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The Qualitative Trade Competitiveness of China in IT Industry: A Comparison to Korea and USA

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Abstract

Purpose – The purpose of this paper is to analyze the trade structure and competitiveness of China's information technology (IT) industry in comparison to that of Korea and the United States, particularly in terms of quality.
Design/methodology/approach – Indices such as trade specialization index (TSI), Revealed Comparative Advantage (RCA), and Market Comparative Advantage (MCA) are used. Further, an Intra-industry Trade (IIT) index is used to analyze qualitative changes in horizontal intra-industry trade and intra-industry trade of high- and low-quality goods.
Findings – China's IT industry has a comparative competitive advantage over that of Korea and the United States, and mainly exports goods of inferior quality and imports goods of superior quality. Further, China's horizontal intra-industry trade has been decreasing, while its vertical intra-industry trade has been increasing and vertical trade of inferior quality goods outweighs that of superior quality goods. This shows that China is rapidly catching up with Korea and the United States, even though its qualitative competitiveness has not significantly improved.
Research limitations/implication - This study has academic and political implications, as it analyzes changes in China's IT trade competitiveness. However, it is somewhat limited as factors determining qualitative aspects has not been considered.
Originality/value – Most studies aggregate analyses of export competitiveness using methodologies such as TSI, RCA, and market share. However, the focus of these methods is price competitiveness. Hence, an examination of the objective and qualitative trade competitiveness of China's IT industry is necessary. this study the trade structure and quantitative competitiveness of the industry by analyzing intra-industry trade focusing on the quality of competitiveness. Therefore, the changes in China's IT industry in the USA and Korea and in foreign trade competitiveness and quality competitiveness are clarified. The results show that the academic and policy implications of these changes in the IT industry will be a useful resource. This is the first study in Korea to attempt such an analysis. This is the first study in Korea to attempt such an analysis.

Keywords: China, Comparative Advantage, Information Technology (IT) Industry, Qualitative Trade Competitiveness
JEL Classifications: F10, F14, L63, L96

1. Introduction

The information technology (IT) industry forms the backbone of the fourth industrial revolution and is essential in measuring international competitiveness in all countries. Moreover, the wave of innovation in the IT industry has been a driving force in economic growth. Leading developed countries such as the United States not only focus on technical development in the IT market but also devise strategies to expand export trade to maintain

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the competitiveness of their IT industries based on open innovation and industry-academia research collaboration.

In the fourth meeting of the 12th National People's Congress, the Chinese government formalized a "New Normal" era by revising the nation's 2016 economic growth rate target downward to 6.5 - 7.0 percent, and implemented plans for a new industrial structure and trade regime reform through initiatives such as "China Manufacturing 2025." This means that the Chinese trade structure will no longer rely on simple manufacturing, transforming instead into a structure that enables the creation of higher value-added goods for which it had previously depended on major developed countries due to its lack of fundamental technology (Park Jin-Woo, 2017).

According to the ladder of comparative advantage in the IT industry, Korea is on the middle and higher value-added rungs while China is at the labor-intensive stage. As of 2016, Korea accounted for a significant share of China's IT trade, or 15.5 percent and 5.3 percent of Chinese imports and exports, respectively. China's competitiveness is expected to change rapidly as it develops its own technology and shifts toward more advanced manufacturing systems.

For China, the United States is not only its largest export destination but also a model to emulate in transforming its industry to a higher value-added structure. As of 2016, China had exported US$385.7bn of goods while importing US$135.1bn, of which IT imports and exports consisted of US$98.3bn and $11.7bn, respectively. This accounts for 19.4 percent of exports and 3.7 percent of imports in China's IT industry, which comprises a significant proportion of the China's IT industry.

The IT industry made up 10.9 percent of global trade in 2016, of which China, Korea and the United States accounted for 45 percent of exports and 37 percent of imports. Specifically, China's IT industry accounted for 31 percent of IT exports and 18 percent of IT imports. The growth rate of global IT imports and exports increased 8.12 percent and 8.84 percent, respectively, over the 10 years since 2006. At the same time, the IT trade growth rate of Korea, the United States, and China also increased rapidly. China's annual average growth rate in exports and imports was 11.86 and 10.02 percent, respectively, while the corresponding figures for Korea were 8.06 and 11.25 percent and those for the United States were 7.65 and 10.53 percent. Total exports for China's IT industry in 2016 were US$508.11bn and imports were US$313.61bn, with Korea and the United States accounting for 24.6 percent and 19.3 percent of exports and imports, respectively.

To summarize, China is leading the growth of the world's IT industry while relying heavily on Korea and the United States for imports and exports.

Given the spillover effects and significant contributions to national economies, this industry needs to be extensively researched. Studies of the trade competitiveness of the three countries' IT industries have multiple implications for China's industry.

2. Literature Review

Studies of the trade competitiveness of China's IT industry have been narrowly focused on the comparison between the competitiveness of China and Korea.

Lee Dong-Whuy (2008) examined the overall trade flow by analyzing business and industry competitiveness of the two countries' IT industries, as well as their import and export structures. The study also reviewed the trade structure of Korea and China in four industrial areas: communications devices, information technology appliances, broadcasting equipment, and components using measures such as Trade Intensity, Revealed Comparative Advantage (RCA), the Grubel-Lloyd index, and Constant Market Share (CMS). Jeong Boon-Do and Yun

Bong-Ju (2009) compared and analyzed the export competitiveness of Korea's IT industry against China's using Trade Specialization (TS) and RCA and proposed a trade policy to increase exports of the industry. Kim Ji-Hyun (2011) analyzed the IT industry export competitiveness of Korea, the United States, and China using measures such as International Market Share (IMS), RCA, and an Export Similarity (ES) index. Kim Hee-Chul (2011) analyzed the export competitiveness of Korea's IT industry in its major markets such as the United States, China, and Japan using a Market Share (MS) index, TS, and Comparative Advantage by Countries (CAC) and examined its correlations with major economic variables such as real exports, competitiveness, and exchange rates. Kim Hee-Chul and Kam Hyung-Kyu (2015) focused on analyzing the export competitiveness of Korea's IT industry in the Chinese market from 2008 to 2015, using tools such as the MS, TSI, RCA, and an Export Bias (EB) index. Yu Jae-Seon and Kim Yung-Keun (2017) analyzed the export competitiveness of Korea's IT industry in the Chinese market and Yu Jae-Seon and Kim Yung-Keun (2018) examined the export competitiveness of Korea's IT industry in the USA market by item through an adjusted analysis method using TSI and RAC.

Most of these studies analyzed export competitiveness by aggregating results from measures and methods such as TSI, RCA, and MS. However, the competitiveness that they derived is, strictly speaking, overall quantitative trade competitiveness, which is similar to price competitiveness. A more objective and qualitative examination of trade competitiveness, which includes changes in the quality of a list of goods, is therefore necessary. This study identifies a qualitative change in the competitiveness of China's IT industry compared to those of Korea and the Unites States, and provides associated academic and political implications. It further examines the characteristics of trade structure by analyzing the intra-industry trade of inferior and superior quality goods in China compared to Korea and the USA.

Thus, this study analyzes the competitiveness of China's IT industry in terms of its quality, including its trade with Korea and the USA and the changes in its qualitative and quantitative competitiveness. We analyze the industry trade's superior and inferior quality. In other words, we examine the changes and characteristics of the trade structure and competitiveness as the causes of China's IT industry's strengthening competitiveness. The results show that China's IT industry aims to improve competitiveness through quantitative as well as qualitative growth.

3. China's Trade in Information Technology (IT) Industry

Table 1 shows the current trends in China's trade in information technology (IT) products in the Korea, USA, and world markets. As shown below, China's IT industry has grown rapidly over the last decade in the global market; its exports surged from $165.6bn in 2006 to $554.3bn in 2015, while its imports also increased from $120.6bn to $335.8bn, simultaneously. In other words, the annual average growth rate for exports and imports was 14.36 percent and 12.05 percent, respectively, during 2006-2015. As exports outpaced imports in terms of value and growth rate, the IT industry's growth in China was primarily driven by exports.

China's total exports of IT products to Korea continually rose from $6.5bn in 2006 to $32.5bn and $31.3bn, respectively, in 2014 and 2015, although there was a decrease in 2015. China's total imports from Korea fluctuated over this 10-year period. However, the data showed a general upward trend for IT imports, which stood at $62.9bn in 2015 and was twice the abovementioned value of exports.

In other words, imports were higher than exports in China and Korea trade in IT products,

which contributed to the China trade deficit over the 10-year period. In addition, the ratio of imports from Korea was also three times larger than that of exports, accounting for 18.74 percent and 5.64 percent, respectively of the total imports and exports of IT products in 2015. Meanwhile, the average annual growth for exports to Korea was 19.11 percent higher than the average annual growth of imports of 13.63 percent.

Table 1. China's Trade in IT Products

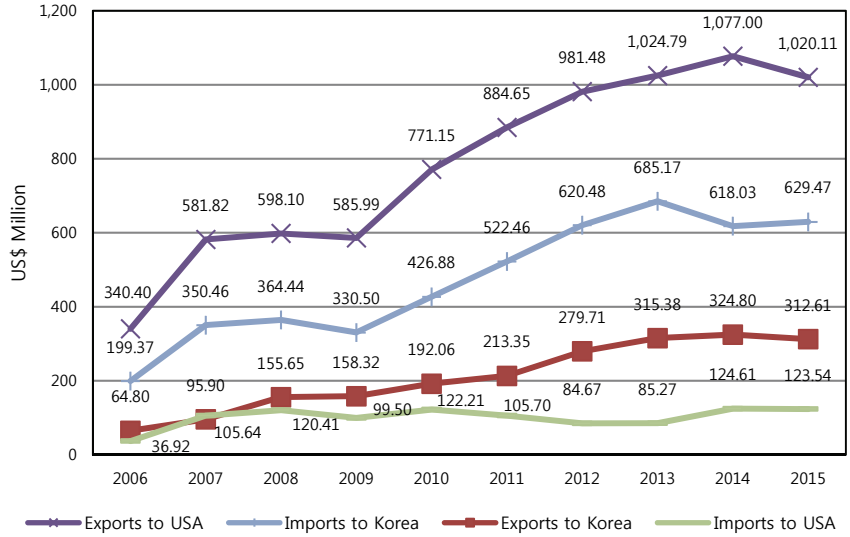
		2006	2008	2010	2012	2014	2015	Description average annual growth (%)		
								06~10	10~15	06~15
World	Exports	1,656	3,348	4,135	5,125	5,637	5,543	20.08	7.60	14.36
	Imports	1,206	2,485	2,788	3,408	3,421	3,358	18.24	4.76	12.05
	Balance	450	863	1,347	1,717	2,216	2,185			
Korea	Exports	65	156	192	280	325	313	24.27	12.95	19.11
		(3.91)	(4.65)	(4.64)	(5.46)	(5.76)	(5.64)			
	Imports	199	364	427	620	618	629	16.45	10.20	13.63
		(16.53)	(14.66)	(15.31)	(18.20)	(18.06)	(18.74)			
	Balance	-135	-209	-235	-341	-293	-317			
USA	Exports	340	598	771	981	1,077	1,020	17.77	7.24	12.97
		(20.55)	(17.86)	(18.65)	(19.15)	(19.11)	(18.40)			
	Imports	37	120	122	85	125	124	27.05	0.27	14.36
		(3.06)	(4.84)	(4.38)	(2.48)	(3.64)	(3.68)			
	Balance	303	478	649	897	952	897			

Note: Unit: value in US$ 100 Million; share to total in percent.
Source: Authors' calculation according to the data from UN Comtrade Database.

On the contrary, exports were higher than imports in China's bilateral trade with the USA. In 2006, China exported $34.0bn and imported $3.7bn from the USA in terms of IT products, and the export value was 9.5 times higher than the import value. After steady increases in both exports and imports over the next decade, China recorded exports worth $102.0bn and imports worth $12.4bn in 2015. Comparing the ratios of exports and imports, the former was six times higher than the latter during the 10-year period. The ratio of exports to the USA was 20.55 percent in 2006, which declined to 18.40 percent in 2015. The ratio of imports from the USA increased slightly from 3.06 percent to 3.68 percent during the same period. In addition, China posted an average annual growth of 12.97 percent in exports and 14.36 percent in imports with the USA over the same period. As such, exports were far outweighed by imports in the USA-China bilateral trade in the IT industry, although its imports from the USA grew rapidly.

Fig. 1 shows the changes in China's trade in IT products with Korea and the USA. Comparing export and import values of both countries, the value of exports to the USA was the highest, followed by import and export values with Korea, and import values from the USA. In the wake of the 2009 financial crisis caused in the USA, the bilateral trade between the two countries reduced. However, China demonstrated an overall increase in exports and imports during the 10 years studied.

Fig. 1. Changes in China Trade in IT Products with Korea and the USA



Note: Unit: value in US$ 100 Million; share to total in percent.
Source: Authors' calculation according to the data from UN Comtrade Database.

4. Industrial Classification and Research Method

4.1. Classification of IT Industry, Research Period, and Data Collection

A classification scheme is a key element for collecting statistical data in empirical analysis. It should be carefully chosen according to the purpose of research that requires industrial-level data because such data encompass a variety of products. In general, the 3-digit Standard International Trade Classification (SITC) is used in statistics on intra-industry trade (IIT) (Grubel and Lloyd, 1975). However, this study uses HS codes to improve the accuracy of an empirical analysis of the IT industry. The HS codes are also widely used in international trade studies. That is, data from the IT industry were classified using 6-digit HS codes, which is an internationally standardized system, and analyzed to determine competitiveness in international trade and intra-industry trade index. The data were classified using the Ministry of Trade and Industry (MTI), which is a classification scheme for exports and imports by industry and product, modified by the Ministry of Trade, Industry and Energy based on HS codes. Using the 3-digit MTI codes, products from the IT industry were classified into broadcasting apparatus(BA)(passive components, electro mechanical components), parts (PA) (equipment for the manufacture of flat panel displays, semiconductor, electrontube, flat display, and sensor), information apparatus(IA)(computer), communication apparatus (CA)(cable communication apparatus and wireless communication apparatus), all of which were then reclassified according to their corresponding HS codes, which were originally used for MTI codes (Table 2).

Accurate import statistics were essential to accomplish the objectives of this study. Therefore, this study used the UN Comtrade database for reliable international trade statistics. During data collection, it was found that China trade data for the last 4-5 years were not complete to use. Due to this problem, this study focused on the period from 2006 through

2015 because it was possible to collect relatively accurate trade statistics needed to identify trends in export competitiveness for this period.

Table 2. Classification of IT Industry

Classification (MTI 3-digit)		HS Code(6-digit)
Broadcasting Apparatus (BA)	Passive Components (833)	853230, 853290, 853310, 853321, 853329, 853331, 853339, 853340, 853390, 853400, 853510, 853610, 853641, 853649, 853650, 853661, 853669, 853670, 853690, 853890
	Electro Mechanical Components (834)	850450, 853090, 853210, 853221, 853222, 853223, 853224, 853225, 853229
Parts (PA)	Equipment for the Manufacture of Flat Panel Displays (736)	848630, 848690
	Semiconductor (831)	381800, 854110, 854121, 854129, 854130, 854140, 854150, 854160, 854190, 854231, 854890
	Electrontube (832)	854011, 854012, 854020, 854040, 854050, 854060, 854071, 854072, 854079, 854081, 854089, 854091, 854099
	Flat Display and Sensor (836)	852290, 853120, 853180, 854390, 901380, 902490, 902590, 902690, 902790, 902990, 903090, 903190
Information Apparatus (IA)	Computer (813)	847130, 847141, 847149, 847150, 847160, 847170, 847180, 847190, 852321, 852329, 852340, 852351, 852359, 852380
Communication Apparatus (CA)	Cable Communication Apparatus (811)	844331, 844332, 851711, 851718, 851762, 851769, 851770, 851830
	Wireless Communication Apparatus (812)	851712, 851761, 852550, 852560, 852580, 852610, 852691, 852692, 852849, 852859, 852869, 852871, 852990

5. Research Method

The most common trade competitiveness indexes to analyze trade competitiveness and comparative advantage include the TSI, RCA, MCA. In addition, researchers use the intra-industry trade index (IIT) to analyze trade structure, such as the qualitative growth of an industry, and specifically the horizontal intra-industry trade between two countries in terms of high and low and quality. Here, i represents an item, c represents a country, w represents the world, p represents a specific import and export partner, X represents exports, and M represents imports.

5.1. Measurement of the Trade Competitiveness and Comparative Advantage Indexes

5.1.1. Trade Specialization Index (TSI)

TSI is the value of the imports/exports of each item divided by the trade volume of the item

(sum of imports and exports). It is a measure of an item's competitiveness in the world market or export destination through the relative size of imports and exports. The value is between -1 and +1, where a value closer to 0 to -1 indicates higher import specialization and a value closer to 0 to +1 indicates a higher the degree of export specialization. Thus, if the value is larger than 0, the item has high trade competitiveness.

$$TSI_{cw}^{i} = \frac{X_{cp}^{i} - M_{cw}^{i}}{X_{cp}^{i} + M_{cw}^{i}} \quad (1)$$

5.1.2. Revealed Comparative Advantage (RCA) Index

RCA is the value of the market share of a particular item in the world market divided by the total market share of the country as a way to compare the comparative advantage (competitiveness) among countries with different economies of scale. As the export volume of a country increases, the RCA reflects the relative size of economy. The measure takes the total market share as a substitute variable, considering that market share increases, even if there is no comparative advantage. If the market share of a particular export item in the world market is greater than the average market share of all items in that country, the RCA will have a value greater than 1, which means that the item has a comparative advantage over the country's other items. It is also possible to judge the degree of comparative advantage between countries by comparing the index values. However, RCA can be distorted if it has a biased export structure for a particular product. Thus, to avoid having extreme values, the RCA is transformed as in the equation below to calculate the Revealed Symmetric Comparative Advantage (RSCA) Index, which yields a value between -1 and +1. A value greater than 0 is considered a comparative advantage, and a value of less than 0 is considered a comparative disadvantage.

$$RCA_{cw}^{i} = \frac{X_{cw}^{i}/X_{ww}^{i}}{X_{cw}/X_{ww}} = \frac{X_{cw}^{i}/X_{cw}}{X_{ww}^{i}/X_{ww}} \quad (2)$$

$$RSCA_{cw}^{i} = \frac{(RCA_{cw}^{i} - 1)}{(RCA_{cw}^{i} + 1)} \quad (3)$$

5.1.3. Market Comparative Advantage (MCA)

The MCA is determined by the relative level of production costs. However, there is very little empirical analysis that compares production costs because it is expensive and requires a lot of data per country and item. Thus, Balassa (1965) examines the comparative advantage of each country using the RCA based on the export performance However, the market shares of the numerator and denominator not only represent the competitiveness of supply-side exporting countries, but also the effect of the market size of importing countries on the demand side. Thus, the market share varies depending on the degree of economic growth of individual importing countries, which are export markets, and the measure also reflects the effects of changes in the importing countries' import demand. Here, we can obtain an index that can reflect the competitiveness of the supply side by eliminating the market size effect using the MCA, which measures the comparative advantage index of a country's i-item to a specific individual market (e.g., Korea and the USA).

$$MCA_{cp}^{i} = \frac{X_{cp}^{i}/M_{pw}^{i}}{X_{cp}/M_{pw}} \quad (4)$$

The MCA is calculated as the ratio of the market share of a specific item (i) that a country (c) exports to a specific market (p) to the market share of the p market country. If the market

share of a particular export item in a specific market is greater than the average market share of all items in that country, the MCA will have a value greater than 1, which means that the item has a comparative advantage over the country's other items. If the MCA is less than 1, then the product's export performance is below the average. The MCA has the same issues as the RCA. Thus, for the analysis, the Market Symmetric Comparative Advantage (MSCA) Index is calculated.

$$MSCA_{cp}^{i} = \frac{(MCA_{cp}^{i}-1)}{(MCA_{cp}^{i}+1)} \tag{5}$$

5.2. Measuring the Intra-Industry Trade Index

In the IT industry, not only is inter-industry trade taking place, but also intra-industry trade (IIT). All existing competitiveness research methods are basically based on comparative advantage theory, and none explain the IIT phenomenon. Therefore, this study uses the IIT analysis method to examine the trade structure and characteristics of major countries in the material parts industry.

To analyze the characteristics of the trade structure among major countries in the IT industry, the IIT analysis was divided into Vertical Intra-Industry Trade (VIIT) and Horizontal Intra-Industry Trade (HIIT). The former was again divided into High Quality Vertical Intra-Industry Trade ($VIIT^{H}$) and Low Quality Vertical Intra-Industry Trade ($VIIT^{L}$) for analysis. In addition, in the case of IIT based on the trade value, when the trade of a certain item is large, the IIT index cannot grasp the overall change in the quality of the industry due to the specific item. To overcome these limitations, this study also conducts an IIT analysis based on the number of items.

As with most IIT research, this study uses the Grubel and Lloyd (1975) measurement method is used. Grubel and Lloyd (1975) defines trade duplication as the sum of exports (imports) in the same industry that exactly duplicates the imports (exports) of one industry as the IIT of the industry. In this study, the IIT index is calculated using Equation (6), which indicates the overlap as the ratio of the total import and export amounts of an industry.

$$GL_i = \frac{(X_i-M_i)-|X_i-M_i|}{(X_i+M_i)} \times 100 = \left[1 - \frac{|X_i-M_i|}{(X_i+M_i)}\right] \times 100 \tag{6}$$

Here X_i and M_i represent the exports and imports of industry i. This index measures the total amount of trade between two countries for the industry; that is, the proportion of the overlap between exports and imports. It has a value of 0 if there is no IIT at all and 100 if there is complete IIT. In Equation (6), if the IIT index of all n industries is taken as the weighted average of the imports and exports of each industry and used to modify Equation (6), then the following Equation (7) can be derived.

$$GL_i = \frac{\sum_{i=1}^{n}\left[1-\frac{|X_i-M_i|}{(X_i+M_i)}\right](X_i+M_i)}{\sum_{i=1}^{n}(X_i+M_i)} \times 100 = \left[1 - \frac{\sum_{i=1}^{n}|X_i-M_i|}{\sum_{i=1}^{n}|X_i+M_i|}\right] \times 100 \tag{7}$$

Next, the GL index is classified into HIIT and VIIT following Greenaway, Hine and Milner (1994). Here, the import and export unit prices of each item are used. That is, if the export unit price of the product is divided by the import unit price and the ratio (export-import unit price index) falls within a certain range (1-α and 1+α), then it is regarded as HIIT; if it is outside a certain range (below 1-α or above 1+α), then it is classified as VIIT. Equation (8) provides the calculation.

$$IIT_i = HIIT_i + VIIT_i$$

$$HIIT_i: 1-\alpha \le \frac{UVX_{ij}}{UVM_{ij}} \le 1+\alpha \tag{8}$$

$$VIIT_i: \frac{UVX_{ij}}{UVM_{ij}} < 1-\alpha \ \ or \ \ 1+\alpha < \frac{UVX_{ij}}{UVM_{ij}}$$

$HIIT_i$: industry i's Horizontal Intra-Industry Trade, $VIIT_i$: industry i's Vertical Intra-Industry Trade
UVX_{ij}: Export unit price of item j in industry i, UVX_{ij}: Import unit price of item j in industry i
α: The arbitrary value (0.25), which is a criterion for distinguishing between HIIT and VIIT

The criteria for determining the HIIT and VIIT indices are arbitrary. That is, if the unit price of export items is almost the same as the unit price of import items, then it can be classified as horizontal. If there is some difference, it can be said to be vertical. However, since there is no absolute standard for this classification, the researcher chooses α. Greenaway, Hine and Milner (1994) assigned values of 0.15 and 0.25 for α. However, following the general practice, this study uses the value of 0.25. From the standpoint of the exporting country, if the unit price ratio of exports is more than (1+α), then it is considered VIIT ($VIIT^H$) of high quality, and if it is less than (1-α), then it is regarded as VIIT ($VIIT^L$) of low quality.

Prior studies generally measure IIT based on trade value. However, in this case, if the trade volume of a certain item is large, then the quality of the other item is not reflected because this item generally influences the degree of the overall IIT. For example, suppose that 10 items are classified as high quality and remain in this category for the next 10 years, but 90 other items fell to lower quality. In this case, if the trade portion of the lower quality items increased but the trade volume of the high quality item accounts for most of the total trade volume, the IIT index will still appear as high quality intra-industry trade. Thus, if the trade volume of a particular item is too large, the IIT index will not be able to identify the overall change in the quality of the industry. Therefore, in this study, the IIT index is also calculated based on the number of items to mitigate the effects of specific items and to identify the overall change in the number of high quality or low quality items. Intra- and inter-industry trade is classified following Fontagne and Freudenberg (1997) that is, if the ratio of exports to imports is less than 10 percent or more than 90 percent, it is classified as inter-industry trade, and everything else is classified as intra-industry trade. Equation (9) expresses intra-industry trade.

$$IIT = \frac{Min(X_{ij} \cdot M_{ij})}{Max(X_{ij} \cdot M_{ij})} < 0.1 \ or \ \ 0.9 < \frac{Min(X_{ij} \cdot M_{ij})}{Max(X_{ij} \cdot M_{ij})} \tag{9}$$

Then, using Equations (6) - (8), this study classifies intra-industry trade as horizontal and high and low quality. Equation (10) provides the IIT index based on the number of items is the weight of the number of items in each group of all trade items.

$$\mathrm{IIT^G} = \frac{\mathrm{n^G}}{\mathrm{N}} \tag{10}$$

Here, N is the total number of items traded and $\mathrm{n^G}$ is the number of transaction items by category. Items within the IIT are items in which the overlap of exports and imports is between 10 percent and 90 percent and classified into HIIT, $\mathrm{VIIT^L}$, and $\mathrm{VIIT^H}$ based on the import/export unit price ratio. Thus, the number of items classified as IIT is $n^{IIT} = n^{HIIT} + n^H + n^L$, and thus $\mathrm{IIT} = \mathrm{HIIT} + \mathrm{VIIT^H} + \mathrm{VIIT^L}$.

6. Analysis Results

6.1. Changes in Export Competitiveness (TSI)

The trade specialization index (TSI) ranges between -1 and 1; a value greater than 0 indicates strong competitiveness. Table 3 shows changes in specialization of China's IT exports to Korea and the USA.

Table 3. TSI Indices Measured for IT Exports to Korea and USA

	Korean Market					USA Market				
Year	**All**	**BA**	**PA**	**IA**	**CA**	**All**	**BA**	**PA**	**IA**	**CA**
2006	-0.51	-0.46	-0.81	0.40	-0.26	0.80	0.18	0.13	0.91	0.86
2007	-0.57	-0.47	-0.84	0.07	-0.02	0.69	0.20	-0.38	0.88	0.90
2008	-0.40	-0.42	-0.82	0.45	0.24	0.66	0.24	-0.40	0.88	0.88
2009	-0.35	-0.49	-0.80	0.59	0.26	0.71	0.26	-0.33	0.91	0.89
2010	-0.38	-0.48	-0.79	0.60	0.27	0.73	0.29	-0.23	0.92	0.90
2011	-0.42	-0.46	-0.79	0.37	0.20	0.79	0.33	0.00	0.93	0.92
2012	-0.38	-0.46	-0.81	0.16	0.22	0.84	0.40	0.10	0.95	0.94
2013	-0.37	-0.47	-0.81	0.05	0.20	0.85	0.38	0.08	0.95	0.95
2014	-0.31	-0.37	-0.77	-0.03	0.26	0.79	0.22	-0.13	0.96	0.96
2015	-0.34	-0.39	-0.75	-0.07	0.26	0.78	0.39	-0.16	0.96	0.96

Source: Authors' calculation according to the data from UN Comtrade Database.

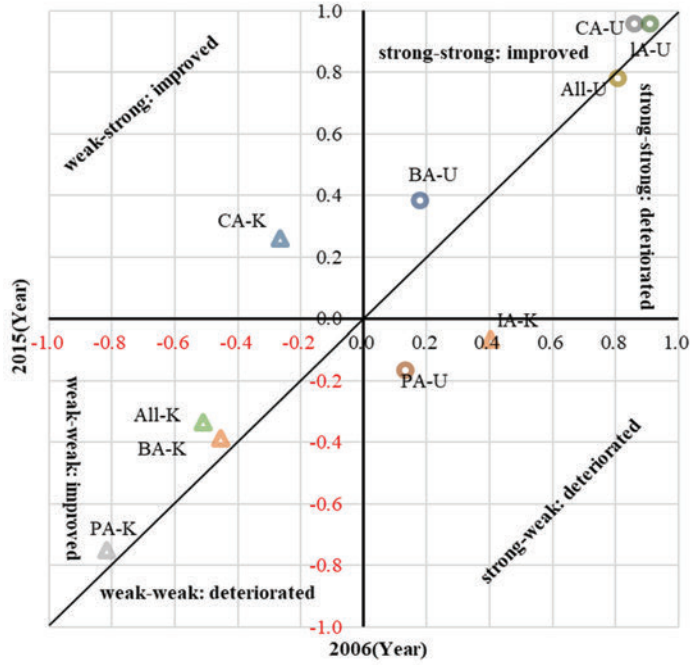
First, China's export specialization in overall IT exports to Korea showed minus values for the 10-year period, indicating weak competitiveness. However, the trend of export competitiveness increased at the levels of individual products (broadcasting apparatus and parts) and industry. China's specialization in communication apparatus was weak at -0.26 in 2006. However, it became much stronger, showing a TSI index of 0.26 in 2015. Information apparatus, however, demonstrated contradictory results, showing 0.4 in 2006 and -0.07 in 2015.

Meanwhile, China's competitiveness of overall IT exports remained strong in USA exports. In particular, the competitiveness of information and communication apparatus was significantly high with the respective TSI values being close to 1 while it remained on a rising trend. The competitiveness in broadcasting apparatus also improved to 0.39 in 2015. However, the competitiveness in parts only deteriorated, exhibiting -0.16 in 2015.

The changes in China's specialization of IT products exported to Korea and the USA for 2006 (base year) and 2015 (current period) are illustrated as a matrix in Fig. 2 The 1st quadrant indicates strong specialization between the two years, the 2nd quadrant shows a weak-to-strong transition in specialization, the 3rd presents a weak specialization, and the 4th describes a strong-to-weak transition in specialization. In the matrix, the diagonal extends from the upper left corner describing improved specialization to the lower right indicating deteriorated specialization.

China's specialization of overall IT exports to Korea largely fell in the 3rd quadrant and the upper left corner in the diagonal, indicating lower specialization, although it had improved. By product category, communication apparatus fell in the 2nd quadrant, showing a weak-to-strong transition in specialization, while broadcasting apparatus and parts remained in the 3rd quadrant due to weak specialization despite their upward trend shown in the upper left in the diagonal.

Fig. 2. China's Specialization of IT Exports to Korea and the USA (2006→2015)



Note: The suffix of "K" stands for Korea and "U" stands for the USA.

On the other hand, information apparatus fell in the 4th quadrant, showing a strong-to-weak transition in specialization. China's specialization of overall IT exports to the USA is largely located in the 1st quadrant, indicating sustaining competitiveness. By product category, the specialization of information, communication, and broadcasting apparatuses remained strong after improvement, given their places in the 1st quadrant and the upper left corner in the diagonal. However, parts fell in the 4th quadrant, showing a strong-to-weak transition in specialization.

In sum, these findings confirm overall increase in China's competitiveness in IT products exported to Korea and the USA, although the specialization in information apparatus exported to Korea and parts exported to the USA remained sluggish as illustrated on the matrix.

6.2. Analysis of Comparative Advantage (RSCA, MSCA)

Table 4 shows China's comparative advantage in IT products in the Korean, USA, and world markets. Like TSI, the RSCA and MSCA range between -1 and 1; a value greater than 0 indicates a comparative advantage, and a value less than 0 indicates a comparative disadvantage.

As shown in the Table 4, it was found that China's IT products had gained a comparative advantage in the Korean, USA, and world markets. By product category, broadcasting apparatus's RSCA index increased from 0.17 in 2006 to 0.18 in 2015, indicating improved comparative advantage. The remaining IT products saw a decline in their comparative advantage. China had comparative advantage in the IT industry in the Korean market, which

showed an upward trend. In terms of product category, China's comparative advantage was maintained in all categories except for parts (-0.09), although it decreased in 2006. Its comparative advantage over parts was maintained (0.02) since 2007, when the country shifted from a position of comparative advantage to one of disadvantage. Finally, China also had comparative advantage in the USA market with respect to the IT industry despite there being a downward trend (0.05 in 2006 → 0.34 in 2015). Among products classified, only broadcasting apparatus saw improved comparative advantage (-0.03 in 2006 and 0.01 in 2015), while the other showed deteriorating comparative advantage. In particular, China remained comparatively disadvantaged in parts, given the MSCA indicator of -0.08 in 2015 after it experienced the shift of comparative advantage (0.01 in 2005) to disadvantage in 2013.

Table 4. China's Comparative Advantage in IT Products in the Korean, USA and World Markets

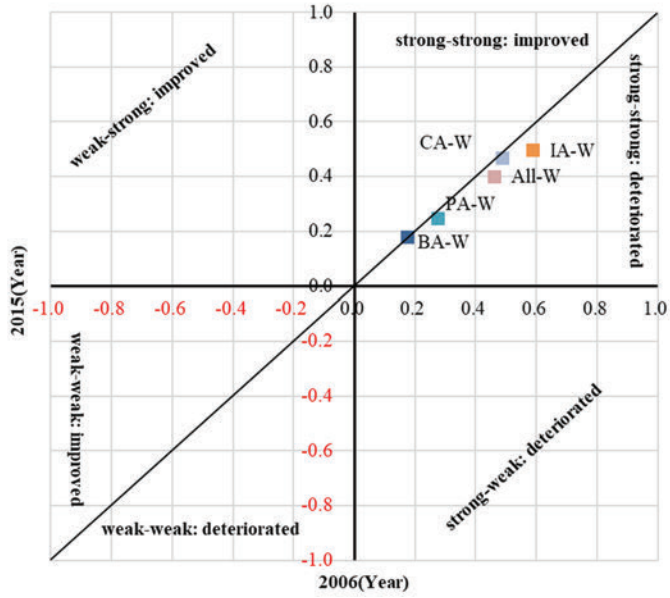
	World Market					Korean Market					USA Market				
Year	**All**	**BA**	**PA**	**IA**	**CA**	**All**	**BA**	**PA**	**IA**	**CA**	**All**	**BA**	**PA**	**IA**	**CA**
2006	0.46	0.17	0.27	0.59	0.49	0.37	0.12	0.02	0.44	0.75	0.50	-0.03	0.01	0.58	0.52
2007	0.45	0.18	0.29	0.55	0.51	0.15	0.15	-0.30	0.26	0.60	0.44	-0.04	0.06	0.58	0.39
2008	0.46	0.20	0.32	0.58	0.50	0.31	0.15	-0.29	0.54	0.71	0.43	0.04	0.10	0.61	0.33
2009	0.45	0.20	0.27	0.58	0.49	0.41	0.15	-0.17	0.64	0.76	0.40	0.03	0.08	0.61	0.23
2010	0.45	0.19	0.29	0.59	0.49	0.40	0.17	-0.10	0.60	0.74	0.40	0.02	0.10	0.60	0.24
2011	0.46	0.20	0.31	0.59	0.51	0.42	0.20	-0.03	0.53	0.73	0.42	0.05	0.08	0.60	0.29
2012	0.46	0.20	0.32	0.59	0.50	0.54	0.20	-0.03	0.55	0.86	0.42	0.08	0.00	0.58	0.36
2013	0.46	0.23	0.34	0.58	0.49	0.56	0.19	-0.04	0.57	0.87	0.42	0.05	-0.02	0.57	0.38
2014	0.44	0.21	0.27	0.55	0.48	0.51	0.29	-0.03	0.50	0.80	0.41	0.03	-0.01	0.55	0.38
2015	0.40	0.18	0.25	0.50	0.47	0.39	0.10	-0.09	0.42	0.70	0.34	0.01	-0.08	0.47	0.34

Fig. 3 illustrates changes in China's comparative advantage in its IT industry in the world market during the 10-year period, and Fig. 4 illustrates such changes in the Korean and USA markets during the same period. The patterns of comparative advantage plotted in each quadrant can be interpreted in the same way as those in Fig. 2.

As illustrated in Fig. 3, where a large cluster was formed in the 1st quadrant, China maintained comparative advantage in the world market with respect to IT products as a whole. However, it somewhat declined in product categories, given that the lower right corner in the diagonal was dominant.

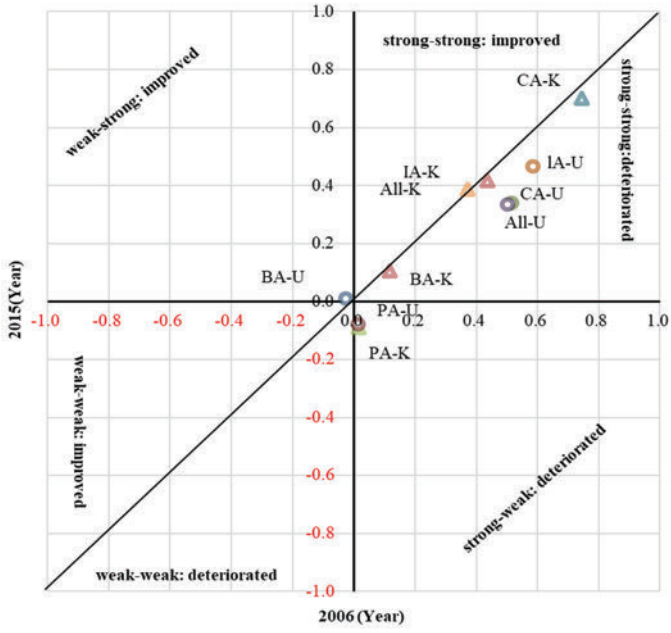
Fig. 4 illustrates changes in China's comparative advantage in IT products in the Korean and USA markets during the 10-year period. As the 1st quadrant was generally dominant, China was found to be comparatively advantaged in IT products in the Korean and USA markets. However, the level of its comparative advantage was deteriorating because the products were primarily clustered in the lower right in the diagonal. In terms of product category, China significantly improved its comparative advantage in broadcasting apparatus, for which the country experienced the shift of comparative disadvantage to advantage. However, the country saw the opposite shift in parts, which was manifested in comparative disadvantage in the 4th quadrant. The disadvantage in parts suggests that China exported more non-IT products than IT-related parts to Korea and the USA and imported large volumes of scale of parts from the two countries.

Fig. 3. Changes in China's RSCA in the World Market (2006→2015)



Note: The suffix of "W" stands for world.

Fig. 4. Changes in China's MSCA in the Korean and USA Markets (2006→2015)



Note: The suffix of "K" stands for Korea and "U" stands for the USA.

In sum, China generally maintained comparative advantage in IT products in the Korean, USA, and world markets. However, its comparative advantage position weakened. In particular, the country experienced a shift to comparative disadvantage in parts in the Korean and USA markets. However, it saw improved comparative advantage in broadcasting apparatus in the USA and world markets.

6.3. Qualitative Competitiveness in Foreign Trade with Korea and the USA

Analysis of IIT performance can provide further insights into cross-border trade patterns that cannot be explained by traditional comparative advantage theory. In this study, IIT analysis was performed to identify structural changes in international trade or changes in product quality supplied. Given the correlation between quality improvement, export competitiveness, and trade surplus, changes in trade patterns and product quality were investigated using IIT analysis. IIT indicators were computed based on trade value and volume. IIT indicators were divided into HIIT and VIIT, and the latter was further grouped into $VIIT^{H}$ and $VIIT^{L}$.

6.3.1. Analysis of Qualitative Competitiveness in IIT with Korea

Table 5 and Fig. 5 present China's IIT with Korea by trade value and volume. On the basis of trade value, China's IIT with Korea expanded from 49.06 in 2006 to 66.37 in 2015. The proportion of HIIT in total IIT was higher in 2006, compared to that of VIIT. However, since 2007, the share of VIIT had increased, and the increase in $VIIT^{L}$ was absolutely prominent, compared to the increase in $VIIT^{H}$. In this trade pattern established since 2007, China imported high-quality or competitive IT products and exported low-quality IT products to Korea. Furthermore, greater increases in low-quality products in total IIT implies that China's qualitative competitiveness in IT products did not significantly increase in trade with Korea over the 10-year period.

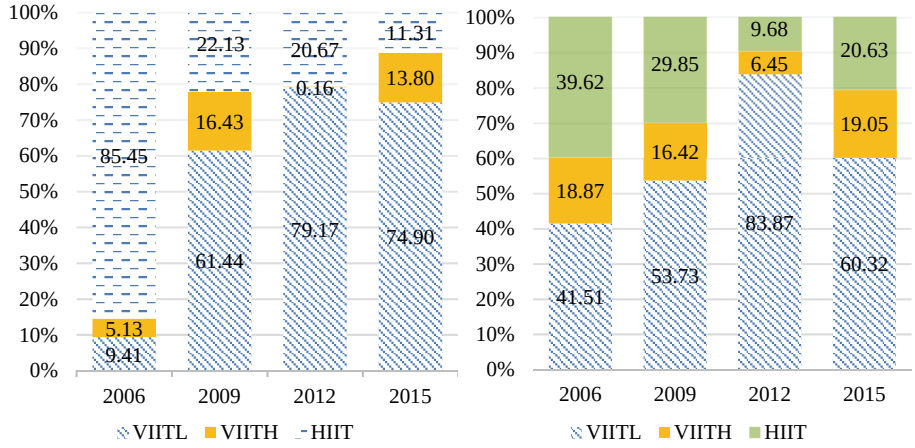
China's IIT with Korea was also analyzed in terms of trade volume to prevent a distortion that may occur when trade was highly concentrated in specific products. The results revealed lower IIT indices, compared with value-based IIT indices, showing an increase from 51.96 in 2006 to 61.76 in 2015, which constitutes nearly 62 percent of the total IT trade with Korea.

Table 5. Analysis Results of IIT with Korea

	Trade Value				Trade Volume			
Year	**IIT**	**HIIT**	**$VIIT^{H}$**	**$VIIT^{L}$**	**IIT**	**HIIT**	**$VIIT^{H}$**	**$VIIT^{L}$**
2006	49.06	41.92	2.52	4.62	51.96	20.59	9.80	21.57
2007	72.60	16.09	2.35	54.16	66.67	17.65	10.78	38.24
2008	59.86	12.55	8.35	38.95	71.57	18.63	7.84	45.10
2009	64.78	14.34	10.64	39.80	65.69	19.61	10.78	35.29
2010	62.06	17.02	3.86	41.18	65.69	14.71	7.84	43.14
2011	57.99	16.59	2.86	38.53	64.71	18.63	7.84	38.24
2012	62.14	12.84	0.10	49.20	60.78	5.88	3.92	50.98
2013	63.04	18.16	8.94	35.95	59.80	14.71	4.90	40.20
2014	68.90	29.47	2.55	36.88	56.86	19.61	8.82	28.43
2015	66.37	7.50	9.16	49.70	61.76	12.75	11.76	37.25

Source: Authors' calculation according to the data from UN Comtrade Database.

Fig. 5. Changes in IIT Patterns with Korea in Terms of Trade Value(left) and Trade Volume (right)



Unlike trade value, since 2006 the shares of $VIIT^{L}$, HIIT and $VIIT^{H}$ have continuously increased in a descending order. In addition, in 2015, the shares of $VIIT^{L}$ and $VIIT^{H}$ increased (21.57→37.25) and (9.80→11.76), respectively, whereas the share of HIIT decreased (20.59→12.75), indicating that China maintained a certain trade pattern with Korea in which low-quality IT products were exported and high-quality IT products were imported over the 10-year period. Meanwhile, its export competitiveness did not improve significantly. These findings cannot be derived from the analysis of trade specialization.

6.3.2. Analysis of Qualitative Competitiveness in IIT with the USA

Table 6 and Fig. 6 present China's IIT with the USA by trade value and volume. In terms of trade value, China's IIT with the USA increased steeply from 19.57 in 2006 to 30.73 in 2007 before moving downward afterwards. It represented 21.60 in 2015, meaning that IIT accounted for nearly 21 percent. In 2006, the proportion of HIIT was higher than that of VIIT, but the trend was reversed in 2015, showing greater VIIT. In VIIT, $VIIT^{L}$ continued to be more dominant than $VIIT^{H}$, indicating that China's IIT with the USA was more concentrated in low-quality IT products.

On the basis of trade volume in IT products, the IIT indices in China's trade with the USA were higher, compared with those value-based indices showing 59.8 in 2015, which accounted for nearly 60 percent of total trade volume. The share of VIIT increased more significantly than that of HIIT during the research period, and VIIT mostly comprised $VIIT^{L}$. As a result, the shares of $VIIT^{H}$ (3.92→6.86) and $VIIT^{L}$ (32.35→46.08) increased, while the proportion of HIIT (16.67→6.86) decreased in 2015, compared with the base year (2006). These findings confirm that China's trade patterns with the USA are identical with those with Korea in terms of IT products as the country generally imported high-quality products and exported low-quality products without improving its qualitative export competitiveness.

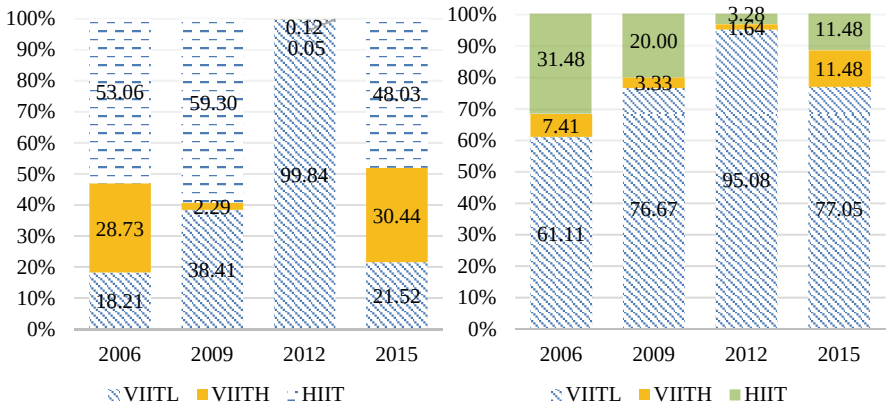
In other words, China's IT industry was characterized by low-quality vertical IIT with Korea and the USA, and such a trade pattern was more prominent with the latter. The share of HIIT decreased, and that of VIIT ($VIIT^{H}$+$VIIT^{L}$) increased during trade with both countries, indicating that China's IT industry was rapidly catching up with technological capabilities and bridging the gap between itself and these two countries, although its qualitative export competitiveness was not boosted significantly.

Table 6. Analysis Results of IIT with the USA

	Trade Value				Trade Volume			
Year	**IIT**	**HIIT**	**VIIT^{H}**	**VIIT^{L}**	**IIT**	**HIIT**	**VIIT^{H}**	**VIIT^{L}**
2006	19.57	10.38	5.62	3.56	52.94	16.67	3.92	32.35
2007	30.73	10.21	1.96	18.57	64.71	14.71	4.90	45.10
2008	33.52	14.31	2.54	16.66	59.80	7.84	4.90	47.06
2009	29.03	17.21	0.66	11.15	58.82	11.76	1.96	45.10
2010	27.36	14.53	2.43	10.40	59.80	6.86	0.98	51.96
2011	21.35	12.58	2.32	6.45	60.78	6.86	1.96	51.96
2012	15.88	0.02	0.01	15.86	59.80	1.96	0.98	56.86
2013	15.36	8.67	3.17	3.52	59.80	3.92	0.98	54.90
2014	20.74	15.42	1.14	4.18	60.78	10.78	2.94	47.06
2015	21.60	10.38	6.58	4.65	59.8	6.86	6.86	46.08

Source: Authors' calculation according to the data from UN Comtrade Database.

Fig. 6. Changes in IIT Patterns with USA in Terms of Trade Value(left) and Trade Volume (right)



7. Conclusion

This study aimed to identify changes in the qualitative export competitiveness of China's IT industry in trade with Korea and the USA during 2006–2015 period by analyzing general trade specialization and IIT. The results of the study are outlined below.

First, the analysis of China's trade specialization in IT products found that the country's export competitiveness was weak in the Korean market although it showed an upward trend. In contrast, it was strong and sustainable in the USA market over the research period. By product category, China's competitiveness in broadcasting and communication apparatus as well as parts was weak but with an upward trend. However, information apparatus showed deterioration in competitiveness. In terms of trade with the USA, China's competitiveness in all IT products except parts was strong. In particular, information and communication apparatuses had a significantly high competitiveness, while parts showed poor competitiveness with a downward trend.

Second, China's IT industry maintained comparative advantage in the Korean, USA and world markets during 2006–2015. Its comparative advantage showed an upward trend in Korea and a downward trend in the USA. By product category, China's comparative advantage in broadcasting apparatus improved in the USA and world markets. However, the comparative advantage in other products exhibited a downward trend. In particular, China was comparatively advantaged in parts in trade with Korea and the USA in 2006. On the other hand, its competitiveness of parts kept declining and revealed comparative disadvantage in 2015.

Third, IIT analysis was performed to determine changes in qualitative export competitiveness, which cannot be identified in analyses of trade specialization and comparative advantage. As a result, China's IT industry was engaged in a more active IIT with Korea, compared to that with the USA, and the industry mainly exported low-quality IT products to these countries. Specifically, the share of HIIT decreased, while that of VIIT rose significantly due to a great increase in $VIIT^{L}$, which indicates that China was rapidly catching up with IT technological capabilities and eventually bridging the gap with these two countries even though no significant improvement was found in its qualitative competitiveness during 2006–2015.

Based on the results of the analysis, this study suggests the following implications.

China's IT industry had comparative advantage in the Korean market although its export competitiveness remained weak, whereas it showed strong export competitiveness and comparative advantage in the USA market. These findings indicate that China maintained a strong competitiveness in IT products exported to Korea although the associated trade volume was not high. However, its competitiveness in trade with the USA remained strong with larger trade volume. Hence, this study underlines the need for policy support and further research to improve the competitiveness of the IT industry in line with technical advancements.

In terms of IT products, communication apparatus showed improved competitiveness in Korea and the USA, which is attributable to advanced IT development in the world and expanded production capacity in China after the widespread use of smartphones. The declined comparative advantage in parts is explained by the fact that China's IT industry was still importing important high-tech parts from Korea and the USA. However, China's competitiveness in parts is expected to become stronger in the future given that its IT imports from Korea and the USA are still rising and that the Chinese government implements the 2025 policy for manufacturing and policy whereby imported intermediate goods will be replaced with locally produced parts to promote localization. However, without perspective on the central role of the IT industry expected in the fourth industrial era, focusing policy and support from the government on specific areas based on current comparative advantage is not recommended.

A separate analysis of qualitative export competitiveness of China's IT industry revealed that China's IIT in IT products saw a greater increase in the Korean market, compared with the USA market, suggesting more active IIT with the former. As China's IT industry exported low-quality products and imported high-quality products, it is believed that the industry made progress to both catch up with the two countries and bridge its technological gap. However, a high proportion of low-quality products in IT exports calls for continued R&D efforts, improvement in technology, and policy support to bolster qualitative competitiveness at the government level.

This study analyzed trade patterns and export competitiveness to assess qualitative competitiveness in cross-border trade. The findings highlight the need to investigate determinants of such competitiveness in future studies.

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