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THE EFFECTS OF INDUSTRY-LEVEL EXCHANGE RATES ON INDUSTRIAL EXPORTS: EVIDENCE FROM KOREA

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Abstract: This study examines the effects of the industry-level effective exchange rates on the Korean industrial exports. We used the EGARCH model, and the analysis period was from January 2001 to May 2016. The results are as follows. First, the BIS' real effective exchange rates showed significant negative coefficients except for general machinery and metal industries. Second, an increase in the RITIE's real effective exchange rates significantly reduced total exports and exports by industry, except for the general machinery and metal industry. In addition, using the industrial RITIE's industry-specific real effective exchange rates recorded more significant values than the BIS' real effective exchange rates did. Third, for the period of before global financial crisis, an increase in the RITIE's real effective exchange rates reduced total exports and exports by industry except for metal industry, but it is not significant. Fourth, for the period of before global financial crisis, an increase in the RITIE's real effective exchange rates significantly reduced total exports and significantly reduced all five industries' exports except for general machinery industry. The results also indicate that to examine the effect of real effective exchange rates on industrial export performance, it is more suitable to use the industrial real effective exchange rates of RITIE than to use the real effective exchange rates of the BIS. In addition, we find that industrial real effective exchange rates had a larger impact on industrial exports after the global financial crisis than they did before the global financial crisis. This finding suggests that policy makers should be interested in changes in industrial real effective exchange rates.

Keywords: Real effective exchange rate, Industrial exports, Global financial crisis, GARCH model

I. INTRODUCTION

Since the global financial crisis, the global economic environment is changing and advanced economies are relaxing their financial policies. These advanced economies, including the US, Europe, and Japan, have depreciated their currencies through quantitative easing, causing sharp fluctuations in exchange rates worldwide. South Korea is a small open economy that is highly dependent upon the global market, so South Korea is heavily influenced by exchange rate fluctuations, which reinforces the need for rigorous studies that examine the impact of changing exchange rates of major currencies on exports.

Previous findings on the impact of changing exchange rates on exports are not consistent. Klaassen (2011), Ollivaud *et al.* (2015), and Ahmed *et al.* (2015) found that exchange rates had no impact or a decreasing impact on exports. On the other hand, Wisdom & Granskog (2003), Dincer & Kandil (2011), Erdal *et al.* (2012), Caglayan *et al.* (2013), and Haseeb & Rubaniy (2014) argue that exchange rates do have a significant effect on exports.

Earlier studies on the impact of exchange rates on exports focused on how the changes in exchange rates affected total exports. However, using the aggregated total rate may lead to underestimating the effect of exchange rate changes. Rose & Yellen (1989) and Wang *et al.* (2002) argued that the use of aggregated data underestimated the impact of exchange rates and made it difficult to define the relationship between exchange rates and trade

volumes. To eliminate this problem, we analyzed not only the total export volume but also the impact of exchange rates on the exports of South Korea's five major industries. This study also looked closely into the impact of real effective exchange rates on each industry.

This study adopts the consensus reached about the relationships among export volumes, level of economic activities, and real exchange rates (Kenen & Rodrik, 1986; Grauwe, 1988; Pozo, 1992; and McKenzie, 1999) and the variables were selected based on the models used by Wang & Barrett (2007) and Lewis (2014). We measure the impact of real effective exchange rates on total exports and then separately on five big industries—electrical machinery, transport equipment, general machinery, metal, and chemical. The US industrial production index is used to measure the level of global economic activity. The data used for analysis is monthly data from January 2001 to May 2016 and includes 185 observations derived from the data of Bank of Korea, Korea International Trade Association, and RITIE (Research Institute of Economy, Trade and Industry).

This study differentiates itself from earlier studies in that this study examines the impact of real effective exchange rates on not only total exports but also on each of five major industries to avoid potential errors that may occur in using aggregated exports. Second, this study considers the impact of industrial real effective exchange rates on each industry. Third, this study compares and analyzes the before and after of the global financial crisis.

This paper is comprised of the following: in chapter 2, the data and models used for analysis are described; in chapter 3, the results of the empirical study are shown; in chapter 4, conclusions are made.

II. METHODOLOGY

The data used for this study include the Korean total exports volumes (TO) and exports volumes of six industries-electrical machinery (EM), transport equipment (TE), general machinery (GM), metal (MT), and chemical (CE), real effective exchange rates of BIS (Bank for International Settlements) and RIETI (Research Institute

Table 1
Descriptive Statistics

	Mean	*Max.*	*Min.*	*Skewness*	*Kurtosis*	*J-B*	*Q(12)*	$Q^2_{(12)}$
EX_TO	0.006	0.222	-0.252	-0.092	3.557	2.64	77.7**	124.0**
EX_EM	0.006	0.215	-0.337	-0.394	4.266	17.07**	70.8**	129.1**
EX_TE	0.009	0.507	-0.500	-0.165	3.609	3.68	84.2**	84.7**
EX_GM	0.005	0.241	-0.304	-0.225	3.553	3.90	103.8**	156.0**
EX_MT	0.007	0.212	-0.358	-0.404	5.263	44.24**	59.3**	161.0**
EX_CH	0.008	0.210	-0.430	-0.762	5.782	77.14**	27.6**	80.1**
IPI	0.001	0.015	-0.044	-2.167	13.160	935.4**	30.7**	36.8**
RE	0.001	0.078	-0.138	-1.677	13.478	927.9**	26.6**	37.4**
RE_EM	-0.003	0.052	-0.082	-0.727	5.502	64.17**	38.5**	38.7**
RE_TE	-0.000	0.068	-0.122	-1.299	10.260	455.9**	31.5**	37.2**
RE_GM	0.000	0.077	-0.122	-1.297	10.187	520.1**	31.8**	41.5**
RE_MT	0.001	0.075	-0.018	-1.050	8.720	284.6**	35.8**	43.3**
RE_CH	0.000	0.071	-0.117	-1.097	9.205	332.1**	40.4**	41.5**
RE_MA	-0.000	0.068	-0.115	-1.309	10.975	540.1**	27.6**	44.4**

Notes: EX_TO, EX_EM, EX_TE, EX_GM, EX_MT and EX_CH represent the total, electrical machinery, transport equipment, general machinery, metal, and chemical exports respectively. IPI and RE represent industrial production index and real exchange rates respectively. RE_EM, RE_TE, RE_GM, RE_MT, RE_CH and RE_MA represent electrical machinery, transport equipment, general machinery, metal, chemical and manufacturing all exports respectively. *, ** indicate a significance level of 5% and 1% respectively.

of Economy, Trade and Industry) and RIETI's industry-specific real effective exchange rates of five industries, and IPI in US.

In the descriptive statistics of Table 1, the skewness is a distribution with a long left tail, as all the variables showed negative values. As shown in the Jarque-Bera statistics, the hypothesis for a normal distribution, except for the total exports, exports in transport equipment and exports in general machinery are rejected. The Ljung-Box Q-statistics on the 12-lag autocorrelation of each variable's level and square had autoregression (AR) properties. Accordingly, this study used the GARCH model for analysis and used Eviews 9.0 as the analysis tool.

In general, it is known that each time-series variable is a non-stationary process. The stationarity of the variables must be examined prior to analysis of time-series data. We used the Schwart information criterion-based Augmented Dickey Fuller (ADF) test and the Phillips-Perron (PP) test to perform unit root tests. Separate tests were run for intercept-only cases and trend-and-intercept cases, with two lags applied. As shown in Table 2, the test results of first-differenced variables reject the null hypothesis that all variables have a unit root. Accordingly, the variables subject to analysis are confirmed to have stationary time-series at a significance level of 1% and constitute I (1) process. Therefore, we used first-differenced variables for analysis.

The GARCH (p, q) model has p order of GARCH terms and q order of ARCH terms. EGARCH model is another form of the GARCH model. The AIC, BIC, and HQIC information criteria-based analyses were performed to determine a suitable model to examine the effects of industry-specific real exchange rates on the Korean industrial exports, and the results showed that the EGARCH(1,1)-GED model would be most suitable. Accordingly, this study uses that model to examine the industry-specific real exchange rates on the Korean industrial exports. Mean equation and variance equation are as follows.

Table 2
Unit Root Test Results

	ADF		*PP*	
	Intercept	*Trend and intercept*	*Intercept*	*Trend and intercept*
EX_TO	-3.7947***	-4.5437***	-20.3879***	-26.4591***
EX_EM	-3.4469**	-3.9861***	-20.7824***	-27.2102***
EX_TE	-5.3423***	-5.6051***	-23.8916***	-27.3596***
EX_GM	-7.8109***	-7.7766***	-21.7439***	-21.7891***
EX_MT	-5.9050***	-6.0273***	-16.7121***	-16.8963***
EX_CH	-15.1032***	-15.1609***	-15.1897***	-15.2393***
IPI	-3.4131**	-3.3950**	-11.9582***	-11.9397***
RE	-10.0545***	-10.0292***	-9.6665***	-9.9901***
RE_EM	-9.0790***	-9.0747***	-9.0790***	-9.0747***
RE_TE	-10.2485***	-10.2418***	-10.2485***	-10.2418***
RE_GM	-9.6500***	-9.6234***	-9.1995***	-9.4714***
RE_MT	-10.2878***	-10.4102***	-10.0852***	-10.1352***
RE_CH	-8.8633***	-8.8641***	-8.4306***	-8.4002***
RE_MA	-9.7379***	-9.7152***	-9.5954***	-9.5688***

Notes: EX_TO, EX_EM, EX_TE, EX_GM, EX_MT and EX_CH represent the total, electrical machinery, transport equipment, general machinery, metal, and chemical exports respectively. IPI and RE represent industrial production index and real exchange rates respectively. RE_EM, RE_TE, RE_GM, RE_MT, RE_CH and RE_MA represent electrical machinery, transport equipment, general machinery, metal, chemical and manufacturing all exports respectively. *, ** indicate a significance level of 5% and 1% respectively.

$$\Delta \ln EX_{i,t} = a_0 + b_1 \Delta \ln IPI_t + b_2 \Delta \ln RE_{i,t} + \varepsilon_t \quad (1)$$

$$\ln h_t = a_1 + \beta \ln \sigma_t^2 + \gamma \left| \frac{\epsilon_{t-1}}{h_{t-1}} \right| + \delta \frac{\varepsilon_{t-1}}{h_{t-1}} + c_1 \ln \epsilon_{IPI_t}^2 + c_2 \ln \epsilon_{RE_{i,t}}^2 \quad (2)$$

Where, $\Delta \ln EX_{i,t}$ denotes industry (or total) i's first differences of log export volumes at time t. $\Delta \ln IPI_t$ indicates the US industrial production index as a measure of global economic activity at time t. $\Delta \ln RE_{i,t}$ refers to industry i's real effective exchange rate at time t. In theory, it can be expected that a rise in global economic activity increases exports. a_0, a_1 are constant terms, b_1, b_2 are parameters of the US industrial production index and real effective exchange rates respectively, and c_1, c_2 each represent the parameters of the log values of the square of the residual of the US industrial production index and real effective exchange rates. Parameter γ and δ denote leverage effects. This means if γ is a positive value, the conditional variance increases when the size of market innovation is larger than expected; if δ is a negative value, it indicates the presence of an asymmetric volatility effect.

III. EMPIRICAL RESULTS

Table 3 shows the effect of BIS's real effective exchange rates on the Korean industrial exports. The industrial production index as a proxy of global economic activity showed negative but insignificant coefficients in total exports and five industries, contrary to the expectation. As expected, the BIS's real effective exchange rates showed significant negative coefficients except for general machinery and metal industries, indicating that a rise in the BIS's real effective exchange rates brings total exports and electrical machinery, transport equipment and chemical industries' exports down.

Table 3
The Effects of BIS' Real Effective Exchange Rates on the Korean Industrial Exports

	EX_TO	*EX_EM*	*EX_TE*	*EX_GM*	*EX_MT*	*EX_CH*
a_0	-0.001	0.008	-0.011	-0.001	0.011*	0.009
b_1	-0.803	-1.499	-0.201	-0.293	-0.187	-0.868
b_2	-0.523*	-.319	-1.302**	-0.314	-0.354	-0.597*
a_1	-0.837**	-0.977	-1.179**	-0.207	-2.031	-2.016**
β	0.840***	0.771***	0.675***	.961***	0.645	0.556***
γ	0.025	-0.223	-0.044	0.036	0.242	-0.241
δ	-0.348***	-0.187*	-0.481***	-0.175	0.049	-0.248*
c_1	1.037	2.240	0.313	0.787	-6.827	-23.889
c_2	-2.357	-6.222**	2.867	-3.137	-7.613	-11.369*
Log-L	222.521	205.240	88.711	180.939	219.813	202.441

Notes: EX_TO, EX_EM, EX_TE, EX_GM, EX_MT and EX_CH represent the total, electrical machinery, transport equipment, general machinery, metal, and chemical exports respectively. *, ** and *** indicate a significance level of 10%, 5% and 1% respectively.

Table 4 shows the effect of RITIE's industry-specific real effective exchange rates on the Korean industrial exports. The real effective exchange rates were derived from the data of the RITIE, with the aggregated exports used with the real effective exchange rates for all manufacturing and the exports by industry used with the industry's own real effective exchange rates. The industrial production index, an indicator of global economic activity level, showed positive values in aggregated exports and industrial exports as expected, except for the metal and chemical industries. An increase in the RITIE's real effective exchange rates significantly reduced total exports and exports by industry, except for the general machinery and metal industry. In addition, using the industrial RITIE's industry-specific real effective exchange rates recorded more significant values than the BIS's real effective exchange rates did. For the transport equipment industry, δ showed a significantly negative value, indicating that it shows a significant increase in the conditional variance in response to bad news shocks.

Table 4
The Effects of RITIE's Industry-Specific Real Effective Exchange Rates on the Korean Industrial Exports

	EX_TO	*EX_EM*	*EX_TE*	*EX_GM*	*EX_MT*	*EX_CH*
a_0	-0.001	0.011***	-0.011	-0.000	0.010	0.009
b_1	1.429**	1.268**	1.586	0.394	-0.100	-0.586
b_2	-1.646**	-1.080**	-2.565**	-0.165	0.251	-0.548*
a_1	-0.714***	-0.471***	-1.193**	-0.187	-2.136	-1.806***
β	0.860***	0.854***	0.676***	0.968***	0.619	0.603***
γ	-0.002	-0.389***	-1.004	0.045	0.195	-0.247
δ	-0.377***	-0.127	-0.505***	-0.157	0.064	-0.241*
c_1	-5.874	-8.998***	8.326	0.439	-4.805	-18.526
c_2	3.253	2.902	-6.202	-3.388	-7.946***	-14.014**
Log-L	228.030	208.865	89.666	186.408	220.365	214.559

Notes: EX_TO, EX_EM, EX_TE, EX_GM, EX_MT and EX_CH represent the total, electrical machinery, transport equipment, general machinery, metal, and chemical exports respectively. *, ** and *** indicate a significance level of 10%, 5% and 1% r respectively. *, ** and *** indicate a significance level of 10%, 5% and 1% respectively.

Table 5
The Effects of Three Investor Group Trades on KOSPI in Net Buying or Selling Period of Individual Investors

	EX_TO	*EX_EM*	*EX_TE*	*EX_GM*	*EX_MT*	*EX_CH*
a_0	0.006	-0.010	0.031	0.022***	0.012	-0.001
b_1	2.633*	2.369	2.906	2.166	-1.147	3.803*
b_2	-0.288	-0.374	-0.399	-1.170***	0.209	-0.031
a_1	-5.641**	-7.504***	-3.028	-0.836***	-8.131***	-6.928***
β	0.037	0.396	0.085	0.745***	0.508	0.138
γ	-0.174	0.479	-0.414	-0.611***	0.321	0.206
δ	-0.422**	-0.319*	-0.093	0.410*	0.018	-0.136
c_1	36.812	41.645*	31.274	-14.017	23.749	16.025
c_2	-32.404**	-16.390*	8.053	-2.125	-26.754*	-35.686***
Log-L	107.465	101.053	29.791	98.593	96.334	97.480

Notes: EX_TO, EX_EM, EX_TE, EX_GM, EX_MT and EX_CH represent the total, electrical machinery, transport equipment, general machinery, metal, and chemical exports respectively. *, ** and *** indicate a significance level of 10%, 5% and 1% respectively.

Table 5 shows the effect of RITIE's industry-specific real effective exchange rates on the Korean industrial exports for the period of before global financial crisis. The industrial production index, an indicator of global economic activity level, showed positive values in aggregated exports and industrial exports as expected, except for the metal industry.

Table 6 shows the effect of RITIE's industry-specific real effective exchange rates on the Korean industrial exports for the period of after global financial crisis. The industrial production index, an indicator of global economic activity level, showed positive values in aggregated exports and industrial exports as expected, except for the metal and chemical industries. An increase in the RITIE's real effective exchange rates significantly reduced total exports and significantly reduced all five industries' exports except for general machinery industry. And δ showed a significantly negative value except for

Table 6
The Effects of Three Investor Group Trades on KOSPI in Net Buying or Selling Period of Individual Investors: The Period of after Global Financial Crisis

	EX_TO	*EX_EM*	*EX_TE*	*EX_GM*	*EX_MT*	*EX_CH*
a_0	-0.001	0.004	0.006	0.001	0.003	0.003
b_1	0.729	1.325	1.554	2.918	-3.152**	-3.114**
b_2	-0.477	-0.465**	-0.680**	-0.708	-0.933*	-0.430**
a_1	-3.252**	-1.172	-1.218	-2.210	-2.228**	-0.342***
β	0.332	0.755***	0.748***	0.432	0.362	0.870***
γ	-0.328	-0.069	-0.068	-0.519	-0.854**	-0.349***
δ	-0.657***	-0.381**	-0.398**	-0.323	-0.304	-0.170***
c_1	26.865	-29.071	-30.456	-9.248	-18.147	-23.254***
c_2	6.573	5.082	3.067	10.063	9.780	-1.744***
Log-L	109.786	104.953	104.976	96.576	96.059	105.061

Notes: EX_TO, EX_EM, EX_TE, EX_GM, EX_MT and EX_CH represent the total, electrical machinery, transport equipment, general machinery, metal, and chemical exports respectively. *, ** and *** indicate a significance level of 10%, 5% and 1% respectively.

general machinery and metal industries, indicating that it shows a significant increase in the conditional variance in response to bad news shocks.

IV. CONCLUSION

This paper reports on an empirical study that examines how the real effective exchange rates impact the Korean industrial exports. Data used in the analysis includes the Korean total exports volumes and exports volumes of five industries-electrical machinery, transport equipment, general machinery, metal, and chemical, real effective exchange rates of BIS and RIETI and RIETI's industry-specific real effective exchange rates of five industries, and IPI in US. The analysis period was from January 2001 to May 2016.

The results are as follows. First, the BIS's real effective exchange rates showed significant negative coefficients except for general machinery and metal industries.

Second, an increase in the RITIE's real effective exchange rates significantly reduced total exports and exports by industry, except for the general machinery and metal industry. In addition, using the industrial RITIE's industry-specific real effective exchange rates recorded more significant values than the BIS's real effective exchange rates did.

Third, for the period of before global financial crisis, an increase in the RITIE's real effective exchange rates reduced total exports and exports by industry except for metal industry, but it is not significant.

Fourth, for the period of before global financial crisis, an increase in the RITIE's real effective exchange rates significantly reduced total exports and significantly reduced all five industries' exports except for general machinery industry

The results also indicate that to examine the effect of real effective exchange rates on industrial export performance, it is more suitable to use the industrial real effective exchange rates of RITIE than to use the real effective exchange rates of the BIS. In addition, it was shown that industrial real effective exchange rates had a larger impact on industrial exports after the global financial crisis than they did prior to the crisis. This finding suggests that to manage industrial exports performance, more attention needs to be paid to changes in industrial real effective exchange rates.

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