, 231, 276, 292, 512, 514, 671, 672, 673, 674, 677, 678, 684, 689, 691, 693, 697, 718, 725, 729, 831, 851, 891, 892, 897, 899	031, 266, 282, 332, 513, 521, 531, 541, 553, 554, 599, 629, 641, 651, 653, 655, 663, 664, 665, 672, 673, 674, 678, 681, 682, 684, 689, 695, 711, 712, 714, 715, 717, 718, 722, 723, 724, 726, 729, 735, 861, 862, 891, 893, 894, 931, **tim**	ykr, yjp
I(2)	n/a	n/a	n/a

Notes: 1. The tests are performed at 10% level of significance.
2. The numbers in the table represent the SITC products at 3-digit level of industry (031=SITC031) and tex=total exports, tim=total imports.
3. The full details of the ADF tests are available upon request.

Table 3. Short Run and Long Run Coefficients of Export Demand Model

SITC	Industry	%	Short run coefficients				Long run coefficients		
			Δvol_t	Δvol_{t-1}	Δvol_{t-2}	Δvol_{t-3}	yjp_{t-1}	rex_{t-1}	vol_{t-1}
031	Fish, fresh/preserved	4.23	-0.07 b				0.86 b	-0.04	0.05
			(0.02)				(0.03)	(0.93)	(0.70)
032	Fish in airtight contain	0.77	-0.13 b				2.30 a	1.22 a	-0.18 b
			(0.02)				(0.00)	(0.00)	(0.02)
053	Fruit, preserved/ prep.	0.30	-0.04	0.08	0.35 a	-0.12	-1.20	-3.58	-1.87
			(0.69)	(0.45)	(0.00)	(0.26)	(0.86)	(0.19)	(0.28)
054	Vegetables, fresh/dried	0.48	-0.01	-0.22 b			-7.44	3.72	0.73
			(0.93)	(0.04)			(0.11)	(0.14)	(0.28)
099	Food preparat, n.e.s.	0.49	-0.11 c				11.98 a	-2.27	-0.87
			(0.09)				(0.00)	(0.20)	(0.17)
112	Alcoholic beverages	0.55	0.06				5.93 b	-0.62	0.19
			(0.58)				(0.04)	(0.71)	(0.59)
231	Crude rubber	0.27	-0.03	-0.74 b	0.38		21.85 a	-0.04	3.75
			(0.93)	(0.02)	(0.19)		(0.00)	(0.99)	(0.23)
276	Other crude minerals	0.20	0.11 b	0.07	-0.09 c		0.25	-1.49 b	0.18
			(0.03)	(0.16)	(0.10)		(0.74)	(0.02)	(0.27)
282	Iron and steel scrap	0.30	0.06				6.68 a	-1.15	-0.90
			(0.84)				(0.00)	(0.45)	(0.22)
284	Non-ferrou metal scrap	0.23	0.07				5.39 a	-3.27 a	0.48 b
			(0.62)				(0.00)	(0.00)	(0.05)
332	Petroleum products	12.6	-0.39				0.88	0.88	-0.39
			(0.14)				(0.55)	(0.30)	(0.14)
512	Organic chemicals	2.65	-0.01	0.01	-0.01	0.17 a	-1.06	1.60	-1.04 c
			(0.88)	(0.84)	(0.87)	(0.01)	(0.55)	(0.24)	(0.08)
513	Inorg. chemical elems.	0.48	0.09	-0.15	0.09	0.42 a	0.42	-0.72	-2.14
			(0.38)	(0.17)	(0.39)	(0.00)	(0.22)	(0.80)	(0.35)
521	Crude chemi from coal	0.52	0.04				0.36 a	1.46	0.18
			(0.76)				(0.01)	(0.29)	(0.76)
541	Medicinal/pharma prod.	0.49	-0.04	0.12 c	0.13 c		-1.52	-1.50	-1.15 c
			(0.54)	(0.10)	(0.07)		(0.23)	(0.12)	(0.06)
553	Perfumery, cosmetics	0.20	-0.32				-0.79	13.14 c	-2.10
			(0.31)				(0.22)	(0.06)	(0.34)
581	Plastic materials	2.63	-0.03	-0.15 c	0.13 c	0.13 c	0.47	1.40	-0.85
			(0.73)	(0.07)	(0.10)	(0.08)	(0.45)	(0.80)	(0.82)
629	Articles of rubber	0.41	0.01				-2.52 b	1.31 c	-0.47 c
			(0.91)				(0.04)	(0.09)	(0.08)
641	Paper and paperboard	0.38	-0.57 b	-0.24	0.20	0.47 b	-8.87 a	7.93 a	-3.76 a
			(0.02)	(0.22)	(0.30)	(0.02)	(0.01)	(0.01)	(0.01)
651	Textile yarn, thread	0.81	-0.10	0.02	0.22 b	-0.14	-1.84	-2.42	-0.75
			(0.28)	(0.83)	(0.02)	(0.14)	(0.51)	(0.18)	(0.37)
653	Text fabrics woven	1.08	-0.02				0.44 a	0.18	-0.36
			(0.69)				(0.00)	(0.74)	(0.18)
655	Special textile fabrics	0.33	0.05				0.42	1.57 a	0.06
			(0.65)				(0.58)	(0.00)	(0.65)
661	Lime, cement	0.65	-0.10 c	-0.09 c			2.82 a	-1.22	-0.27
			(0.06)	(0.10)			(0.00)	(0.21)	(0.33)
671	Pig iron, spiegeleisen	0.24	0.36	-0.19	0.79 a	0.43 c	-7.07	2.80	-2.73
			(0.18)	(0.49)	(0.00)	(0.08)	(0.19)	(0.65)	(0.35)
672	Ingots & primary iron	2.69	-0.04	-0.14	0.11	0.25	0.79 b	-2.78	0.30
			(0.86)	(0.47)	(0.56)	(0.18)	(0.03)	(0.41)	(0.89)
673	Iron/steel, bars/rods	0.62	0.04				6.24 a	-0.84	0.47 c
			(0.79)				(0.00)	(0.30)	(0.08)
674	Universals/plates iron	4.05	0.18				-0.01	7.37 b	0.67
			(0.57)				(0.96)	(0.04)	(0.56)
677	Iron & steel wire	0.62	-0.05	-0.04	0.26 a		2.18 b	1.54 c	-0.41 c
			(0.65)	(0.69)	(0.01)		(0.04)	(0.06)	(0.09)
678	Tubes, pipes iron	0.73	-0.06				3.85 a	-0.01	-0.11
			(0.48)				(0.00)	(0.99)	(0.49)

681	Silver/platinum metals	1.35	-0.10	-0.43 b	0.60 a	0.35 c	-12.9 a	2.49 b	-0.98
			(0.63)	(0.05)	(0.00)	(0.10)	(0.00)	(0.02)	(0.11)
682	Copper	0.53	0.05				1.03 b	-5.74	0.35
			(0.76)				(0.05)	(0.33)	(0.76)
684	Aluminium	0.39	0.08	0.23			5.33 b	0.10	-2.69 c
			(0.61)	(0.13)			(0.02)	(0.97)	(0.07)
689	Misc. non-ferrou metal	0.21	-0.16	-0.17	0.11	0.66 a	-4.14	0.36	-4.30 c
			(0.46)	(0.45)	(0.60)	(0.00)	(0.49)	(0.94)	(0.08)
693	Wire & fencing grills	0.22	0.17				5.38 a	-1.06	0.24
			(0.27)				(0.00)	(0.24)	(0.23)
695	Tools for hand/machin	0.31	0.09	0.14 c	0.05	0.12 c	-2.53 a	2.12 a	-0.45
			(0.30)	(0.10)	(0.58)	(0.09)	(0.01)	(0.00)	(0.11)
698	Manufactures of metal	0.68	0.00				-1.15	1.69 c	-0.52
			(0.96)				(0.43)	(0.08)	(0.13)
711	Power gener machine	0.62	0.18				9.32 a	-0.95	0.34
			(0.38)				(0.00)	(0.39)	(0.38)
714	Office machines	3.30	0.06				2.11	6.01 a	0.54
			(0.64)				(0.17)	(0.01)	(0.22)
715	Metalworking machine	0.27	-0.08				8.78 a	-4.16 a	0.32
			(0.72)				(0.00)	(0.00)	(0.47)
722	Elect power mach	1.71	-0.21 a	-0.16 a	0.08	0.11 b	0.41 a	-0.30	-2.18
			(0.00)	(0.00)	(0.13)	(0.03)	(0.01)	(0.85)	(0.16)
724	Telecommu apparatus	5.25	-0.11	-0.01	0.10 c	0.02	-1.12	12.51 b	-7.76
			(0.19)	(0.87)	(0.05)	(0.72)	(0.32)	(0.05)	(0.35)
725	Domestic electric equip	0.53	0.19	-0.05	0.46 b	0.03	3.90 c	2.81	-0.25
			(0.40)	(0.81)	(0.05)	(0.89)	(0.07)	(0.11)	(0.69)
729	Other electric machine	12.2	-0.16 a	0.03	0.24 a	0.08	4.03 b	1.37	-1.90 a
			(0.01)	(0.65)	(0.00)	(0.19)	(0.04)	(0.16)	(0.00)
732	Road motor vehicles	1.21	-0.13	0.05	0.27 a		0.91	1.38 b	-0.56 b
			(0.24)	(0.67)	(0.01)		(0.33)	(0.02)	(0.03)
821	Furniture	0.37	-0.11				2.62 b	0.66	-0.27
			(0.16)				(0.05)	(0.39)	(0.19)
831	Travel goods, handbag	0.61	-0.10				7.47 c	0.32	0.31
			(0.20)				(0.06)	(0.93)	(0.77)
841	Clothing except fur	5.51	-0.04				3.25 a	1.36 c	-0.13
			(0.50)				(0.01)	(0.09)	(0.52)
851	Footwear	0.95	0.07	-0.12	-0.12		0.65 b	-0.12	3.25 c
			(0.38)	(0.16)	(0.14)		(0.04)	(0.96)	(0.07)
861	Scientific meas. instru	2.23	-0.16	-0.29 c	0.33 b	0.25 c	-0.07	3.39	-3.98 b
			(0.26)	(0.07)	(0.03)	(0.07)	(0.80)	(0.12)	(0.05)
891	Musical instruments	1.90	-0.05				2.01 c	2.66 a	-0.10
			(0.61)				(0.10)	(0.00)	(0.60)
892	Printed matter	0.21	-0.07				-3.19	3.02 c	-0.20
			(0.54)				(0.16)	(0.07)	(0.54)
893	Artificial plastic	0.80	0.01				-1.62	3.23 a	-0.26
			(0.90)				(0.24)	(0.00)	(0.32)
894	Perambulators, toys	0.65	-0.10 c				3.54 a	1.49 a	-0.04
			(0.08)				(0.00)	(0.00)	(0.71)
897	Jewellery gold/silver	0.22	-0.17 a	0.01	0.11 b		-0.32	1.53 a	-0.53 a
			(0.00)	(0.92)	(0.04)		(0.69)	(0.00)	(0.01)
931	Special transactions	2.37	-0.10				0.55 a	0.06	-0.58
			(0.28)				(0.00)	(0.97)	(0.32)
tex	Total exports	1.00	-0.06 c	-0.05	0.08 b		-0.12	0.81 a	-0.16
			(0.10)	(0.14)	(0.02)		(0.77)	(0.01)	(0.15)

Notes: 1. Statistical significance is denoted as a, b, c for 1%, 5%, 10%, respectively (P-values are in parenthesis).
2. % indicates share of each exporting industry to total exports in per cent.

cointegration tests are performed by using the F-test. There are two critical values in the bounds test, upper-bound and lower-bound critical value (Pesaran, Shin and Smith, 2001). The cointegration among the variables is established if the calculated F-statistic from the model is bigger than the upper-bound critical value, whereas the cointegration does not exist if it is smaller than the lower-bound critical value.

The results of cointegration tests are displayed in <Table 5> for export demand model. It reveals that the studied variables are cointegrated in 55 out of 69 Korean exporting commodities. The results for import demand model are presented in <Table 8> which suggest that 45 out of 57 products are cointegrated. As a result, the estimation for short run and long run coefficients will be conducted only in 55 and 45 of Korean exporting and importing industries vis-à-vis Japan, respectively.

3. The Short Run and Long Run ARDL Model

3.1. Export Demand Model

This section reports the coefficients from the estimations. The long run coefficients are obtained from equation (3) and (7) and the short run coefficients are estimated using equation (4) and (8) for exports and imports of Korea, respectively. The lag lengths n

Table 4. Summary of Affected Exporting Industries

		Short run impact				
Negative impact		Positive impact		Mixed impact		No impact
SITC	Industry	SITC	Industry	SITC	Industry	
031	Fish, fresh/preserved	053	Fruit, preserved/ prep.	276	Other crude minerals	The other
032	Fish in airtight contain	512	Organic chemicals	581	Plastic materials	28 industries
054	Vegetables, fresh/dried	513	Inorg. chemical elems.	641	Paper and paperboard	
099	Food preparation	541	Medicinal/pharma prod.	681	Silver/platinum metals	
231	Crude rubber	651	Textile yarn, thread	722	Elect power mach	
661	Lime, cement	671	Pig iron, spiegeleisen	729	Other electric machine	
894	Perambulators, toys	677	Iron & steel wire	861	Scientific meas. instru	
		689	Misc. non-ferrous metal	897	Jewellery gold/silver	
		695	Tools for hand/machin	tex	Total exports	
		724	Telecommu apparatus			
		725	Domestic electric equip			
		732	Road motor vehicles			
		Long run impact				
Negative impact		Positive impact		Mixed impact		No impact
SITC	Industry	SITC	Industry	SITC	Industry	
032	Fish in airtight contain	284	Non-ferrou metal scrap	n/a	n/a	The other
512	Organic chemicals	673	Iron/steel, bars/rods			40 industries
541	Medicinal/pharma prod.	851	Footwear			and tex
629	Articles of rubber					
641	Paper and paperboard					
677	Iron & steel wire					
684	Aluminium					
689	Misc. non-ferrou metal					
729	Other electric machine					
732	Road motor vehicles					
861	Scientific meas. instru					
897	Jewellery gold/silver					

($n_1 - n_4$ for export demand and $n_5 - n_8$ for import demand model) are chosen by minimizing the AIC. We follow Bahmani-Oskooee and Zhang (2014) by imposing a maximum of four lags in the estimation. The coefficient estimates of exports are presented in <Table 3>. All three long run coefficient estimates are reported, whereas only short run coefficients of exchange rate volatility are presented owing to the large volume of the empirical results.

For simplicity purpose, <Table 3> is summarized as <Table 4>. The <Table 4> presents the impact of exchange rate volatility on the industries which show cointegration among the studied variables according to <Table 5>.

The results of the short run coefficients of exchange rate volatility reveal that, there is at least one significant short run coefficient in 27 out of 55 industries (positive effect in 12 industries, negative effect in 7 industries, mixed effect over time in 8 industries). In the long run, the negative impacts of exchange rate volatility are found in 12 industries, which are SITC032 (fish in airtight containers), SITC512 (organic chemicals), SITC541 (medicinal and pharmaceutical products), SITC629 (articles of rubber), SITC641 (paper and paperboard), SITC677 (iron and steel wire), SITC684 (aluminium), SITC689 (non-ferrous base metals), SITC729 (other electrical machinery), SITC732 (road motor vehicles), SITC861 (scientific measuring instruments) and SITC897 (jewellery and goldsilver wares). The 12 affected industries constitute 21.73 per cent of total exports from Korea to Japan. They include the second biggest exporting products of Korea to Japan, other electrical machinery and apparatus (SITC729), which make up 12.15 per cent.

The study at 1-digit level of SITC industry by Baek Jung-Ho (2013) on exports from Korea to Japan asserted that only the products of SITC6 (manufactured goods classified chiefly by material), which accounts for approximately 20.73 per cent of total exports to Japan, are negatively affected by the exchange rate volatility. Our empirical results are in line with his works in that 5 out of 12 industries, negatively affected by volatility, are SITC6 products. In addition, in terms of export shares, the affected industries from our findings account for 21.73 per cent of total exports from Korea to Japan which are almost similar to the findings of Baek Jung-Ho (2013). Nevertheless, the affected products from our studies are not only the SITC6 commodities, but also the SITC0, SITC5, SITC7 and SITC8 products.

In addition, our empirical results indicate that the positive impacts of exchange rate volatility are found in 3 industries in the long run, which are SITC284 (non ferrous metal scrap), SITC673 (iron and steel bars-rods shapes) and SITC851 (footwear) products. They constitute only 1.81 per cent of total exports to Japan.

Although our works examine the impact of exchange rate volatility on exporting products at 3-digit level of SITC commodities, we also investigate the effect of volatility on aggregate level to observe the aggregation bias problem. The empirical results indicate that while the volatility shows mixed impact over time in the short run on total exports from Korea to Japan, it has no impact in the long run. The insignificant impact of volatility in the long run on total exports, whereas the empirical findings show both negative and positive impact on exporting products at 3-digit level of industry, reflects the aggregation bias

Table 5. Diagnostic Statistics of Export Demand Model

SITC	Industry	Bound	Coint	ECM_{t-1}		LM	RESET	CS	CSS	R^2
031	Fish, fresh & simply preserved	8.68	y	-0.28	(0.00)	1.52	0.02	S	S	0.83
032	Fish, in airtight containers, nes	6.24	y	-0.70	(0.00)	0.23	0.79	S	S	0.46
048	Cereal/flour preps of fruits, vegs	1.67	n							
053	Fruit, preserved & preparations	7.40	y	-0.22	(0.07)	1.85	1.41	S	S	0.72
054	Vegetables, roots, fresh/dried	4.92	y	-0.30	(0.04)	2.06	1.04	S	S	0.61
055	Vegetables, roots, pres or n.e.s.	2.68	n							
099	Food preparations, n.e.s.	9.12	y	-0.12	(0.01)	1.58	0.50	S	S	0.83
112	Alcoholic beverages	6.74	y	-0.33	(0.00)	0.03	1.60	US	US	0.54
231	Crude rubber incl. synthetic	7.49	y	-0.23	(0.03)	0.32	0.38	S	S	0.58
276	Other crude minerals	6.32	y	-0.54	(0.00)	2.75	0.24	S	S	0.63
282	Iron and steel scrap	6.26	y	-0.61	(0.00)	0.42	0.88	S	S	0.40
284	Non ferrous metal scrap	6.57	y	-0.79	(0.00)	0.20	0.61	S	S	0.58
292	Crude vegetable materials, n.e.s	1.61	n							
332	Petroleum products	5.85	y	-0.99	(0.00)	1.70	1.91	S	US	0.52
512	Organic chemicals	5.25	y	-0.32	(0.00)	0.02	3.69	S	S	0.67
513	Inorg. chemicals elems., oxides	4.11	y	-0.10	(0.01)	0.46	2.10	S	S	0.77
514	Other inorganic chemicals	1.75	n							
521	Crude chemicals from coal/gas	5.97	y	-0.23	(0.00)	1.73	1.77	S	S	0.33
541	Medicinal & pharmaceu products	7.74	y	-0.43	(0.01)	0.34	0.76	S	S	0.77
553	Perfumery, cosmetics, dentifrices	3.31	y	-0.15	(0.01)	0.21	0.12	S	S	0.30
581	Plastic materials, cellulose/resins	8.21	y	-0.04	(0.16)	0.01	1.20	S	S	0.63
599	Chemical materials n.e.s.	0.99	n							
629	Articles of rubber, n.e.s.	20.53	y	-0.40	(0.00)	1.72	0.01	S	S	0.85
641	Paper and paperboard	7.13	y	-0.56	(0.01)	0.18	0.56	S	S	0.85
642	Articles of paper, pulp	0.13	n							
651	Textile yarn and thread	6.98	y	-0.32	(0.02)	0.20	0.63	S	S	0.70
653	Text fabrics woven, not cotton	5.63	y	-0.30	(0.00)	0.50	0.19	S	S	0.71
655	Special textile fabrics, n.e.s.	11.97	y	-0.81	(0.00)	0.41	3.57	S	S	0.72
656	Made up articles, wholly/chiefly	0.37	n							
661	Lime, cement & fabr. bldg. mat.	7.74	y	-0.29	(0.00)	0.33	2.87	S	S	0.79
664	Glass	1.24	n							
671	Pig iron, spiegeleisen	4.37	y	-0.22	(0.02)	0.33	0.21	S	S	0.59
672	Ingots & primary forms of iron	8.22	y	-0.27	(0.00)	0.76	1.56	S	S	0.80
673	Iron and steel bars/rods shapes	7.40	y	-0.83	(0.00)	0.22	4.89	S	S	0.71
674	Universals, plates/sheets of iron	4.52	y	-0.26	(0.00)	0.04	29.09	US	S	0.70
677	Iron & steel wire, excl wire rod	11.47	y	-0.76	(0.00)	1.06	1.96	S	S	0.86
678	Tubes, pipes and fittings of iron	6.97	y	-0.58	(0.00)	3.69	1.36	S	S	0.74
681	Silver and platinum metals	8.44	y	-0.82	(0.00)	4.28	1.69	S	S	0.63
682	Copper	11.15	y	-0.14	(0.01)	1.24	1.61	S	S	0.76
684	Aluminium	4.30	y	-0.19	(0.01)	0.00	0.14	S	S	0.58
689	Miscell. non-ferrous base metals	5.45	y	-0.29	(0.01)	0.70	0.13	S	S	0.73
691	Finished structural parts n.e.s.	1.73	n							
693	Wire products & fencing grills	4.18	y	-0.72	(0.00)	0.02	2.75	S	S	0.68
695	Tools for use in hand/machines	7.17	y	-0.58	(0.00)	10.0	1.72	S	S	0.76
697	Household equip of base metals	2.55	n							
698	Manufactures of metal, n.e.s.	4.79	y	-0.37	(0.00)	0.01	0.11	S	S	0.78
711	Power generating machinery	6.15	y	-0.53	(0.00)	1.03	0.44	S	US	0.38
714	Office machines	5.77	y	-0.41	(0.00)	3.80	0.02	S	S	0.82
715	Metalworking machinery	7.81	y	-0.64	(0.00)	0.00	2.18	S	S	0.61
718	Machines for special industries	1.05	n							
719	Machinery non electrical parts	2.00	n							
722	Elect power mach & switchgear	5.71	y	-0.10	(0.08)	0.77	1.84	S	S	0.81
723	Equip for distributing electricity	1.23	n							
724	Telecommunications apparatus	17.51	y	-0.07	(0.02)	0.45	3.06	S	S	0.93
725	Domestic electrical equipment	5.43	y	-0.88	(0.00)	0.15	42.41	S	S	0.82
729	Other electrical machinery	12.84	y	-0.36	(0.00)	0.01	0.61	S	S	0.86
732	Road motor vehicles	23.32	y	-0.77	(0.00)	1.98	0.68	S	S	0.81
821	Furniture	9.72	y	-0.43	(0.00)	1.87	0.10	S	US	0.76
831	Travel goods, handbags	3.85	y	-0.09	(0.02)	0.43	0.72	S	S	0.72
841	Clothing except fur clothing	5.58	y	-0.33	(0.00)	0.91	0.23	S	S	0.82
851	Footwear	5.81	y	-0.10	(0.01)	0.33	1.78	S	S	0.77
861	Scientific, medic, meas. instrum.	3.90	y	-0.19	(0.01)	0.71	2.81	S	S	0.54
891	Musical instruments	9.49	y	-0.44	(0.00)	1.23	2.86	S	US	0.57
892	Printed matter	4.64	y	-0.33	(0.01)	0.12	0.00	S	S	0.32
893	Articles of artificial plastic	7.27	y	-0.45	(0.00)	2.73	0.96	S	S	0.59
894	Perambulators, toys, games	4.50	y	-0.72	(0.00)	0.92	1.46	S	S	0.77
897	Jewellery and gold/silver wares	10.82	y	-0.49	(0.00)	0.10	1.66	S	S	0.80
899	Manufactured articles, n.e.s.	2.50	n							
931	Special transactions not classd.	8.72	y	-0.17	(0.00)	0.33	1.97	S	S	0.69
tex	Total exports	11.15	y	-0.56	(0.00)	0.17	3.00	S	S	0.77

Notes: 1. Bound=F-statistic from the bounds test, Coint=Cointegration existence, y=Yes, n=No, LM=LM statistic, RESET=Chi-square statistic, CS=CUSUM, CSS=CUSUM of Squares, S (US)=Stable (Unstable) at 5% level of significance, R^2=Goodness of fit.

2. ECM_{t-1} represents coefficient or speed of adjustment, with p-values in parentheses.

problem when the data at aggregate level are used in the analysis.

The long run coefficients also exhibit that Japan's income shows significant positive effects in 29 out of 55 exporting industries, although the negative impacts are found in 4 industries. The income plays no role on 22 industries. Consequently, the role of income on exports complies with the prediction of export demand model. Finally, the real exchange rate exhibits positive coefficient in 19 industries, while 3 industries display the negative values. This indicates that a real depreciation of KRW against JPY raises exports from Korea to Japan only in 19 (out of 55) industries. The effects of real exchange rate are not detected in exports of the other 33 industries.

The results from diagnostic tests of the ARDL model for the industries which the cointegration exist (55 out of 69 industries) are presented in <Table 5>. The coefficients of the ECM_{t-1} present negative values and less than 1 in all 55 industries, with only 3 insignificant coefficients at 5 per cent level of significance. This ascertain that the deviation from the long run equilibrium is adjusted toward the equilibrium point in almost industries. The Breusch-Godfrey serial correlation LM test indicates that the LM statistic is insignificant at 5 per cent level of significance in 53 industries, implying that the optimum models in our study are free from autocorrelation problem. The chi-square statistic from the Ramsey's RESET test displays the insignificant value in 52 industries, indicating that the models are precisely specified at 5 per cent level of significance. Finally, the stability tests are performed for both short run and long run coefficients through the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residual (CUSUM of Squares). By denoting the stable models with "S" and unstable ones with "US", the results in <Table 5> reveal that most of the coefficients are stable. The values of R^2 suggest that the models are justify regarding the goodness of fit, generally.

3.2. Import Demand Model

The short run and long run coefficients of 45 industries which Korea imports from Japan are presented in <Table 6>.

The impact of exchange rate volatility in <Table 6> is simplified into <Table 7>. The <Table 7> indicates the affected importing industries of Korea. Only the industries which pass the cointegration tests, based on <Table 8>, are presented in <Table 7>.

The short run coefficients reveal that there are 29 affected importing industries from the volatility of exchange rate (positive effect in 12 industries, negative effect in 13 industries, mixed effect over time in 4 industries). These 29 affected industries reduce to 14 industries in the long run. The 11 industries are negatively affected by the exchange rate volatility, which are SITC533 (pigments and paints), SITC629 (articles of rubber), SITC665 (glassware), SITC674 (universals, plates, sheets of iron and steel), SITC698 (manufactures of metal), SITC719 (machinery non electrical parts), SITC732 (road motor vehicles), SITC861 (scientific measuring instruments), SITC862 (photographic supplies), SITC891 (musical instruments) and SITC893 (articles of artificial plastic).

The findings at 1-digit level of SITC products from Baek Jung-Ho (2013) postulated that machinery and transport equipment

Table 6. Short Run and Long Run Coefficients of Import Demand Model

SITC	Industry	%	Short Run Coefficients				Long Run Coefficients		
			Δvol_t	Δvol_{t-1}	Δvol_{t-2}	Δvol_{t-3}	ykr_{t-1}	rex_{t-1}	vol_{t-1}
231	Crude rubber	0.37	-0.12 b	-0.09 b	0.14 b	-0.12 b	0.78 a	-1.28 b	-0.15
			(0.03)	(0.03)	(0.02)	(0.03)	(0.00)	(0.02)	(0.54)
512	Organic chemicals	6.32	0.04	0.09 c	0.05		-0.57	1.14	-0.27
			(0.42)	(0.06)	(0.19)		(0.45)	(0.11)	(0.28)
514	Other inorganic chemicals	0.44	-0.05				1.93 a	-3.48 c	-0.26
			(0.23)				(0.01)	(0.07)	(0.35)
521	Crude chemical from coal	0.68	-0.76 a	0.48 b	0.24	0.12	0.72 a	-4.58 b	-4.72
			(0.01)	(0.04)	(0.33)	(0.58)	(0.01)	(0.04)	(0.11)
531	Synth. organic dye stuffs	0.25	-0.04	-0.10	0.00	-0.09	1.02 a	-1.30 b	0.31
			(0.54)	(0.11)	(0.99)	(0.14)	(0.00)	(0.02)	(0.34)
533	Pigments, paints	0.93	-0.07	0.11 b	0.16 a	0.15 a	-1.05	2.21	-0.94 c
			(0.21)	(0.04)	(0.00)	(0.01)	(0.34)	(0.11)	(0.06)
541	Medicinal/pharma product	0.44	-0.08 c				2.11 a	-0.55	-0.17 c
			(0.07)				(0.00)	(0.12)	(0.10)
553	Perfumery, cosmetics	0.27	0.06				3.18 b	0.30	0.10
			(0.75)				(0.02)	(0.78)	(0.75)
554	Soaps, cleansing preps.	0.27	-0.03				1.09 a	-0.62 b	-0.06
			(0.45)				(0.00)	(0.02)	(0.50)
581	Plastic materials & resins	4.80	-0.13 a	0.08 b			1.15 b	-2.25	3.81
			(0.00)	(0.05)			(0.05)	(0.46)	(0.34)
611	Leather	0.21	-0.06	-0.23 a	-0.22 a	-0.23 a	-1.89 a	-0.85	2.47 a
			(0.40)	(0.01)	(0.01)	(0.01)	(0.00)	(0.56)	(0.00)
629	Articles of rubber, n.e.s.	0.32	-0.19 a				2.86 a	0.27	-0.33 a
			(0.00)				(0.00)	(0.41)	(0.01)
641	Paper and paperboard	0.40	0.01	-0.03	-0.08 c	-0.12 a	1.59 a	-1.57 c	0.90
			(0.80)	(0.57)	(0.10)	(0.01)	(0.00)	(0.10)	(0.11)
651	Textile yarn and thread	0.44	-0.06	-0.01	-0.02	-0.15 c	1.03 a	-4.76 b	1.00
			(0.50)	(0.88)	(0.77)	(0.07)	(0.00)	(0.03)	(0.34)
653	Text fabrics woven	0.59	-0.05	-0.12 a			0.64 a	-1.83 c	0.05
			(0.23)	(0.01)			(0.00)	(0.08)	(0.92)
655	Special textile fabrics	0.29	-0.07 c	-0.06			0.55 a	0.45	0.17
			(0.06)	(0.14)			(0.00)	(0.34)	(0.41)
664	Glass	1.45	-0.10				1.13 a	0.71	-1.42
			(0.13)				(0.01)	(0.54)	(0.17)
665	Glassware	0.23	-0.18	0.43 a			6.56 a	-4.14 b	-1.52 b
			(0.24)	(0.01)			(0.00)	(0.04)	(0.02)
673	Iron/steel bars/rods shape	1.63	0.06				0.54 a	0.03	-0.40
			(0.33)				(0.00)	(0.95)	(0.17)
674	Universals/plates iron/steel	3.81	-0.04	0.12 b	0.14 b		0.81 a	1.17	-1.74 c
			(0.51)	(0.05)	(0.04)		(0.01)	(0.28)	(0.08)
678	Tubes, pipes iron/steel	0.80	0.02	0.07			0.88 a	0.26	-0.42
			(0.83)	(0.29)			(0.00)	(0.63)	(0.19)
684	Aluminium	0.40	-0.09	-0.12 c			2.33 a	0.60	-0.20
			(0.19)	(0.09)			(0.00)	(0.30)	(0.19)
689	Mis. non-ferrous metals	0.31	-0.06	0.17 c	0.19 b		-4.28	32.66	-20.42
			(0.49)	(0.07)	(0.04)		(0.67)	(0.63)	(0.64)

695	Tool use in hand/machine	0.44	-0.08				1.60 a	-0.83	-0.24
			(0.32)				(0.00)	(0.38)	(0.36)
698	Manufactures of metal	0.47	-0.02	0.15 a	0.10 b		0.53 a	0.28	-0.45 a
			(0.60)	(0.00)	(0.03)		(0.00)	(0.17)	(0.00)
711	Power generate machine	1.97	0.09	0.12	0.03	-0.14 c	-1.08	1.20	0.20
			(0.25)	(0.13)	(0.75)	(0.08)	(0.37)	(0.29)	(0.52)
712	Agricultural machinery	0.26	0.22 c				2.55 b	-2.18 b	0.50 c
			(0.07)				(0.03)	(0.03)	(0.07)
714	Office machines	1.37	-0.05				4.40 a	0.03	-0.15
			(0.59)				(0.00)	(0.98)	(0.60)
715	Metalworking machinery	2.05	0.00	0.18	0.19		-0.86	1.74	-0.76
			(0.97)	(0.12)	(0.12)		(0.69)	(0.30)	(0.16)
717	Textile & leather machine	0.84	0.15	-0.05	-0.26 a		0.54 a	0.33	1.66 b
			(0.13)	(0.60)	(0.01)		(0.00)	(0.79)	(0.04)
718	Mach. for special industry	1.12	0.06	0.11	0.05	-0.19 a	1.61 a	-1.04	0.67
			(0.45)	(0.13)	(0.55)	(0.01)	(0.01)	(0.48)	(0.33)
719	Machine non electric part	12.7	0.02	0.14 b	0.10		1.29 a	0.50	-0.45 b
			(0.79)	(0.03)	(0.15)		(0.01)	(0.23)	(0.04)
722	Electric power machinery	4.65	-0.01	0.15 a			1.14 c	0.76	-0.34
			(0.75)	(0.00)			(0.09)	(0.14)	(0.15)
723	Equip for distrib electricity	0.30	0.11 c	0.16 a			0.42 a	0.42	-0.14
			(0.08)	(0.01)			(0.00)	(0.66)	(0.77)
724	Telecommunica apparatus	1.62	-0.08				0.37 a	1.52	-0.43
			(0.34)				(0.01)	(0.22)	(0.36)
726	Elec. app. medical purp.	0.29	0.05	0.04	0.05	-0.32 a	0.75 b	-1.25	1.57
			(0.60)	(0.62)	(0.59)	(0.00)	(0.04)	(0.67)	(0.26)
729	Other electrical machinery	12.3	-0.02				0.84 a	3.16 a	-0.06
			(0.71)				(0.00)	(0.00)	(0.71)
732	Road motor vehicles	2.46	-0.01	0.26 a	0.08		0.85 a	0.72	-0.83 a
			(0.87)	(0.01)	(0.38)		(0.00)	(0.12)	(0.01)
861	Scientific meas. instrum.	5.62	-0.13 a				2.58 a	1.22 b	-0.53 a
			(0.01)				(0.00)	(0.03)	(0.00)
862	Photographic supplies	1.15	-0.02				3.21 a	0.24	-0.49 c
			(0.45)				(0.00)	(0.74)	(0.09)
891	Musical instruments	1.12	-0.13 b				0.32 a	1.20	-1.22 b
			(0.02)				(0.00)	(0.12)	(0.02)
892	Printed matter	0.51	-0.20 a	0.04	0.18 a	0.11 c	0.39	1.36	-3.77
			(0.00)	(0.55)	(0.00)	(0.08)	(0.59)	(0.42)	(0.11)
893	Articles of artificial plastic	0.34	-0.07				1.09 a	0.55	-0.48 b
			(0.13)				(0.00)	(0.24)	(0.05)
894	Perambulators toys/games	0.42	-0.04				1.52 a	0.22	-0.47
			(0.50)				(0.00)	(0.69)	(0.11)
931	Special transactions	3.38	-0.07	-0.09			0.01	5.40	-1.71
			(0.25)	(0.13)			(0.98)	(0.19)	(0.36)
tim	Total imports	1.00	-0.01	0.09 a	0.06 b		0.84 a	0.72 a	-0.45 a
			(0.65)	(0.00)	(0.04)		(0.00)	(0.00)	(0.00)

Notes: 1. Statistical significance is denoted as a, b, c for 1%, 5%, 10%, respectively (P-values are in parenthesis).
2. % indicates share of each importing industry to total imports in per cent.

(SITC7) and chemicals and related products (SITC5) were affected by volatility negatively. These two product groups represent 61.28 per cent of total imports from Japan. However, the 11 affected industries from our studies including SITC5, SITC6 (manufactured goods classified chiefly by material), SITC7 and SITC8 (miscellaneous manufactured articles), constitute only 29.14 per cent of Korea's imports from Japan. Nonetheless, the empirical results from our study are consistent with Baek Jung-Ho (2013) in that the commodities from SITC7 are the most negatively affected by the volatility, in terms of import shares (15.15 per cent out of 29.14 per cent). This includes the largest importing products of Korea from Japan, machinery and appliances non electrical parts (SITC719), which account for 12.69 per cent.

The 3 industries which are positively

Table 7. Summary of Affected Importing Industries

Short Run Impact						
Negative impact		Positive Impact		Mixed Impact		No Impact
SITC	Industry	SITC	Industry	SITC	Industry	
541	Medicinal/phar product	512	Organic chemicals	231	Crude rubber	The other
611	Leather	533	Pigments, paints	521	Crude chem from coal	16 industries
629	Articles of rubber nes.	665	Glassware	581	Plastic materials/resins	
641	Paper and paperboard	674	Universals iron/steel	892	Printed matter	
651	Textile yarn & thread	689	Mis. non-ferrous metals			
653	Text fabrics woven	698	Manufactures of metal			
655	Special textile fabrics	712	Agricultural machinery			
684	Aluminium	719	Machine non electr part			
711	Power gener machine	722	Electric power machine			
717	Textile/leather machine	723	Equip distribu electricity			
718	Mach. special industry	732	Road motor vehicles			
726	Elec. app. medical pur	861	Scientific meas. instrum			
891	Musical instruments	tim	Total imports			
Long Run Impact						
Negative Impact		Positive Impact		Mixed Impact		No Impact
SITC	Industry	SITC	Industry	SITC	Industry	
533	Pigments, paints	611	Leather	n/a	n/a	The other
629	Articles of rubber, nes.	712	Agricultural machinery			31 industries
665	Glassware	717	Textile/leather machine			
674	Universals iron/steel					
698	Manufactures of metal					
719	Machine non elec part					
732	Road motor vehicles					
861	Scientific meas. instru					
862	Photographic supplies					
891	Musical instruments					
893	Articles artificial plastic					
tim	Total imports					

affected by volatility constitute only 1.32 per cent of total imports from Japan. They are leather (SITC611), agricultural machinery and implements (SITC712) and textile and leather machinery (SITC717).

While the analysis at 3-digit level of industry reveals that 11 and 3 industries are negatively and positively affected by the exchange rate volatility, respectively, the empirical result at the aggregate level indicates that the volatility gives negative impact on total imports in the long run. The negative effects from volatility on total imports can be explained by the empirical results at 3-digit level of product. Since the numbers of negatively affected industries (11 industries) are significantly higher than the numbers of positively affected industries (3 industries), the positive effects in 3 industries are cancelled out by the negative effects from 11 industries. As a result, the net impact of exchange rate volatility on total imports is negative. This evidence also indicates the existence of the aggregation bias problem when the analysis is conducted by using the aggregate trade data.

Korea's income exhibits positive effects remarkably in most of importing industries (37 out of 45 industries), with only one negative impact on leather (SITC611). The income has insignificant role only on 7 industries. Therefore, a rise in Korea's income induces more imports from Japan significantly. The distinct role of Korea's income on imports (37 out of 45 industries) relative to the role of Japanese income on exports (29 out of 55 industries) might be connected to the instability of Japanese economy for several decades. While Korea's income exhibits the notable role on imports, the real exchange rate shows weak effects on imports considerably. A real depreciation of KRW against JPY lowers imports of Korea from Japan only in 10 (out of 45) industries, while the real exchange rate plays no role on the imports of 33 industries. The positive effects are found in 2 industries. The little role of real exchange rate on imports is analogous to the case of exports.

The diagnostic statistics for importing industries which the cointegration exist (45 out of 57 industries) are presented in <Table 8>. The coefficients of ECM_{t-1} show negative values and less than 1 in 44 industries, whereas one industry gives insignificant positive value. There are 9 insignificant coefficients at 5 per cent level of significance. Nevertheless, the number of insignificant coefficients reduces from 9 to only 3 at 10 per cent level of significance. The LM statistics indicate that 43 (out from 45) industries are free from autocorrelation problem at 5 per cent level of significance. The Ramsey's RESET tests indicate that the estimating models of 42 industries are correctly specified at 5 per cent level of significance. Most of the coefficients are stable, according to the results from the CUSUM and CUSUM of Squares. Finally, the values of R^2 suggest that most of the models are fit.

3.3. Comparison of the Research Findings

The empirical results from our study at the 3-digit level of industry indicate that the exchange rate volatility affects the exporting and importing products of Korea vis-à-vis Japan in both short run and long run. In addition, the numbers of affected industries in the short run reduced in the long run. The majority of industries are unaffected in the long run. These findings are in line with the works of Bahmani-Oskooee, Hegerty and

Table 8. Diagnostic Statistics of Import Demand Model

SITC	Industry	Bound	Coint	ECM_{t-1}		LM	RESET	CS	CSS	R^2
031	Fish, fresh & simply preserved	2.59	n							
231	Crude rubber incl. synthetic	7.24	y	-0.48	(0.00)	3.56	1.03	S	S	0.89
266	Synthetic & regener artifici fibres	1.28	n							
282	Iron and steel scrap	2.44	n							
332	Petroleum products	2.60	n							
512	Organic chemicals	4.75	y	-0.40	(0.00)	2.64	1.44	S	S	0.60
513	Inorg. chemicals elems. oxides	1.41	n							
514	Other inorganic chemicals	5.55	y	-0.18	(0.07)	1.17	1.37	S	S	0.68
521	Crude chemicals from coal/gas	5.65	y	-0.31	(0.02)	0.03	0.23	S	S	0.69
531	Synth. organic dye stuffs, lakes	7.66	y	-0.43	(0.00)	0.73	1.71	S	S	0.74
533	Pigments, paints, varnishes mat.	8.00	y	-0.85	(0.07)	0.05	0.12	S	S	0.84
541	Medicinal/pharmaceutical products	5.43	y	-0.45	(0.00)	0.32	0.76	S	S	0.60
553	Perfumery, cosmetics, dentifrices	5.61	y	-0.59	(0.00)	1.24	3.10	S	US	0.37
554	Soaps, cleansing/polishing preps.	4.75	y	-0.54	(0.00)	0.97	0.02	S	S	0.78
581	Plastic materials & resins	3.94	y	0.06	(0.33)	0.14	3.83	S	S	0.73
599	Chemical materials, n.e.s.	2.01	n							
611	Leather	11.55	y	-0.31	(0.00)	2.35	2.67	S	S	0.82
629	Articles of rubber, n.e.s.	6.53	y	-0.79	(0.00)	3.00	0.04	S	S	0.49
641	Paper and paperboard	5.70	y	-0.29	(0.01)	0.05	1.91	S	S	0.79
651	Textile yarn and thread	5.53	y	-0.16	(0.00)	2.18	1.02	S	S	0.78
653	Text fabrics woven, not cotton	3.83	y	-0.13	(0.00)	0.13	0.03	S	S	0.71
655	Special textile fabrics	8.41	y	-0.29	(0.00)	0.15	0.02	S	S	0.79
663	Mineral manufactures, n.e.s.	1.54	n							
664	Glass	3.92	y	-0.18	(0.05)	0.41	0.01	S	S	0.68
665	Glassware	7.48	y	-0.53	(0.00)	0.23	1.35	S	S	0.68
671	Pig iron, spiegeleisen	2.10	n							
672	Ingots & other primary iron/steel	0.73	n							
673	Iron/steel bars, rods, shapes	3.59	y	-0.29	(0.00)	3.38	1.32	S	S	0.61
674	Universals/plates/sheets iron/steel	5.90	y	-0.26	(0.06)	0.23	2.72	S	S	0.73
678	Tubes, pipes & fittings iron/steel	3.95	y	-0.37	(0.00)	0.52	1.40	S	S	0.50
681	Silver and platinum group metals	0.36	n							
682	Copper	2.80	n							
684	Aluminium	5.95	y	-0.73	(0.00)	1.22	0.05	S	S	0.85
689	Miscell. non ferrous base metals	3.20	y	-0.03	(0.64)	1.35	0.23	S	S	0.44
695	Tools for use in hand/machines	7.75	y	-0.32	(0.00)	0.00	1.16	S	S	0.67
698	Manufactures of metal, n.e.s.	10.28	y	-0.67	(0.00)	0.94	1.33	S	S	0.80
711	Power generating machinery	8.55	y	-0.61	(0.00)	7.74	3.09	S	S	0.75
712	Agricultural machinery/implements	4.65	y	-0.43	(0.00)	0.03	0.23	S	S	0.47
714	Office machines	5.35	y	-0.32	(0.00)	0.27	0.53	S	S	0.65
715	Metalworking machinery	8.86	y	-0.64	(0.01)	0.04	5.71	S	S	0.87
717	Textile and leather machinery	3.60	y	-0.24	(0.00)	0.40	0.97	S	S	0.78
718	Machines for special industries	4.75	y	-0.26	(0.02)	0.02	0.27	S	S	0.82
719	Machinery non electrical parts	6.05	y	-0.63	(0.00)	0.91	0.15	S	S	0.73
722	Electric power machinery	8.55	y	-0.49	(0.01)	0.19	13.34	S	S	0.82
723	Equip for distributing electricity	6.06	y	-0.19	(0.01)	0.47	0.75	S	S	0.50
724	Telecommunications apparatus	3.26	y	-0.17	(0.06)	7.48	0.66	S	S	0.55
726	Elec. apparatus for medical pur.	3.62	y	-0.16	(0.05)	0.02	0.08	S	S	0.69
729	Other electrical machinery	4.22	y	-0.30	(0.00)	0.39	0.00	S	S	0.74
732	Road motor vehicles	5.53	y	-0.60	(0.00)	0.42	0.40	S	S	0.77
735	Ships and boats	2.49	n							
861	Scientific, medical meas. instrum.	9.27	y	-0.51	(0.00)	1.80	0.68	S	S	0.73
862	Photographic supplies	4.75	y	-0.20	(0.00)	0.10	25.20	S	S	0.77
891	Musical instruments	8.39	y	-0.20	(0.00)	1.42	0.32	S	S	0.79
892	Printed matter	7.69	y	-0.20	(0.07)	0.56	0.16	S	S	0.69
893	Articles of artificial plastic n.e.s.	5.63	y	-0.36	(0.00)	0.01	0.63	S	S	0.75
894	Perambulators, toys, games	4.72	y	-0.33	(0.01)	0.36	0.76	US	S	0.57
931	Special transactions not classd	4.08	y	-0.07	(0.17)	0.09	1.14	S	S	0.50
tim	Total imports	10.64	y	-0.52	(0.00)	1.83	0.81	S	S	0.79

Notes: 1. Bound=F-statistic from the bounds test, Coint=Cointegration existence, y=Yes, n=No, LM=LM statistic, RESET=Chi-square statistic, CS=CUSUM, CSS=CUSUM of Squares, S (US)=Stable (Unstable) at 5% level of significance, R^2=Goodness of fit.

2. ECM_{t-1} represents coefficient or speed of adjustment, with p-values in parentheses.

Zhang (2014) which scrutinized the case of Korea vis-à-vis the rest of the world during 1971 to 2011 and the works of Bahmani-Oskooee, Harvey and Hegerty (2012) which explored the case of Korea vis-à-vis USA during 1965 to 2006. Both studies were also conducted at 3-digit level of product. However, while our findings exhibit that the numbers of negatively affected industries are higher than the positively affected products in the long run, their works show the opposite outcomes which are relatively uncommon, according to their statements. They claimed that the exchange rate volatility could increase trade volume because it gives the effect through the expected profits of risk-neutral firms. Our findings also indicate that the most negatively affected products for both exports and imports are machinery and transport equipment (SITC7) rather than the other categories of products such as chemicals and related products (SITC5) and manufactured goods classified chiefly by material (SITC6). These findings are consistent with Bryne, Darvy and Macdonald (2008) which studied the case of USA during 1989 to 2001. Their works revealed that the exchange rate volatility produces the negative impact on the exports of final goods rather than the exports of intermediate goods. The similar results are found in Jung Moon-Hyun (2016) and Lee Sang-Ho (2011) who investigated the effect of exchange rate volatility on the exports of automotive industry from Korea to 28 major trading partners and the effect of volatility on exports of manufacturing products from Korea to the world, respectively.

In comparison to Baek Jung-Ho (2013) who examined the case of Korea vis-à-vis Japan at 1-digit level of SITC industry, while he reported that only exports of manufactured goods classified chiefly by material (SITC6) are negatively affected by the volatility in the long run, our findings indicate that the negative effects are found not only in SITC6 products, but also in the SITC0, SITC5, SITC7 and SITC8 products. For the importing commodities, while Baek Jung-Ho (2013) detected the negative impact of volatility on machinery and transport equipment (SITC7) and chemicals and related products (SITC5), our empirical results are in line with his works. Nonetheless, we found that the volatility also gives the negative impact on manufactured goods classified chiefly by material (SITC6) and miscellaneous manufactured articles (SITC8). The important difference between our works and Baek Jung-Ho (2013) is that while his works did not find the positive effects of exchange rate volatility, these effects are detected in our studies in both exporting and importing products. This evidence exhibits the aggregation bias problem when the analysis is conducted by using the aggregate trade data clearly.

Although our works examine the impact of exchange rate volatility at 3-digit level of industry, we also investigate the effect of volatility at the aggregate trade level through total exports and imports. For the exporting products, while Baak, Al-Mahmood and Vixathep (2007) found that exchange rate volatility had negative impact on exports from Korea to Japan in both the short run and the long run during 1981 to 2004, our findings show that the volatility produces the mixed effects in the short run and it has no impact in the long run. These findings are in line with Lee Jae-Hwa (2011b) who argued that the adverse effect of exchange rate volatility on exports from Korea to Japan existed only in the short run during 1980 to 2009. For the importing goods, our results exhibit the negative effect of volatility on total imports of Korea from Japan in the long run. These results are similar to Kim Chang-Beom (2011b) who examined the case of imports of Korea from four economic blocks (APEC, ASEAN, EU, NAFTA), Choi Kyong-Wook (2010) and Chun Sun-Eae (2013) for the case between Korea and USA.

Ⅴ. Conclusion

The existing literature, in both theoretical and empirical viewpoints, reveals that the impact of exchange rate volatility on bilateral trade flows is indeterminate. It can show the different effects across trading partners and trading products. Japan is a major trade partner of Korea. Consequently, study on the impact of exchange rate volatility on bilateral trade flows between Korea and Japan is essential for Korea.

To mitigate the aggregation bias problem, this article analyses the impact of exchange rate volatility on bilateral trade flows at 3-digit level of SITC industry. The 57 importing industries and 69 exporting industries of Korea vis-à-vis Japan are examined, using annual data during 1970 to 2016. The ARDL model is employed in the estimation. The findings of our study can be presented in six points.

First, the exchange rate volatility affects the bilateral trade flows between Korea and Japan in both short run and long run. The short run effects of volatility are found in 27 exporting and 29 importing industries, respectively.

Second, nonetheless, the majority of industries are uninfluenced in the long run. The number of unaffected, negatively affected and positively affected exporting products are 40, 12 and 3, respectively. The corresponding export shares of the industries are 76.46, 21.73 and 1.81 per cent, respectively. Likewise, for the importing commodities, they are 31, 11 and 3 for the number of industries and 69.54, 29.14 and 1.32 for the corresponding import shares, respectively. The numbers of negatively affected industries are remarkably higher than the positively affected ones in both exporting and importing industries.

Third, in terms of export shares, the most negatively affected exporting products are machinery and transport equipment or SITC7 products (13.36 per cent of Korea's total exports to Japan). The SITC7 commodities are also the most negatively affected importing products (15.15 per cent of total imports).

Fourth, both major exporting and major importing products are negatively affected by exchange rate volatility. The exporting commodities are other electrical machinery and apparatus (SITC729) which account for 12.15 per cent of total exports from Korea to Japan. The importing commodities are machinery and appliances non electrical parts (SITC719) which constitute 12.69 per cent of total imports.

Fifth, by comparing the empirical results at 3-digit level of industry to the results from total exports and total imports, it is obvious that the study which uses the aggregate trade data in the estimation can create the aggregation bias problem in the analysis.

Sixth, generally, the increase in income of Japan raises exports from Korea and vice versa for increase in Korea's income. Nonetheless, Korea's income has more distinctive role relative to Japanese income. Although the effects of real exchange rate on bilateral trade flows are in line with our expectation, the empirical evidences indicate that the majority of industries are not affected by the real exchange rate in the long run.

The empirical results of our study provide a crucial implication on international trade policy for Korea. Our findings indicate that 12 industries which constitute 21.73 per cent of Korea's total exports to Japan encounter unfavourable effects from exchange rate volatility. The high value of export shares of negatively affected industry suggests that Korean authorities may need to implement the specific policy to stabilize the volatility of exchange rate in order to avoid the decline in exports to Japan. In addition, our findings provide more specific and detailed evidences at the disaggregated level of industry. Therefore, the policy formulation can be done precisely and comprehensively.

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