2013 KIEP VISITING FELLOWS PROGRAM

Edited by Heungchong Kim

KIEP Korea Institute for International Economic Policy

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KIEP possesses highly knowledgeable economic research staff. Now numbering over 195, our staff includes 48 research fellows with PhDs in economics from international graduate programs, supported by more than 79 researchers. Our efforts are augmented by our affiliates, the Korea Economic Institute of America (KEI) in Washington, D.C. and the KIEP Beijing office, which provide crucial and timely information on local economies. KIEP has been designated by the government as its Center for International Development Cooperation and the National APEC Study Center. KIEP also maintains a wide network of prominent local and international economists and business people who contribute their expertise on individual projects.

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Korea Institute for International Economic Policy (KIEP) has expanded its cooperative relations with the world since it took the role of the hub of regional studies in public research areas of Korea. The Outreach Team at KIEP has played a pivotal role of regional studies of the world in Korea.

As a part of our systematic efforts to foster international exchanges and build the knowledge based through interdisciplinary collaboration, KIEP initiated the Visiting Fellows Program in 2008. The program brings together influential professionals from academia and the public sector to advance individual, institutional and national understanding of regional economic matters and to improve international cooperation on related research.

This volume is a part of our achievements through the program. It is comprised of six papers contributed by visiting scholars participated in the Visiting Fellows Program in 2013. I hope this proceeding would work as another channel to deepen the understanding of emerging economies in Korea.

I would like to express my special thanks to all participated scholars who contributed in this book. I would also deeply appreciate my colleagues, Juneyoung Choi and Mijung Woo from the Outreach Team who worked very hard for the publication of this volume.

Heungchong Kim
Vice President
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1

Intra-Industry Trade and Foreign Direct Investment between Iran and South Korea

Abbas Aminifard[1)]

I. Introduction

1.1. Economic relationship between Korea and Iran

In recent decades, Iran and South Korea have made considerable efforts to improve their bilateral trade relations. In February 2005, South Korea's Chamber of Commerce and the Iran's Chamber of Commerce, Industries, and Mines (ICCIM) met in Tehran to explore ways to expand economic and trade ties between the two countries' private sectors. At the meeting, both sides determined they would do their utmost to take steps to increase the level of bilateral trade relations (Iran-Daily, 2005[2)]). Accordingly, they emphasized the importance of closer cooperation between

1) Assistant Professor, Department of Economics, Shiraz Islamic Azad University

2) Published by the Islamic Republic News Agency, IRNA, 2005, www.iran-daily.com.

the two countries in order to pave the way for capital mobility, technology transfer and financial management-necessary for trade expansion.

The ICCIM (2005) has reported that the trade volume between Iran and South Korea was about USD 4 billion in 2004, while Iran's export to South Korea stood at USD 1.8 billion in 2003. Iran's exports to South Korea grew 38% in 2004 in terms of value compared to the previous year; the rise was due to an increase in export of crude oil. South Korea's export to Iran amounted to USD 1.7 billion in 2003, increasing by 44% compared to the previous year. According to this report, among the measures taken by the Iranian government in recent years have been efforts to facilitate export and import, the removal of non-tariff barriers for imports of all goods, the reform of laws supporting investments and the reduction of the income tax rate from 65% to 25%.

In May 2009, South Korean ministers participated in a major conference on foreign investment in Iran. South Korea also attended the Iranian Gas Forum on September 26-27, 2009, alongside Germany, the United Kingdom, Japan, the Netherlands and Malaysia.

According to the latest report released by the South Korea International Trade Association (KITA), the volume of Korea's export to Iran reached USD 3.956 billion in the first 7 months of 2012; export value rose 21.7 percent. During this same period, Iran's export amounted to USD 6.072 billion. The majority of Iran's exports were oil. Iran was the 12th main exporter to South Korea, while Korea is the 20th largest exporter to Iran. The total volume of bilateral exchange between the two countries in 2012 amounted to USD 10.028 billion, an increase of 3 percent over the year 2011.

Throughout their histories, the two countries have maintained a relatively friendly and strong, strategic partnership. South Korea is one of Iran's major commercial partners. Korea, however, has advanced more quickly than Iran in certain specific sectors, such as the commercial and industrial, information and communication, health and education sectors. Korea is a more developed country than Iran. In terms of physical structure, labour efficiency and financial resources, Korea enjoys

a comparative advantage. On the other hand, Iran is one of the richest regions in the world in terms of hydrocarbon resources.

Studies have revealed that Iran possesses several mines and minerals along with huge oil and gas resources. The country is heading towards an economic regime based on industrialization. Preparation of basic infrastructure at the required level for this purpose is underway. Available resources and facilities can be used for economic growth and development. Nevertheless, Iran must still confront problems related to the lack of sufficient capital to invest towards improved outcomes on the one hand, and the desired level of entrepreneurship and skills on the other. Against this background, Korea can cooperate with Iran in many respects. Both countries would share mutual benefits by doing so.

For Iran's part, authorities underscored the country's need to attract foreign capital in its private sector, and called on Korean companies to look more closely at the Iranian market. They also pointed out that Iran's economic policies are moving towards privatization, and downsizing the government would provide a suitable opportunity for bilateral cooperation between the two countries.

1.2. Objectives and scope of the study

This study focuses mainly on the trade relationship between Korea and Iran. After a review of general patterns between Iran and Korea, key features of Intra-Industry Trade (IIT) and the impact of sanctions against Iran on trade patterns with Korea are examined; some policy recommendations to improve trade and relations between the two countries are presented in the last chapter.

From the Korean perspective, the importance of economic and trade relations with Iran should remain unchanged in the future. The significance of these relations is expected to be high in years to come. The trade relationship between Korea and Iran is, by-and-large, considered a smooth one.

In the realm of global trade integration, trade relations between these two countries need to improve further. At the same time, in the present era of trade specialization, both countries need to develop their own specific trade activities based on the scale of economies, value addition and competition. This study aims to explore the scope for trade improvement between Korea and Iran.

This study employs a combined descriptive and explorative research design. Based on secondary data, the study will attempt to derive a firm view with regard to the established objectives of this study. Data and information concerning trade and treaties between Korea and Iran have been used from published and unpublished research papers, books, periodicals, journals, Internet websites and official sources.

II. Key Trends of Bilateral Trade

2.1. Macroeconomic performance of Iran

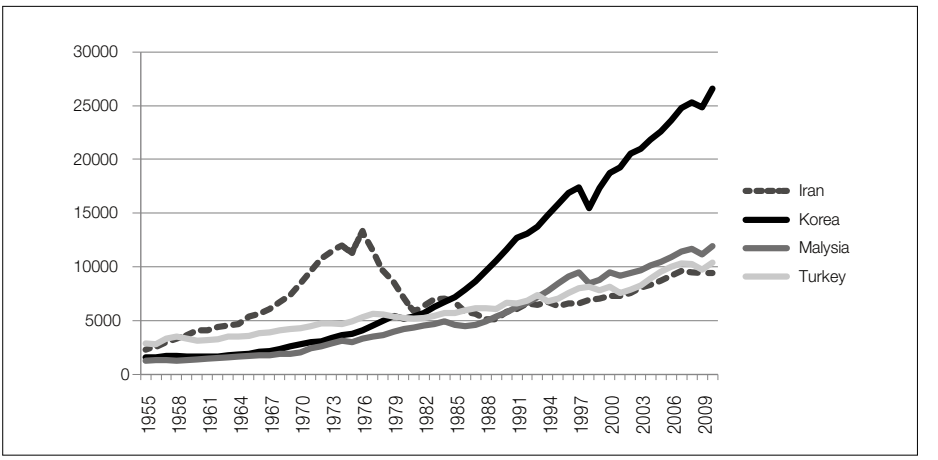
Overall, Iran's economy recorded an annual average real growth rate of 5.3% over the five decades from 1960 to 2010. While this aggregate long-term growth rate is marginally higher than the comparable rate for the Middle East and North Africa (MENA) region (with an average growth rate of 3.8% per annum), it is equal to the rate for the wider group of Lower-Middle Income economies of which Iran is part (5.3% per annum). This record, however, should be qualified in at least three important ways. First, it masks gross discrepancies over time (especially after the late 1970s, as we shall see). Second, it needs to be studied in a comparative context to shed light on Iran's relative performance vis-à-vis her peers. Last, but not least, allowing for population growth (especially after the 1980s) presents a different picture.

In general, evidence suggests that Iran's growth performance deteriorated after

the late 1970s. This is true both in a comparative light as well as compared to the period over time (see Hakimian and Karshenas, 2000, and Karshenas and Hakimian, 2005). The graph below depicts an analysis of Iran's performance against three different comparator groups over different time-periods: a select number of high-performance Least Developed Countries (LDCs), Lower-Middle Income economies (LMCs) and oil economies.

A comparison with high performers such as Korea, Malaysia and Turkey highlights the sharp trend reversal in Iran's growth performance in the last decades of the twentieth century (Figure 1). For instance, in the period from 1955 to 1975, Iran's per capita income grew faster than her three peers did. Since the mid-1970s, however, Iran's growth rate has faltered, with a widening gap emerging in particular compared to South Korea and Malaysia, both of which have consistently increased their per capita GDP (exceeding double their levels in the late 1970s). The fact that another oil economy such as Malaysia has outperformed Iran's growth in this period suggests that being an oil economy need not be the root cause of sluggish

Figure 1. Per Capita GDP Trends in Iran, Malaysia, Korea and Turkey, 1955–2010



Note: Figures refer to real GDP per capita in constant dollars expressed in international prices (base 2005). Penn World Table Version 6.1.

economic performance.

Comparisons with Turkey are no less instructive. Starting from similar per capita income levels in the early 1960s, Turkey has followed a more steady growth path, and after the collapse of growth in Iran in the 1980s, has overtaken Iran. To be sure, much of this catching up by Turkey took place during Iran's war with Iraq in the 1980s (from which Turkey and other neighbouring countries benefitted economically). However, sustained economic growth would not have been possible without far-reaching economic reforms introduced after the early 1980s, which resulted in a higher efficiency of investment and greater economic diversification, especially in rising manufacturing exports.

Table 1. Selective Comparative Economic Indicators–First, Second, Third and Fourth Plan Years (Average Annual Figures)

	First Plan (1989-93)	Second Plan (1994-99)	Third Plan (2000-04)	Fourth Plan (2005-09)
Real GDP growth (%)	7.5	2.8	5.4	5.4
- Non-oil GDP (%)	7.2	3.7	5.8	5.8
Fixed Investment(%GDP, 1997 prices)	29.4	26.7	33.6	33.6
Real Private Consumption (% change)	7.8	2.8	7.3	7.3
Inflation (urban CPI)	18.8	27.2	14.1	14.1
Liquidity (M2)	25.2	26.3	28.9	28.9
Oil Export Revenues (million USD)	15,451.0	15,245.0	26,153.4	26,153.4
Non-Oil Export Revenues (million USD)	2,348.0	3,540.7	5,645.8	5,645.8
Imports (fob, million USD)	19,905.8	13,703.7	24,290.2	24,290.2
Current Balance (million USD)	-4,006.2	3,368.0	5,401.8	5,401.8

Source: Central Bank of Iran.

2.2. Trade policy of Iran

Iran is a large country with population of about 70 million people. Although the country is rich in mineral resources and has some of the largest hydrocarbon reserves in the world, its per capita income is about USD 2300, which places it among lower-middle-income countries (World Bank, 2006).

The Iranian government is of two minds regarding the country's accession to the General Agreement on Trades and Tariffs (GATT) and the World Trade Organization (WTO). Economic arguments militate in favour of joining the WTO, while arguments against joining see GATT as a tool of powerful industrialized states and cite possible disadvantages to following its rules. Membership in the WTO would reinforce the country's current trend towards economic liberalization and lead neighbours to think of Iran as a lucrative country with which to do business (Afrasiabi, 1995).

After the Islamic Revolution in 1979, Iran adopted an inward-looking strategy and the government used duty to control imports and exports. Since the late 1980s, the country began to reform the economy to become more active in the globalized world. Iran applied for WTO membership almost a decade ago (the first time in 1996), but due to rejection by the US, its membership request was not accepted (WTO, 2005). Recently, however, Iran was accepted as an observer member in the WTO (in June 2005).

Iran's export growth has increased dramatically since 2002, thanks to high oil prices; the current account surplus is projected to rise, with international reserves reaching about USD 50 billion by the end of 2006 (World Bank, 2006). Iran's future prospects look challenging. Oil price volatility and capacity constraints in the oil sector, international tensions over the nuclear issue, and the possibility of a prolonged period of "wait and see" on the part of the private sector have adversely affected the economic outlook. Therefore, the likely benefits from economic globalization have been largely out of reach (UNCTAD, 2005).

According to the latest International Monetary Fund (IMF) report, the Tariff

Restrictive Index (TTRI) is 13.1 percent in Iran, which is more restrictive than that of an average Middle East and North Africa (MNA) country (11.9 percent) or LMC (8.4 percent). While almost all of the countries in Iran's comparator groups have higher trade barriers for agricultural than for non-agricultural products, the opposite is true of Iran: its agricultural TTRI of 7.1 percent is lower than its non-agricultural TTRI of 14.6 percent.

Based on this latest TTRI, Iran ranks 110th out of 125 countries (where 1st is considered the least restrictive). Iran's simple average, most-favoured nation (MFN) applied tariff of 25.6 percent tells a similar story: the country's trading regime is more protective than that of its comparators. Its 400 percent maximum MFN applied tariff, excluding alcohol and tobacco, which is applied to opium, is among the highest in the region. In addition, the share of tariff lines with duties higher than 15 percent (international peaks) is 46.1 percent.

Protection for domestic industry is administered through implicit energy subsidies that, if defined as domestic energy consumption multiplied by the differential between global and domestic energy prices, amounted to about 20 percent of GDP in 2008. This gave domestic firms a huge price advantage over their competitors in the production of any energy-intensive outputs. Explicit gasoline subsidies are provided for imported gasoline (Iran's domestic demand outpaces its refining capacity) by compensating the National Iranian Oil Company (NIOC) for the difference between the import cost and the domestic price.

As is typical of oil exporters, Iran faces relatively low barriers to its exports. Its exports, with a Market Access TTRI of 1.9 percent, have better access to international markets than the average country in the MNA region (2.1 percent) or in the LMC group (2.3 percent).

However, Iran does face international trade sanctions that limit its access to markets. The simple average of the overall rest of the world tariff (including preferences) faced by the country's exports is 10.5 percent. When its trade flows are taken into consideration, it is apparent that Iran's exports have good access to international markets, as the weighted rest of the world tariff (including preferences)

is 1.1 percent, corresponding to 5.4 percent for agricultural products and 1.0 percent for non-agricultural products.

Iran was on the receiving end of three anti-dumping investigations in 2008. Two were initiated by India (regarding exports of hot rolled steel and carbon black used in rubber manufacturing) and one by Turkey (regarding exports of certain fabrics).

It should be pointed out that non-oil products comprise less than 20 percent of Iran's total exports. The Iranian rial appreciated by 99.3 percent in real terms in 2012, making exporters less competitive abroad.

The Logistics Performance Index score of Iran, which reflects the extent of trade facilitation in the country, is above regional and income group averages, reflecting a more conducive climate for trade. The country scored 2.51 on a scale of 1 to 5, with 5 being the highest score, while regional and income group averages are 2.42 and 2.47, respectively. It ranked 78th out of 150 ranked countries and 4th in the MNA region. Iran's strongest logistics indicator is domestic logistics costs, while it needs most improvement in the ability to track and trace shipments.

Iran's foreign trade balance deficit (without taking into account petroleum and liquid gases) improved more than USD 7.458 billion in the 12 months of 2012 compared to the previous year.

According to latest report on foreign trade, the balance of Iran improved in 2012. Based on the report of the IT department of the Islamic Republic of Iran Customs Administration (IRICA), during the past year (2012), 68.992 million tonnes of goods worth USD 34.038 billion were exported from the country, while 41.589 million tonnes of goods worth USD 56.998 billion were imported into the country.

Based on this report, exported goods in 2012 grew 9.5 percent in weight and 8.3 percent in value compared to 2011, while the import of goods increased 9.77 percent in weight and decreased 6.44 percent in value during the same period.

The report also states that among 194 trade partners of Iran during the mentioned period, the trade balance of Iran was positive with 98 countries, while it was negative with the other 96 countries.

In the meantime, Iran's trade exchanges with Iraq-allocating 42.45% of a positive trade balance-generated the highest benefit for our country, whereas the United Arab Emirates (UAE)-allocating 22.36% of a negative trade balance-acquired the most benefit from exchanging goods with Iran.

The report further indicates that Iraq, Afghanistan, India, Turkmenistan and Pakistan together represented the five trading partners of Iran with the highest positive trade balance, while the UAE, the Korean Republic, Switzerland, Turkey and China represented the five trading partners of Iran with highest negative trade balance during the 12 months of 2012.

2.3. Macroeconomic performance of Korea

Korea has shown rapid economic growth since the 1960s. The government has provided various incentives to encourage exports, promoting export-led economic growth. Export values increased from USD 87 million in 1963 to USD 17.5 billion in 1980, and then to USD 555.2 billion in 2011. Although import values were more than 6 times larger than export values in 1963 (in 1971 this is 2.3 times larger), trade surpluses have been recorded since 1998. The trade dependence ratio, defined as (export values+import values)/GDP, increased from 46.6 percent in 1972 to 78.9 percent in 1980, to 76.6 percent in 2001 and then to 108 percent in 2011. Thus, the Korean economy is regarded as one with a very high trade dependence ratio. In the meantime, per capita GDP increased from less than USD 100 in 1960 to USD 1,688 in 1980, to USD 12,581 in 1996 and then to USD 21,575 in 2011. It was believed export expansion would be possible through aggressive export promotion (EP) policies, in particular in the early stage of economic development. The Korean government provided tax and financial incentives in addition to incentives by establishing organisations to promote exports. The experience of the economic growth of Korea is regarded as a classic example of pursuing an export-led economic growth strategy.

Although the Korean government provided many types of export incentives in its rapid economic growth, the WTO system strictly regulates most such incentives promoting exports. Developing countries trying today to pursue export-led economic growth strategy are not free to take many of the EP measures that were adopted by the Korean government during that country's period of very rapid economic growth.

2.4. Trade policy of Korea

By the early 1960s, the Korean government had begun pursuing an import substitution policy. In 1964, the government announced its pursuit of EP policies with the slogan "Export Number One," i.e. EP was the most important policy. The government began to increase the amount of export subsidy, placing emphasis on exports of products of the labour intensive 1ight industries (LI), in particular in textile and garment industries, where the Korean economy had a comparative advantage.[3] In 1964, the government introduced a 50 percent reduction of profit tax relating to exports and export finance schemes at low interest rates. Exchange rate devaluation contributed to EP as well. For instance, the exchange rate was devalued from time-to-time, i.e. from 255 KRW/USD in 1964 to 484 KRW/USD in 1974. Under the export-import link system, the government granted exporters the right to use foreign exchange necessary for imports. This was intended to promote exports under a situation of extreme foreign exchange shortage.[4] The government developed land sites for industrial complexes and provided them cheaply to the firms entering.[5] Together with various tax and financial measures to promote exports, the government established institutions to support EP.

In 1965, the Korean government selected the following LI products as those

3) Lee, Sunghoo, Sidong Kim, and Sung-Ho Han (1989).
4) Jeong, Kap-Young (1995).
5) Lee, Jaymin (1995).

appropriate for export-led industrialization, i.e. raw silk, cotton fabrics, plywood, leather, craftwork, potteries, rubber products, radio and electric appliances, fisheries and mushroom cans, wool products, clothes, and miscellaneous products. These products reflected the then economic development level of Korea. The government offered EP measures to manufacturers producing those selected products. As of 1967, in terms of the number of workers (income), the textile industry shared one-third (a quarter in terms of income) of all manufacturing sectors. The Korean government began to establish Woolsan Petrochemical Industrial Estates and the POSCO in the late 1960s. In 1967, Korea became a GATT contracting party and export products of Korea were accorded most-favoured-nation status in the global trading system.[6)]

During the 1970s, the main thrust of the industrial policy of Korea shifted from LI to developing high value-added Heavy and Chemical Industrialization (HCI). The rising wage level, which tended to undermine the international competitiveness of labour intensive LI, also forced the government to change the engine of economic growth.[7)] The government chose iron and steel, non-ferrous metal, shipbuilding, electronics and chemical industries as the most important HCI.[8)] The share of the HCI in all industries increased from 23 percent in 1960 to 39 percent in 1970, and then to 54 percent in 1980. Overall, the spectacular economic growth of Korea in the 1960s and 1970s, as shown in Table 3, was accompanied by rapid export growth. Due to over-investment in HCI, the capacity utilization ratio of HCI declined in the late 1970s. Structural problems, such as those resulting from the government-dependent inefficient banking system, began to be observed in the late 1970s and the early 1980s.[9)] To overcome the problems arising from excess capacity of certain HCI, so-called HCI Rationalization Measures were taken during 1979-1981, which included the postponement or withholding of the capacity expansion schedules with respect to certain HCI such as diesel engine, tire, machinery and shipbuilding.

6) Kim, Jeongryum (2006).
7) Oh, Wonchul (1996).
8) Kim, Jeongryum (2006).
9) Lee, *et al.* (1989).

In 1981, the government began to emphasize the importance of research and development (R&D) and expressed its intention to continue an export-led growth strategy. Consequently, since 1983, the government's attention shifted away from sector-oriented support such as the HCI Drive towards function-oriented support, support for R&D in particular.[10] This meant that the importance of export support granted to specific industries or firms weakened after the mid-1980s. Such an emphasis on R&D led to an increase in exports of technology-based electronic products since the late 1980s.

In the late 1990s, the government decided to promote the capital goods industry. Therefore, in 1995, it announced the Capital Goods Industries Promotion Plan, which was expected to promote high value-added capital goods industries by supporting the development of new products and establishing them as the main export industries. Meanwhile, the government has pursued deregulation and market-opening measures to strengthen the market mechanism. Korea eliminated several remaining direct

Table 2. Economic Growth, Exports and Exports/GDP in Korea

Years	Real GDP growth rate (Percent)	Export values (USD billions)	Exports/GDP (Percent)
1962-1966	8.0	1	7.7
1967-1971	9.7	3	13.7
1972-1976	8.4	22	27.8
1977-1981	6.1	77	31.5
1982-1986	8.7	141	34.4
1987-1991	9.2	307	32.1
1992-1996	7.0	510	28.7
1997-2001	4.3	734	42.8
2002-2006	4.8	1,239	31.2
2007-2011	4.1	1,468	47.2

Source: IMF, International Financial Statistics Yearbook 2004; the Bank of Korea, Economic Statistics Yearbook 2010.

10) *Ibid.*

export subsidies, even right after the occurrence of the economic crisis in 1998. The government currently promotes exports by supporting international marketing activities and exhibitions abroad. In addition to such indirect measures, certain EP measures, such as provision of export insurances and duty drawback not exceeding threshold levels, are provided to the exporters, as these are not prohibited by current WTO regulations.

2.5. Comparison of some economic indicators in Korea and Iran

Korea and Iran share common features in many respects. However, Korea has been more connected with trade world and been more advanced in some of the specific sectors, such as the automobile industry, information and communication, electronic devices, etc. See Table 3: Compare Some Economic Indicators in Iran and Korea.

Table 3. Compare Some Economic Indicators in Iran and Korea

	Iran	Korea
Rank in world trade		
Export	33	7
Import	47	9
Trade per capita (USD, 2008-2010)	2,653	21,575
Trade to GDP ratio (2007-2009)	58	108
% change (2005-2009)		
Export	4	9
Import	6	7
Simple average of import duties		
All goods	26.6	12.1
Agricultural goods (AOA)	30.4	48.6
Non-agricultural goods	26.1	6.6
Share in world total exports	0.72	3.04
Share in world total imports	0.34	2.84

Source: IMF databases.

III. Measurement of Intra-Industry Trade

For more than four decades, theoretical and empirical researchers in the field of international trade have been keenly interested in bilateral trade of products belonging to the same industry, i.e. inter-industry trade (IIT). Theories of comparative advantage or Heckscher-Ohlin factor endowment have focused on ITT. Ricardo's comparative advantage model states that countries with different comparative advantages engaging in trade will profit from it. Both types of trade models assume that the goods traded are homogeneous, and the country will therefore only either export goods within the same industry or only import these goods, but not simultaneously export and import goods within the same industry. One important observation in international trade is that much of the post-war expansion of trade has taken the form of IIT, commonly defined as the simultaneous imports and exports of goods from the same industry. Empirical work on the measurement of IIT began in the mid-1960s with Balassa (1966) and the most well-known work on IIT by Grubel and Lloyd (1975). This empirical work has led to a renewal of interest in the theoretical models of Krugman (1979), Lancaster (1980), Helpman (1981), and Falvey (1981). Falvey and Kierzkowski (1985), and Flam and Helpman (1987) have sought the determinants of IIT; their research demonstrates that large number of firms will produce varieties of different quality. The constant increase in the quality of products is an important competitive driver influencing the success of firms in the global market. In recent years, empirical studies (Bernard and Jensen, 2001; Bernard *et al.*, 2005; Hallak and Schott, 2005) offer clear evidence of the increasing importance of IIT based on vertically differentiated products. In the economic literature, the concept of quality does not only refer to particular physical features of the products, such as materials or embedded technology. For Hallak and Schott (2005), product quality refers to all the features-tangible and intangible-influencing consumer economic valuation. To assess this, the first stage is to develop a methodology for differentiating between qualitatively different bilateral trades in goods from within the same industry. The second stage is to document the

levels, and test for the determinants of vertical and horizontal IIT for trade relationships. A third stage is suggested by Azhar and Elliott. The Azhar and Elliott (AE) index has symmetrical limits, is scaled equally in both upper and lower bounds, and can measure the dispersion of product quality in IIT. This type of trade not only increases consumers' options but also increases the level of competition among producers of a given product in different countries. Given the significant and increasing role of IIT in foreign trade, it is vitally important we pay serious attention to the role of this phenomenon in foreign trade patterns.

Intra-industry trade refers to concurrent imports and exports of similar products. A measure developed by Grubel and Lloyd has been widely employed in measuring IIT. Most studies use the Grubel and Lloyd (GL) index, which is a simple modification of the Balassa formula. The index is defined as

$$GL = \frac{(X_i + M_i) - |X_i - M_i|}{(X_i + M_i)} = 1 - \frac{|X_i - M_i|}{(X_i + M_i)} = 1 - B_j. \quad (1)$$

This index assigns pure IIT a value of 1 and pure inter-industry trade a value of 0. As with the Balassa index, the GL index has been calculated as a weighted average to measure the degree of IIT at the country level. This class of index has been criticized for suffering from categorical/sub-group aggregation issues. These issues have two basic forms that bias the index towards 1: the grouping of two products in the same industry, which should not be classified together, and trade imbalance.

The increasing extent of IIT in the world trading system has some important implications for adjustment of economies to increase trade. By increasing trade, the size of economic sectors may change. Sectors experience an increase in imports and exports, simultaneously. Therefore, there is no need for a shift in resources between sectors. This will decrease the adjustment of trading. Adjustment problems can arise where resources, especially labour, are geographically and occupationally

immobile in the short run. Large-scale structural employment might result. Largely, intra-industry specialization is achieved without the necessity for workers to leave a particular industry or region. The risk of structural unemployment is reduced. (Grimwade, 1989).

$$GL^{/} = 1 - \frac{\sum_{i=1}^{n} \left| X_{ij} - M_{ij} \right|}{(X_j + M_j)} \tag{2}$$

Generally speaking, if a country is a net exporter/importer in both goods, then $GL = GL^{/}$, but if a country is a net exporter in one good and a net importer in another, then $GL < GL^{/}$

In general, I use the GL index in order to calculate the part of balanced trade, overlapped between exports and imports, in all trade in a given industry k between the country i and j.

$$GL_{ij,k} = \left[1 - \frac{\left| X_{ij,k} - M_{ij,k} \right|}{(X_{ij,k} + M_{ij,k})} \right] \times 100, \tag{3}$$

Where $GL_{ij,k}, X_{ij,k}$ and $M_{ij,k}$ represent respectively GL intra-industry trade, X exports and M imports between countries i and j in the industry k. By construction, this indicator displays the trade imbalance as part of inter-industry trade flows and trade overlap representing intra-industry trade. Thus, two distinct theoretical concepts are used to explain the same flow.

Another development in the 1990s with regard to measuring IIT has been related to categorization of IIT into vertical intra-industry trade (VIIT) and horizontal intra-industry trade (HIIT). HIIT/VIIT refers to concurrent imports and exports of products with different apparent features (qualities). Two significant approaches

have been used for dividing intra-industry trades into different types:

- an index used for various types of trade by Fontagne and Freudenberg (1997) was built mainly on the approach developed by Abdol Rahman (1991).
- an index developed by Greenaway, Hine, and Milner (GHM) (1995) was mainly based on Grubel and Lloyd's index.

The index used by Fontagne and Freudenberg (FF) is calculated in two stages. In the first stage and based on overlapping conditions, the trade flow is divided into unilateral and bilateral trade. Based on this criterion, if the value of minority flow is at least 10% (λ = 10%) of the majority flow, the trade for a group of products is bilateral. In the second stage, based on Dixit and Stiglitz's work (1977), it is assumed that differences in a product prices reflect the differences in the quality of the products. From a calculative view, products are regarded as similar if the difference in the unit value (UV)[11] for imports and exports is less than 15%, that is to say:

$$\frac{1}{1+\alpha} < \frac{UV_{likt}^{X}}{UV_{likt}^{M}} < 1+\alpha \tag{4}$$

UV_{likt}^{X} unit value for exports of product ℓ, industry i, with business partner k in the time t

UV_{likt}^{M} unit value for imports of product ℓ, industry i, and with business partner k in the time t.

11) Unit value for each product is obtained by dividing trade monetary value on the amount of the money, which gives the price per tonnage. Therefore, unit value will take the form of the proportion of importation to exports or the other way round, which is shown as r. Besides, a certain limit called disperse percentage is chosen for dividing horizontal and vertical differentiation.

Bilateral trade is classified into different types based on similarity of conditions or the GHM Index. Accordingly, the unit value for imports and exports is employed as follows:

$$1+\alpha < \frac{UV^{X}_{likt}}{UV^{M}_{likt}} < 1-\alpha \tag{5}$$

The overlap percentage α varies from 0 to 1. If the proportion of the net unit value is placed outside Equation 4, intra-industry trade will be horizontal. In contrast, from the native country view, if $\frac{UV^{X}_{likt}}{UV^{M}_{likt}} < 1+\alpha$, the exports are of high quality ($VIIT^{H}$), and if $\frac{UV^{X}_{likt}}{UV^{M}_{likt}} > 1-\alpha$, the exports are of low quality ($VIIT^{L}$). The difference between Fontagne and Freudenberg's index and Greenaway, Hine, and Milner's index is related to the fact that $(1-\alpha)$ replace to $\frac{1}{1+\alpha}$, which indicates there is a kind of symmetry between the upper limit and the lower limit regarding the distance proportion. If the value of α ranges from 0 to 1 the result is always $\frac{1}{1+\alpha} > 1-\alpha$. For instance, if $\alpha =$ 15% and if based on the GHM approach, the proportion of unit value is between $0.85 < \frac{UV^{X}}{UV^{M}} < 1.15$, then the products are included in vertical distinction. However, based on the FF approach, this proportion will be $0.87 < \frac{UV^{X}}{UV^{M}} < 1.15$ and, therefore, a number of products included in horizontal distinction based on GHM are now included in vertical distinction.

3.1. Product Quality Space (PQS):

Product Quality Space (PQS) is a square whose diameter is the geometrical

locus of points where the unit values of exports and imports are equal. In this case, all bilateral trade flows are included in horizontal distinctions. The remaining space in the square is devoted to all possible export and imports unit values in the period under study. The size of the square is dependent on the way PQS is defined. For example, PQS can be studied as the changes in unit value over a few years or the changes that occurred in a product within a year or both. Coordinates of each unit value can be drawn in the PQS square. From the native country view, coordinates of the unit value in the above triangle and left-hand side of the square indicate products whose exports are of higher quality than their imports. In the lower triangle and the right hand side of the square, exports of goods are of a lower quality than their imports.

Product quality indices in IIT: An index developed based on the GL index, representing the product quality in IIT is introduced in this part of the study. The index is first used for quality distinction at the level of products. The related equation can be written in its simplest form as follows:

$$\frac{HIIT}{IIT} = 1 - \frac{\left| UV^X - UV^M \right|}{UV^X + UV^M}$$

Although this index is symmetrical, it is not able to distinguish between the qualities of products in bilateral trade. Since the country is regarded as constant, it is not possible to distinguish between products included in vertical intra-industry trade high[12] (VIITH) and vertical intra-industry trade low[13] (VIITL) in IIT flows. To solve this problem, the absolute value will be omitted from the combined net unit value, resulting in an index that is capable of distinguishing between (VIITH)

12) $\frac{UV^X_{likt}}{UV^M_{likt}} < 1 + \alpha$

13) $\frac{UV^X_{likt}}{UV^M_{likt}} > 1 - \alpha$

and (VIITL), as follows:

$$PQH = 1 - \frac{UV^X - UV^M}{UV^X + UV^M} \qquad 0 < PQH < 2$$

Like Grubel and Lloyd's index, which measures the share of IIT in total trade flows, the above index can be regarded as an index for measuring product quality in IIT.

The Product Quality Horizontal (PQH) index used for measuring vertical distinctions between products in IIT flow can be rewritten as follows:

$$PQV = 1 + \frac{UV^X - UV^M}{UV^X + UV^M} \qquad 0 < PQV < 2$$

In this case, if the bilateral trade has a similar quality (VIIT=0), the Product Quality Vertical (PQV) index will be equal to the unit. Eventually, the sum total of indices for each level of IIT is equal to 2:

$$PQV + PQH = 2 \text{ or } PQV = 2\text{-}PQH$$

3.2. GL Intra-Industry Trade (IIT) for Iran and Korea

I employ (3) to compute the GL index by using data on bilateral trade at the 4-digit from the Harmonized System (HS). These data were extracted from www.tccim.ir for the period 2001-2011. Table 4 indicates GL index values, on average, for a variety of 12 products, which were available in this period.

The Figures in Table 5 show that Iran and Korea had the maximum levels of trade overlap, on average, in products coded by 2712 (petroleum jelly, mineral waxes) and 2803 (carbon, NESOI), while they had minimum values of IIT, on

average, in products coded by 7901 (zinc waste and scrap) and 8534 (printed circuits), respectively. Table 4 also indicates the distribution of IIT indices on average in the period 2001-2011. According to the results, out of a total 12 of items, 5 items had comparatively high levels of IIT ($GL > 10$), while the remaining ones (7 items) had comparatively low levels of IIT ($GL < 10$). Thus, the results show that IIT intensity has been more pronounced between two countries, because the comparatively high levels of IIT for more product items can be attributed to the interests of both countries in expanding their trade relations and economic integration implementation.

Table 4. Measures of GL Intra-Industry Trade, on Average, for Iran and Korea in the 4-digit Level during 2001-2011 (%)

Code	Product	Average of IIT	GHM	PQV	Distribution of IIT
2712	petroleum jelly, mineral waxes & similar products bitum mineral etc,	3.523	0.06	0.12	GL > 10
2803	carbon, NESOI	10.103	0.12	0.21	GL > 10
4012	retread or used pneu tires, solid tires etc., rubber	7.970	0.03	0.06	GL < 10
4819	cartons etc. paper, office box files etc., paper etc.	16.939	0.18	0.3	GL < 10
7901	zinc, unwrought	32.965	0.27	0.43	GL < 10
8422	machines, dishwashing, cleaning etc. cont & fill, pack etc, materials	16.809	1.22	1.1	GL > 10
8431	parts for machinery	19.506	0.55	0.71	GL > 10
8501	electric motors and generators	34.589	0.42	0.59	GL > 10
8534	printed circuits	1.503	0.24	0.39	GL < 10
8703	motor cars & vehicles for transporting persons	1.073	0.69	0.82	GL < 10
8707	bodies (including cabs), for specific motor vehicles	8.168	0.26	0.41	GL < 10
8708	parts & access for motor vehicles	17.585	0.14	0.24	GL < 10

Source: www.tccim.ir, and compiled by author.

According to the results, Iran exports a lower quality variety of product. For example, for the most widely used measure GHM[14] index, where α=15%, HIIT[15] accounts for less than 10% of all IIT, but low quality exports account for around two-thirds of all IIT. The highest share of IIT belongs to VIIT with a low quality. A similarity degree of 25% shows the same number of products belong to VIIT with a low quality. A comparison of the PQV[16] index and GHM similarity index indicates that the PQV index put a greater number of products in the VIIT group. Therefore, from 2001 to 2011, Iran's IIT with Korea was included in VIIT with different product groups of low quality.

One of the reasons for the low level of Iran's IIT with Korea is related to the low share of manufactured goods in exports. Another reason relates to the geographical distance between Iran and Korea.

IV. Sanctions and Iran-Korea Trade Relationship

4.1. Review of sanctions

The ongoing international initiative to adopt new and tighten existing trade sanctions against Iran is presenting companies and financial institutions engaged in or facilitating business with Iran with significant challenges. The sanctions are primarily focused on restricting dealings in the energy sector, particularly in the oil, gas and nuclear industries, while also restricting investment and financing of certain enterprises in Iran. The new restrictions are intended to deprive Iran of such imports and stifle the improvement of related facilities in Iran. The impact of the sanctions also resonates in the international trade, shipping and financial sectors.

14) Greenaway, Hine, and Milner Index (1995).
15) Horizontal Intra-Industry Trade.
16) Product Quality Vertical.

There are four categories of sanctions: United Nations restrictions, European Union restrictions, United States restrictions and national restrictions. In respect of the latter, a number of countries have introduced or are in the process of introducing national legislation to implement international sanctions into domestic law and/or to introduce domestic sanctions packages of their own.

Companies that are based in countries not directly subject to EU/US sanctions have to take a view on whether their economic interests are best served by maintaining a trading relationship with Iran or foregoing that connection in order to protect their share of the market elsewhere. For example, there have been recent reports that a Japanese carmaker suspended exports to Iran in order to preserve its primary position in the US car market. South Korea has apparently caved in to pressure from the US to close down Bank Mellat's Seoul branch, albeit this closure is said to be temporary.

In addition, countries such as the UAE are seeking to achieve a balance between their international commitments pursuant to the relevant UN resolutions and their legitimate business transactions with Iran. Nonetheless, reports indicate that imports from and through the UAE are already being affected, with ships carrying petroleum to Iran facing greater scrutiny and closer tracking at UAE ports, which have previously been used by Iran to transport fuel cargoes. Insurers operating within the UAE are also reportedly not underwriting new risks of Iranian interests that fall within the UN/US sanctions.

4.2. How will these sanctions affect bilateral trade?

4.2.1. Shipping contracts

The sanctions have implications for those involved in the chartering of ships and in the transfer of negotiable documents. In the first instance, reliable systems will have to be put in place to ascertain the identity of all parties to a transaction or chain of transactions, including the owners of ships, the charterers and the owners

and consignees of cargo. Notwithstanding such systems being operational, there remains a risk that blacklisted entities/ships and prohibited cargo might slip through the net, not least, because blacklisted entities have and will no doubt continue to take steps to try to conceal the ownership or identity of vessels and/or to take whatever steps they can to enable them to continue trading.

4.2.2. Insurance

Protection and indemnity (P&I) Clubs are at risk if cover is inadvertently placed over a prohibited cargo or ship engaged in prohibited activities, and if members (or their brokers) engage in prohibited activity or contract with a target entity. This potential exposure has led to the insertion of sanctions compliance clauses into policies, for example, declaring that cover under the policy will be suspended if the assured is in breach of sanctions; the assured must then indemnify the insurer in respect of loss sustained because of such breach. Some Clubs have also changed their rules or are in the process of doing so, with a view to preventing the Clubs being found to be in breach. Such changes include loss of cover or termination of membership as soon as the Club is exposed to the risk of contravention; for example, if a member's vessel, whether entered with the Club or not, is employed in a carriage, trade or voyage which will expose the Club to the risk of being or becoming subject to any sanction. A number of the P&I Clubs have been issuing circulars to their members to keep them updated on developments relating to the various sanctions, advising them how to proceed and on what the potential effects might be. It is recommended that any owner or time charterer entered with one of the P&I Clubs keep a close eye on guidelines and briefings issued by its Club.

More generally, Lloyd's of London, the world's largest insurance market, has confirmed it will back the US sanctions. Cover for shipments to Iran has consequently been significantly curtailed. Furthermore, the Lloyd's Market Association (LMA) has now produced a sanctions clause for its members, which, although designed for the marine insurance market, may also be used in non-marine policies.

4.2.3. Finance

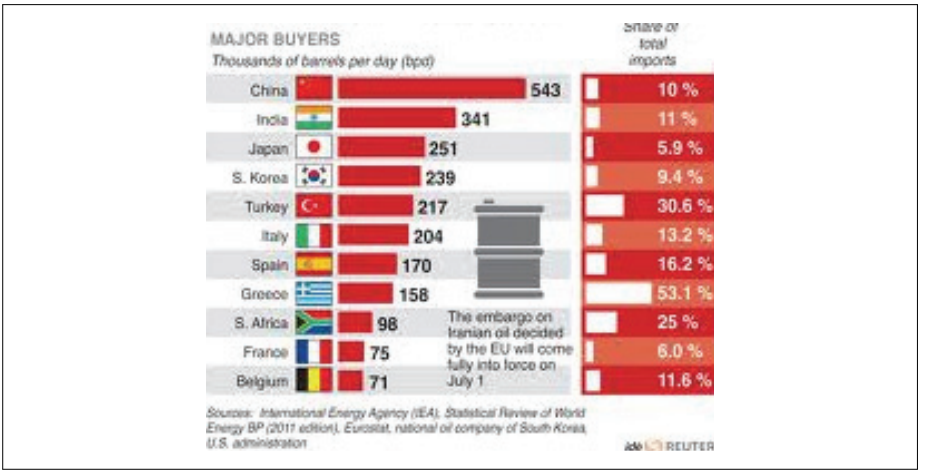
Given that many contracts provide for transactions to be undertaken in US dollars, there will be an ongoing risk that international trade and financial dealings will contravene US sanctions and incur significant penalties. US lawyers would have to be consulted for specific advice in the event that there is any concern in this regard. However, in broad terms, any US dollar transactions passing through the US banking system may be at risk of being frozen if they can be traced to Specially Designated Nationals under the US legislation.

A number of banks have already paid the price of past non-compliance with US sanctions. One recently settled a claim for over USD 200 million in respect of breaches that took place in relation to non-US banks outside the US but where funds passed through the US and were related to prohibited transactions. Other banks have also recently been ordered to pay substantial fines in respect of US sanctions violations relating to various countries including Iran, said violations going back a number of years.

4.3. Who is benefitting from the sanctions?

Iran is a major supplier of crude oil to China, the world's second-largest consumer of oil after the US. In the first half of 2010, Iran was China's biggest supplier of crude oil, with shipments of nine million tonnes. While China has backed the latest UN sanctions, it is reportedly resisting US pressure to cut back on its existing oil and trade projects with Tehran. China's vice-premier was recently quoted as saying that China was Iran's main economic partner. Given that reportedly a number of leading traders and oil companies have stopped selling refined products and frozen gasoline sales, a great opportunity has been created for Chinese oil traders.

Figure 2. Imports of Iran Oil in 2011

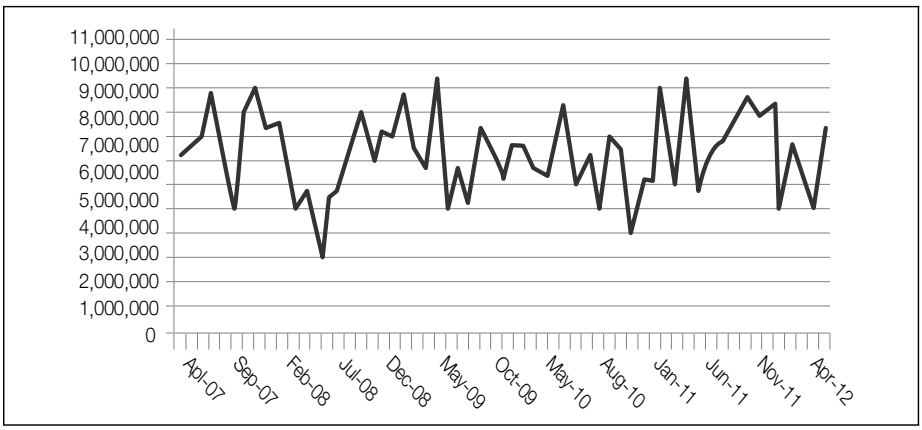


Russian oil traders are also expected to benefit. The Russian press has reported that Russian companies are discussing significant deliveries to Iran later this year. One Russian oil company is reported to have resumed gasoline sales to Iran in partnership with a Chinese state-run firm, notwithstanding that it has significant exposure in the US. The company has indicated these were one-off shipments that took place within the framework of previously concluded contracts. Nonetheless, Russia's energy minister has stated that Russian companies would supply fuel to Iran if the terms were attractive and there were significant commercial interests involved.

4.4. Developments in the failure of sanctions

In March 2013, South Korea announced it had dramatically decreased the pace of its crude oil imports from Iran, and Chinese officials said their Iranian oil imports continued unabated. Imports of oil by South Korea were down 30% in February 2013 compared with February 2012 and down 25% versus January

Figure 3. Korea Imports of Iran Oil



2013, according to preliminary data from the state-run Korea National Oil Corp. China, meanwhile, saw its imports from Iran rise by 2.7% in the first two months of 2013 after rising by 74% year-on-year to 2 million tonnes. (Wall Street Journal, March 2013)

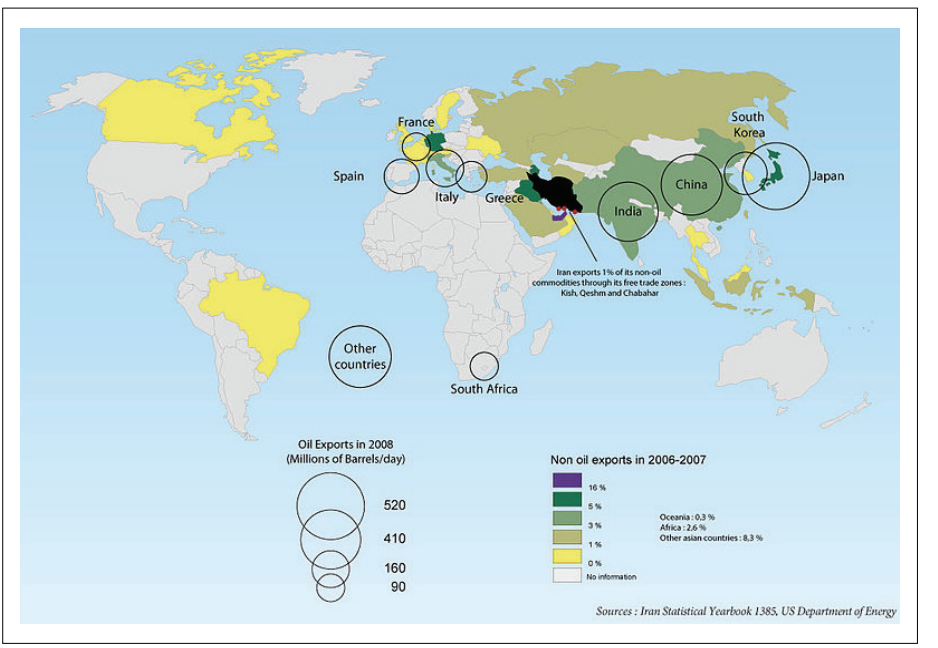
According to a report from the International Atomic Energy Agency (IAEA), Iranian oil shipments advanced 13 percent in February 2013, even as the U.S. implemented additional sanctions complicating sales from the Islamic Republic. Countries purchased 1.28 million barrels a day from Iran that month, compared with 1.13 million barrels daily in January 2013. "The only thing clear is that the current stalemate between Iran and the West is unsustainable," the International Energy Agency (IEA) said in the report. "Sooner or later, something has to give."(Bloomberg News, March 2013)

4.5. A few facts about bilateral trade between Iran and Korea

Iran is a founding member of OPEC and the Organization of Gas Exporting. Petroleum constitutes 80% of Iran's exports with a value of USD 46.9 billion

in 2006. For the first time, the value of Iran's non-oil exports is expected to reach the value of imports, at USD 43 billion, in 2011. Pistachios, liquefied propane, methanol (methyl alcohol), hand-woven carpets and automobiles are the major non-oil exports. Technical and engineering service exports in 2007-08 were USD 2.7 billion of which 40% of technical services went to Central Asia and the Caucasus, 30% (USD 350 million) to Iraq, and close to 20% (USD 205 million) to Africa. The country has made non-oil exports a priority by expanding its broad industrial base, and benefitted from its educated and motivated workforce and favourable location, which gives it proximity to an estimated market of some 300 million people in the Caspian, Persian Gulf and some Economic Cooperation Organisation (ECO) countries further east. Figure 4 shows the destination of Iran's exports in case of oil and non-oil exports.

Figure 4. Iran's Exports

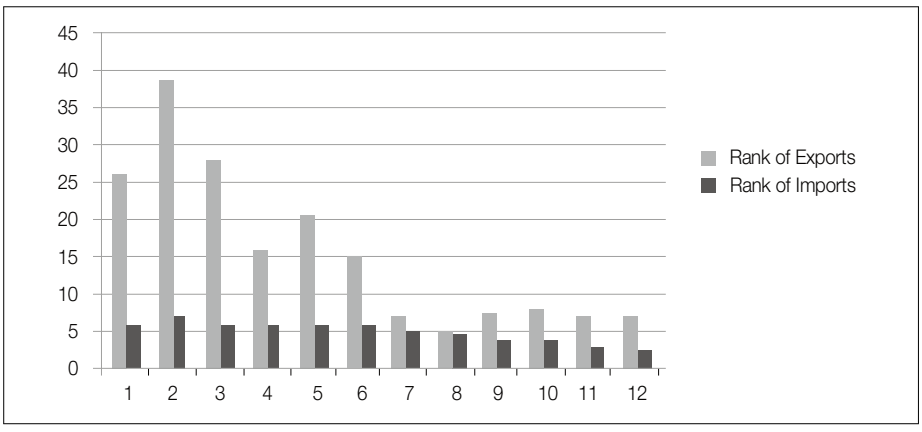


Total import volume rose by 189% from USD 13.7 billion in 2000 to USD 39.7 billion in 2005 and USD 55.189 billion in 2009. Iran's major commercial partners are China, India, Germany, South Korea, Japan, France, Russia and Italy. Since the mid-1990s, Iran has increased its economic cooperation with other developing countries in "south-south integration" including Syria, India, China, South Africa, Cuba and Venezuela. Iran's trade with India passed USD 13 billion in 2007, an 80% increase within a year. Iran is expanding its trade ties with Turkey and Pakistan and shares a common objective with its partners of creating a common market in West and Central Asia through the ECO.

According to recent reports by the IMF on Iran's economy published last August 2013, Iran's is not exactly a creaking economy on its knees in the face of sanctions. Sanctions have created pressure on Iran, but Iran is also a large regional economy with a relatively diversified structure. Oil is very important, but the Iranian economy is not entirely dependent on oil.

In case of bilateral trade with Korea based on updated Teheran Chamber of Commerce & Industries & Mines (TCCIM) data, Korea's rank in 2012 was third

Figure 5. Rank of Korea on Trade with Iran (2001-2012)



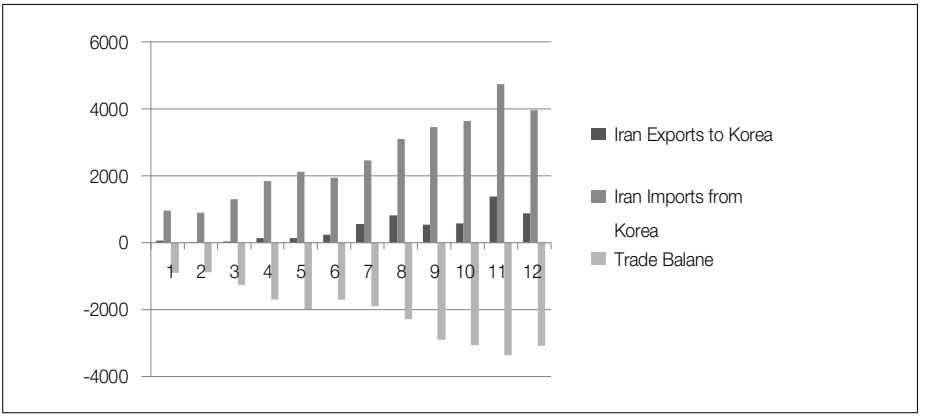
Source: Compiled from official statistics of the Tehran Chamber of Commerce (www.tccim.ir).

in terms of imports (after UAE and China) and seventh in terms of exports (after Iraq, China, UAE, Afghanistan, India and Turkey), while in 2002 the respective ranks were 39th and 7th. The data shows that the volume of trade with Korea used to be quite a large volume. This means the share of Korea in the total volume of trade with Iran trade has been increasing, though this is not very considerable for Korea. Alternatively, it suggests that Iran has not expanded its trade with other countries. In recent years, due to sanctions, trade has increased with countries like Korea instead of EU countries; it is expected that this trend may well lead to more cooperation on other issues.

4.5.1. Trade imbalance

It has frequently been noted that Iran possesses limited non-oil exportable articles compared to Korea. On the other hand, Iran being predominantly an oil country, the country requires many articles and items in bulk in order to continue on its path towards an industrial era. Various industrial raw materials, semi-finished and finished products are required in huge quantities for developmental works in

Figure 6. Iran Merchandise Trade with Korea, 2001–2012 (Million Dollars)



Source: Compiled from official statistics of the Tehran Chamber of Commerce (www.tccim.ir).

addition to meeting people's increasing needs.

Korea exports manufactured goods and articles in higher proportion to total export. Due to the persistence of an unequal balance between demand and supply of goods and articles, the question of balance of trade and balance of payments has been central when considering the Iranian and Korean trade relation. Trade balance in total with Korea in value increased significantly, as shown in Figure 6.

V. Conclusion

Korea and Iran are two traditional trade partners. Bilateral trade between the two countries has been increasing significantly. However, there persist ups-and-downs in trade flow and structure, a frequent topic in the research literature. In recent years, international sanctions imposed on Iran have created problems for both countries, from each their own perspectives. With the recent negotiation between Iran and the 5 +1 group in Vienna, 2014, many of these problems seemed to have been solved.

Generally, in light of new theories, monopolistic competition and increasing returns leads to IIT between similar countries, whereas the old comparative advantage is still applied to countries separated by a great economic distance. I do not expect to see a high degree of IIT between Iran and South Korea. In fact, Iran does not have competitive power relative to Korea. However, examining IIT variations in time can yield useful insights for adopting suitable trade policies. In addition, by considering IIT in different categories of products, we can determine the categories where significant advantages for specialization can be found. This is helpful in trade decision making and to some extent determines how well we can compete in the new trade environment, while also indicating what adjustments are required.

The result shows that Iran and Korea have maximum levels of trade overlap, on average, in products coded by 2712 (petroleum jelly, mineral waxes) and 2803

(carbon, NESOI), while they have minimum values of IIT, on average, in products coded by 7901 (zinc waste and scrap) and 8534 (printed circuits), respectively. In addition, out of 12 items, 5 items have comparatively high levels of IIT ($GL >$ 10), while the remaining items (7 items) have comparatively low levels of IIT ($GL <$ 10). Thus, the results show that IIT intensity has become more pronounced between two countries, since the comparatively high levels of IIT for more product items can be attributed to the interest both countries have in expanding their trade relations and implementing economic integration.

According to the GHM Index, less than 10% of all IIT is horizontal with low quality. The highest share of IIT belongs to VIIT with a low quality. A similarity amount of 25% shows the same number of products belong to VIIT with a low quality. A comparison of the PQV index and the GHM similarity index indicates that the PQV index places a greater number of products in the VIIT group. Therefore, from 2001 to 2011, Iran's IIT with Korea was included in VIIT with different product groups of low quality.

Another finding in this research relates to the trend of bilateral trade between Iran and Korea in last decade. During this period, four international sanctions were imposed on Iran and consequently, the Iranian pattern of trade shifted from countries like UK and France to Korea. However, year-to-year variability notwithstanding, the major trade partners of Iran from 2007 to 2012 were China, UAE, South Korea, and India. The corresponding average for individual countries is China, 30-35 percent; UAE, 20-25 percent; South Korea, 8-10 percent; and India, 5-7 percent. During the same period, these four countries (combined) accounted for an average 10-15 percent of the total trade deficit of Pakistan. Moreover, export commodity diversification remains weak.

Korea and Iran share common features in many respects. However, Korea has been more advanced than Iran in some of the specific sectors, such as the commercial and industrial, information and communication, health and education sectors. On other hand, Iran being a large country-based on physical structure, population and resources-possesses comparative advantage. The labour force growth

is 5 percent. Comparatively, labour is cheap. Iran is heading towards an industrialization regime. Preparation of basic infrastructure at the required level for this purpose is underway. Available resources and facilities can be used for economic growth and development. Nonetheless, the country is still facing problems with finding adequate capital to invest to seek improved outcomes on the one hand, and the desired level of entrepreneurship and skills on the other hand. Against this background, Korea can cooperate in many respects with Iran. Doing so will provide mutual benefits to both countries.

5.1. Prospects

5.1.1. Oil and petrochemical Industry

Iran is one of the richest regions in the world in terms of hydrocarbon resources. A total of 102 fields are oil and the remaining 43 are gas, and there are 205 oil reservoirs and 92 natural gas reservoirs. According to the Iran Energy Balance Sheet (2009, in Persian), 78 of these fields are currently active, with 62 onshore

Figure 7. Oil Reserves-Top Twelve Countries Jan. 1, 2006 (Billion Barrels)

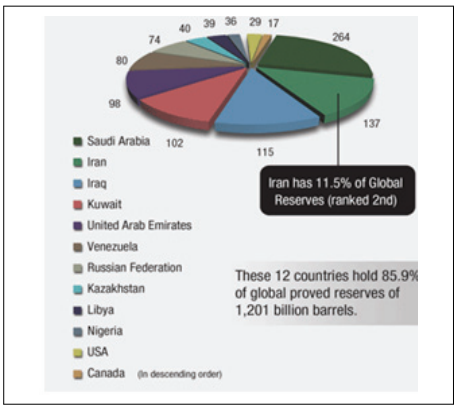
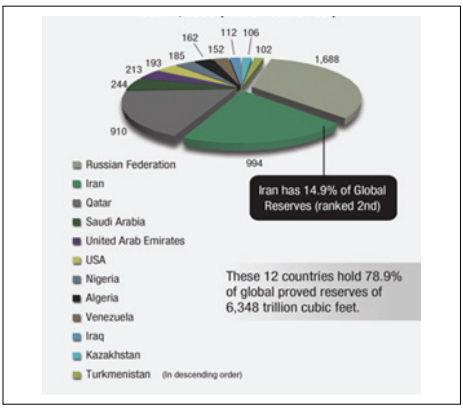


Figure 8. Gas Reserves-Top Twelve Countries Jan. 1, 2006 (Trillion Cubic Feet)



and 16 offshore, leaving 67 fields inactive at present. Some 23 hydrocarbon fields lie in border areas and are shared between Iran and adjacent countries, including Kuwait, Iraq, Qatar, Bahrain, UAE, Saudi Arabia and Turkmenistan. According to the Iran Petroleum Ministry, Iran's proven natural gas reserves are about 1,045.7 trillion cubic feet (29.61 trillion cubic metres) or about 15.8% of world's total reserves, of which 33% are as associated gas and 67% are in non-associated gas fields. Iran has the world's second-largest reserves after Russia.

Figure 9. Oil and Gas Disparity Reserve in Iran

Most of the country's hydrocarbon production activity has been located in the southwest, both offshore and onshore. About 40 fields are producing, and several other fields are under development. The construction of new hydrocarbon refineries, which included the Anahita refinery at Kermanshah, the Caspian refinery in Golestan Province, the Horumuz refinery adjacent to NIOC's Bandar Abbas refinery, the Khuzestan extra heavy crude oil refinery at Abadan, the Pars refinery at Shiraz, the Persian Gulf Star refinery at Bandar Abbas, and the Shahriyar refinery at Tabriz, were expected to begin to increase the domestic supply of gasoline by 2013. International sanctions, however, have adversely affected the availability of financing for and international oil company participation in oilfield development and oil refinery construction (U.S. Energy Information Administration, 2009; Mirza, 2010c).

5.1.2. Tourism industry

Tourism stands out as a most important sector in which Iran has a comparative advantage and vast potential due to its rich cultural heritage, and unrivalled natural scenic beauty. Tourism has emerged as one of the most dynamic and promising sectors in the country providing employment opportunities, and income generation for small and large entrepreneurs.

This sector provides room for economic cooperation in a number of areas like tourism infrastructure, hotels and resorts, games and amusement centres etc. Tourism products such as holiday homes, mountain sports, adventure travel and amusement parks are some other potential areas. The construction and operation of hotels and resorts offer very promising prospects for profitable investment. Similarly, investment in popular tourist activities and recreations are perceived to be successful undertakings. Foreign direct investment has been encouraged in capital-intensive tourism industries such as hotels, resorts and in the areas, which transfer modern technology and skills.

Iran currently ranks 68th in tourism revenues worldwide. In view of its attractive natural and historical sites, Iran is rated among the ten most touristic countries

in the world in terms of its history. The landscape of Iran is diverse, providing a range of activities from hiking and skiing in the Alborz Mountains, to beach holidays by the Persian Gulf and the Caspian Sea. Over the next five years, a number of tourism-friendly infrastructure projects will be undertaken on the Persian Gulf island of Kish, which at present attracts around 1 million visitors per year, the majority of whom are Iranian.

5.1.3. Privatization in Iran

According to the Fourth Economic Development Plan, the Privatization Organization of Iran affiliated with the Ministry of Economic Affairs and Finance is in charge of setting prices and ceding shares to the general public and on the Tehran Stock Exchange. The privatization effort is primarily backed by reformist members of the Iranian government and society who hope that privatization can bring about economic and social change.

This program forms a key part of efforts to enhance private sector participation in the economy. It extends an opportunity to participate in the private sector as well as joint ventures in the national commercial domain of the country. Many large industrial,

Figure 10. Implementation of Privatization in Iran Proceeds in Current Prices (March 2005–March 2006; March 2010–March 2011)

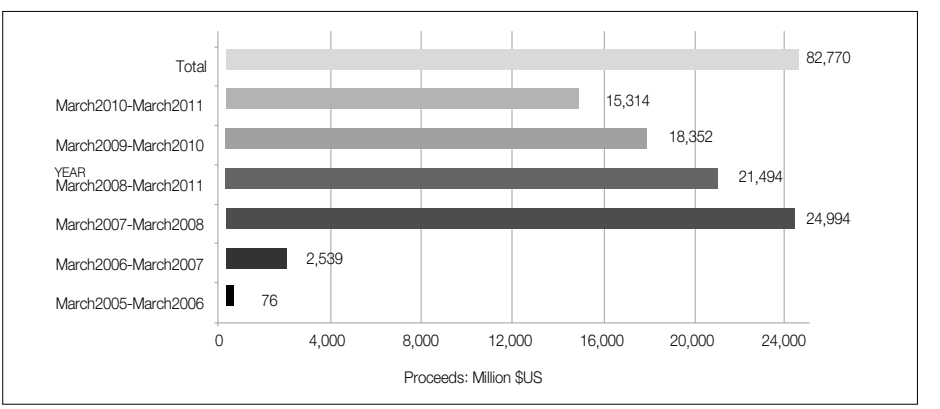
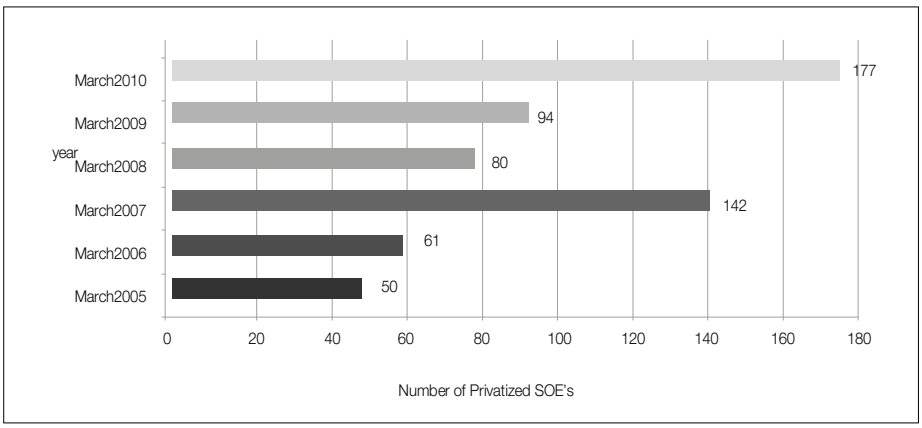


Figure11. Implementation of Privatization in Iran; Number of SOE's (March 2005–March 2006; March 2010–March 2011)



business and service-oriented enterprises are selling in the Tehran Stock Market.

Khozestan Steel Company is the latest enterprise to be privatized. This company is the second-largest crude steel producer in Iran and one of the most pioneering economical agencies in the country; it plays a vital role in the region and national interests. Few other enterprises are in the pipeline for privatization proceeds.

These Figures show that although the number of companies that have been sold has increased, the speed of divestment and sales of governmental companies to private sectors was slow.

5.1.4. Education and training

Trade also demands a fair amount of education and training in the respective fields and sectors. Korea has been extending cooperation in education and training for some time now. In accordance with the changing scenario, both countries can promote mutual understanding and cooperation through a process of wide sharing of knowledge and professional talents in both academic pursuits and technical specializations.

5.1.5. Mineral exploration and exploitation

Mineral resources, which can be commercially exploited, are identified as iron ore, copper, magnetite, clay, construction stone, lead and zinc, etc. Several major iron ore deposits have been identified in Iran, and exploitation of some of these deposits for the manufacture of cooper and zinc and industrial lime is already underway. Major iron ore deposits have been found in Kerman and Yazd.

Owing to international sanctions, the government increased its emphasis on the development of local self-sufficiency in the areas of mine and mineral-processing plant construction, design, and planning. In addition to increased use of domestic consulting engineering services for mine and plant design, the government promoted local manufacturing of mineral-industry-related equipment, machinery, and parts (Mining & Development, 2010a, p. 8).

The government's Fifth Development Plan for the years 2011 to 2015 proposed that the production capacities of several mineral commodities would be increased by 2015. Production capacity expansions included that of the cement sector, which was proposed to be increased to 100 million metric tonnes per year (Mt/Yr); crude steel, to 42 Mt/Yr, and copper cathode, to 910,000 metric tonnes per year (t/YR). The USD 27 billion Fifth Development Plan targeted 108 mineral projects (Mining & Development, 2010b, pp. 1-2).

5.1.6. Information and communication technology

Developments in the areas of information and communication technology (ICT) are growing rapidly. Korea has already moved into the advance stage in ICT components, particularly in software development. The demand for ICT is likely to increase in the future as well. This has been one of the prominent service trades with a potential for high value addition. Iran has a well-educated and trained work force in this sector. A science technology park has also been established to facilitate and promote such activities. A couple of joint ventures in this sector have already emerged. In view of the comparatively cheap labour and the growing demand

for information technology, the private sector has excellent opportunities to invest in this service trade. This sector offers wide scope for serving common interests.

5.2. Challenges

5.2.1. Market demand

The major problem for the unfavourable balance of trade on the part of Iran can be noted as not finding a proper market for the Iranian manufactured goods in the Korean market. There could be many reasons for this. The prominent factors include, in business terms, an inability to compete in the Korean market on grounds of quality, price, supply capability etc. In trade terms, it could be quantitative restriction, product disqualification etc.

5.2.2. Frequent revisions in duties and rules

It takes a fair amount of time to find a place in the market for goods and articles. Market-structure development depends upon many factors. Rules and regulations relating to exports and imports, and the import and export duties of the exporting and importing country play a dominant role in foreign trade. It has been frequently noted that rules, procedures and duties can be revised through the government budget and through provisions of trade and transit treaties. Such changes and modifications create confusion within business communities, which can ultimately affect trade dramatically. For example, in October 2012, the Iran oil ministry did not allow the export of some petrochemical products.

5.2.3. Trade restrictions

Trade is governed, largely, by trade regulations and related administrative procedures. Entry and exit from the market, as well as the volume of trade, depends on the transparency and simplicity of trade and administrative procedures.

Unfortunately, EU sanctions prohibiting European insurers and reinsurers from covering tankers carrying Iranian petrochemicals came into effect on May 1, 2012, forcing out most of the ships operating in this niche market.

Conclusion

Korea and Iran are two traditional trade partners. Bilateral trade between the two countries has been increasing significantly. In recent years, international sanctions imposed on Iran have created some problems for both countries, each from its own perspective.

I do not expect to see a high degree of IIT between Iran and South Korea. In fact, Iran does not have competitive power relative to Korea. However, examining IIT variations in time can yield useful insights, helpful in adopting suitable trade policies. The research results shows that Iran and Korea have maximum levels of trade overlap, on average, in products coded by 2712 (petroleum jelly, mineral waxes) and 2803 (carbon, NESOI), while they have minimum values of IIT, on average, in products coded by 7901 (zinc waste and scrap) and 8534 (printed circuits), respectively.

The data shows that from 2001-2011, the trade relationship between Iran and Korea improved year-by-year; in 2012, Korea's rank as a trading partner with Iran was 4th, whereas it had been only 39th in 2001.

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2

A Comparative Study of the Relationship between Industrial Economic Growth and Energy Consumption in China and South Korea

Hu Wen-Long[1)]

I. Introduction

Energy is an important strategic resource that acts as the lifeblood of a country's industrial and economic growth. Since the beginning of the industrial revolution, the pace of industrial economic growth has closely tracked the amount of available energy. "Linkages" exist between energy consumption and industrial economic growth: many countries and regions show a striking positive correlation between industrial growth and energy consumption trends.[2)] However, in the 1970s, two oil crises caused America and other European countries to wake up and realize

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2) Luken R A, Piras S., A Critical Overview of Industrial Energy Decoupling Programs in Six Developing Countries in Asia. Energy Policy, 2011, 39: 3869-3872.

their energy supplies were not adequate. All countries took note of the poverty of the world's total energy supplies and the vulnerability of the energy supply system. Consequently, each country separately began to strengthen their efforts to build their own energy security system and improve their standards of energy conservation. The goal of reducing energy consumption in industry is achieved by adjusting industrial structure, energy intensity and energy structure; this implies a "decoupling" of energy consumption and industrial growth-cutting off the close relationship between them.[3] The relationship between industrial economic growth and energy consumption has emerged as one of the core concepts in energy economics research with a host of familiar questions. Does industrial economic development increase energy consumption or does industrial energy consumption spur economic growth? Does a long-term equilibrium exist between them? If so, what is the relationship between them? If not, are there other relationships? This article explores these questions.

Currently, China not only exhibits the most rapid economic growth of any country in the world, but also the most rapidly increasing energy consumption. After 30 years of rapid development, China has entered a period of late industrialization, but the job of China's industrialization is not yet complete. Energy-intensive industries will develop at a faster rate in the future. The dominance of an industrial economic structure and an industrial structure dominated by heavy industry is expected to continue; this, associated with industrialization and urbanization, will further increase the energy pressures currently hampering continued rapid development. These projections have become the focus of attention of the government and all sectors of society. The 2011 BP Energy Calculator shows that, due to the growth rate of China's primary energy consumption at 11.9% in 2010, China has surpassed the U.S. as the world's largest energy consumer. A thorough understanding of not only the relationship between China's economic growth and energy consumption,

3) De Freitas L C, Kaneko S. Decomposing the Decoupling of CO2 Emissions and Economic Growth in Brazil. Ecological Economics, 2011, 70: 1459-1469.

but also of how to properly handle the pressure of China's rapid energy consumption, is therefore essential to achieving sustainable economic development in China.

Korea on the other hand, one of the "New Industrial Economies", has attracted worldwide attention as the "Han River Miracle" by developing in mere decades from one of the most backward countries in the world to a medium-developed country. The industrialization process in China over the past 30 years has been similar to Korea's economic growth phase. A comparative study of the relationship between Chinese and South Korean industrial economic growth and energy consumption can provide us with a reference for China's economic development, and aid in adjusting and optimizing China's industrial structure. A comparison of the characteristics of Chinese and South Korean industrial economic development and energy consumption could also offer insight into opportunities for cooperation between the Chinese and South Korean industrial sectors in the areas of economy and energy.

The article is divided into five parts: Part I is the introduction; Part II is a literature review of past research on the relationship between industrial economic growth and energy consumption; Part III presents the basic situation of industrial growth and energy in China and South Korea; Part IV is a report on an empirical study of the relationship between industrial energy consumption and economic growth, comparing China and South Korea; and Part V presents our main conclusions and policy suggestions.

II. Literature Review

Energy is the material basis of human life and indispensable to human survival and development. Energy is also a strategic concern, essential to national economic development and the improvement of people's living standards. The proper understanding of the relationship between energy consumption and economic growth

is of vital significance to the sustainable development of a nation's social economy. We can see discussion of the relationship between energy consumption and economic growth in some of the academic literature. One key question addressed in the literature concerns the causal relationship between these problems: does economic growth cause increased energy consumption or does energy consumption promote economic growth? Scholars have attempted to explain the causal relationship between these two factors; however, for a host of reasons-because of different countries and areas, the use of different models, different parameter estimate methods, different sample data, different time intervals, structural dependencies-conclusions regarding the relationship between these two variables differ widely in different literatures.

2.1. Review of international literature

The Granger causality test is a standard test used in research to model the relationship between energy consumption and economic development. British economist Clive Granger first suggested this test and method of causal analysis in 1969. In subsequent decades, the test methods employed in Granger causality analysis have been further developed and widely applied. Ganger causality analysis also became an important tool in the study of the relationship between energy consumption and economic growth in the world.

Kraft and Kraft (1978) first carried out pioneering research in this regard on data from the USA. According to their research, where they use annual data of the USA from 1947 to 1974, the relationship of GNP to energy consumption is characterized by unidirectional causality: economic growth drives energy consumption. However, research conducted by Akarca and Long (1980) showed that different results can be obtained using the same time series data, though it should be noted they employed shorter sample intervals than Kraft and Kraft (1978). This indicates that different sample intervals affect empirical analysis, leading to two different results. Yu and Hwang (1984) updated the US sample interval for

1947-1979, in the process finding that there is no causal relationship between energy consumption and GNP growth. Yu and Jin (1992) proposed the two-step Engle-Granger (EG) test first presented by Engle and Granger (1987). USA quarterly data of the test results from 1974 to 1990 show that there is no long-term co-integrated relationship between two variables. Stern (1993) employs four variables (GDP, capital, labor and energy) in a vector autoregressive (VAR) model of the United States of America to analyse the annual data from 1947 to 1990 in a standard causality test. Results show, however, that Granger causality does not exist in the relation of total energy consumption to GDP. If energy consumption measurement data is adjusted on fuel composition, the test may reveal the existence of energy consumption to the unidirectional Granger causality GDP. In a follow-up study, Stern (2000) uses single equation co-integration analysis and multiple static dynamic co-integration analysis to expand the analysis of his own (Stern, 1993) results. In this case, he found that energy consumption has significant impact on the interpretation of changes in the GDP, and clearly confirms the existence of a long-run equilibrium relationship on the whole among GDP, capital, labor and energy. Ramakrishnan Ramanathan (2006) used data envelopment analysis (DEA) to analyse the relationship among GDP, carbon emissions and energy consumption. He took GDP and carbon emissions as output, non-fossil energy consumption as input. The results showed that the efficiency index was highest in 1980; over the next 7 years, this index fell sharply, later indicating a downward trend; it only began to rise again in 1996. The curve of carbon emissions and energy consumption was obtained based on DEA prediction analysis (technology forecasting). By using the VAR model of GDP, carbon emissions, energy consumption, labor and capital amount of variables, Ugur Soytas, *et al.* (2007) examined the causal relationship among energy consumption, carbon emissions and GDP in the United States of America. Studies found that the cause of carbon emissions is not the growth of GDP, but the energy consumption; a proposed carbon-reduction policy should consider reducing energy intensity and should increase the use of clean energy, such as wind and solar power, improving the utilization of renewable energy. Later, Ugur Soytas,

et al. (2009) reached a similar conclusion based on empirical research on Turkey.

The conclusions reached are different for some Asian countries and regions covered by the data. Masihet (1997) tested the causal relationship in India, Pakistan, Malaysia, Singapore, Indonesia, Philippines, South Korea and the Taiwan region between actual income and total energy consumption within the framework of a multivariate econometric model. The results revealed that structural dependence was neutral between energy consumption and real income in Malaysia, Singapore and Philippines; India showed unidirectional causality from energy consumption to GNP; Indonesia indicated reverse causality from GDP to energy consumption; whereas, there is a bidirectional causal relationship between energy consumption and GDP for Pakistan and Taiwan. Glasure and Lee (1997), using a traditional co-integration test and error-correction model, discovered bidirectional Granger causality between energy consumption and GDP in South Korea and Singapore. By applying a co-integration and error-correction model-estimation approach, John (2000) was able to estimate the relationship between energy consumption and economic growth in India, Indonesia, Thailand and the Philippines. The results showed short-term unidirectional causality from energy to GDP in India and Indonesia, but a bidirectional causal relationship between energy consumption and GDP in Thailand and the Philippines. Similarly, employing a Toda-Yamamoto causality and autoregressive distributed lag model (ARDL), Fatai (2004) found bidirectional Granger causality between GDP and energy consumption both in Thailand and Philippines, and unidirectional Granger causality between energy consumption and economic growth in India and Indonesia. The conclusions reached by John (2000) and Fatai (2004) *et al.* are apparently consistent, but their results are not the same as those reached by Masihet (1997). Yoo (2006) obtained results for Malaysia and Singapore indicating a bidirectional causal relationship, whereas there is unidirectional causality running from economic growth to energy consumption in Indonesia and Thailand. P. Paul, Bhattacharya (2004), Oh and Lee (2004) and Chand (2008) studied individual countries such as India, South Korea and Malaysia. They concluded that South Korea has unidirectional causality-from economic growth to energy consumption; India has

a bidirectional causal relationship; whereas, in Malaysia, there is unidirectional causality from energy consumption to economic growth.

2.2. Domestic literature review

In the test on the data of Taiwan and the region of China, Hwang, Gum (1992) and Masihet (1997) found a bidirectional causal relationship between energy and GDP. Using Hsiao's approach of a unit root test, a co-integration test and a Granger causality test, Cheng and Lai (1997) tested samples in Taiwan from 1955 to 1993; they found a unidirectional causal relationship from GDP to energy consumption. Yang (2000) further updated the sample interval for 1954-1997, and examined the structural dependence between GDP and various sources of energy (coal, oil, natural gas and electricity), finding a bidirectional causal relationship between GDP and the total energy, coal, electricity variables, and a unidirectional causal relationship between natural gas to GDP and GDP to oil. Xing-Ping Zhang and Xiao-Mei Cheng (2009) studied the Granger causal relationship and direction among Chinese energy consumption, carbon emissions and economic growth: the empirical results show that GDP exhibits unidirectional Granger genesis for energy consumption and energy consumption has unidirectional Granger genesis for carbon emissions. However, carbon emissions and energy consumption do not indicate Granger genesis for economic growth. Lee Chien-Chiang (2005) obtained results showing that energy consumption exhibits a unidirectional causal relationship to economic growth, based on a panel co-integration analysis of 18 developing countries from 1975 to 2001. Chien-Chiang pointed out that in the short-term and in the long-term, reduction in energy consumption will have an adverse impact on economic development. Apergis and Nicholas (2009) argue, based on the 1991-2005 data from 11 CIS countries, that a unidirectional causal relationship exists from energy consumption to economic growth in the short-term, but the long-term interaction between energy consumption and economic growth reveals a bidirectional causal

relationship.

For the Chinese data, we consider the main research literatures. Zhao Lixia (1998) use energy as a new variable in the Cobb-Douglas production function, establishing a VAR model. China's resulting energy consumption and economic growth are positively related. Lin Boqiang (2003a, 2003b) employed a co-integration test and error-correction model to research the relationship in China between electric power consumption and economic growth. Results show that there is a long-term co-integration relationship between equilibrium in GDP, capital, human capital and power consumption, and the efficiency and energy demand for long-term forecasts. Han Zhiyong (2004), using the "E-G" two-step method (a statistical method named after Engle and Granger) and without considering the stability of the standard Granger causality test, analysed GDP sequences and total energy consumption data from 1978 to 2000. He concluded that there is no long-term equilibrium relationship, though there is a bidirectional causal relationship between energy consumption and GDP. Ma Chaoqun (2004) used the "E-G" two-step method to analyse the annual data from 1954 to 2003. The results obtained indicated a long-term equilibrium relationship between GDP and total energy consumption. There is no co-integration relationship between oil, natural gas and hydropower, without considering stationarity conditions. The Granger test shows that there is a bidirectional causal relationship between GDP and the total energy consumption. Chen Shiyi (2009), using the super-logarithmic production function, estimates China's industrial total factor productivity change and green GDP. Results show that energy consumption, capital utilization and technology progress are the main reasons underlying industrial economic growth in China since the reform and opening up. Qi Shaozhou (2009), who studied the relationship between the intensity of energy consumption and per capita GDP differences among China and eight developed countries using empirical methods, found that the capita GDP can decrease energy consumption intensity. Wang Shaoping and Yang Jisheng (2006) established the panel co-integration model of industrial energy consumption and industrial growth in China. Results show a short-term equilibrium between energy consumption and industrial growth. QuXiaoe

and Yuan Xiaoling (2008) analysed ten high-energy consumption industries by the same method and came to a similar conclusion.

2.3. Summary

In general, Payne (2010) and Ilhan Ozturk (2010) systematically summarize four kinds of hypotheses concerning the relationship between energy consumption and economic growth: (1) "growth assumptions" (there is unidirectional causality from energy consumption to economic growth); (2) the "saving hypothesis" (there is causality from economic growth to energy consumption); (3) the "feedback hypothesis" (there is a bidirectional causal relationship between economic growth and energy consumption); and (4) "neutrality" (economic growth and energy consumption is not a causal relationship). Chinese scholars have correspondingly used the data and methods covering a different period to investigate these kinds of hypotheses. The following literature is representative: scholars who support "growth assumptions" include Lin Boqiang (2003), Zhao Jinwen and Fan Jitao (2007), Li Xiaojia and Liu Peng (2009); scholars who support the "saving hypothesis" include Wu Qiaosheng *et al.* (2005), and Lin Baiqiang *et al.* (2007); scholars who support the "feedback hypothesis" include Han Zhiyong *et al.* (2004), Wu Qiaosheng *et al.* (2008), and Zhou Jieqi and Wang Tongsan; typical literatures about "neutrality" have been written by Wang Haipeng *et al.* (2006) and Yuan *et al.* (2008).

Based on the above analysis, we know that the intrinsic relationships between energy consumption and economic growth in different countries vary. The intrinsic relationship is not even the same in different development stages of the same country. Many reasons cause this complicated situation. First, many factors are different; for example, different countries have different economic structures and systems, and the same countries in different periods will have a different energy and economic policy. The factors (structures, systems, periods, policy and so on) mentioned above may result in the different conclusions. Secondly, the methodologies adopted in

the literature were not the same; for example, the above research literature relied on linear assumptions, but it did not conduct econometric methods strictly testing whether the relationship between economic growth and energy consumption is linear. Furthermore, some methods suffer from obvious defects or deficiencies; for example, Engle and Granger proposed the "E-G" two-step method in the co-integration theory on the early literature by (1987). The defect here is the first step cannot be statistical inference and hypothesis testing. In addition, Monte Carl simulation results also show that the power of the "E-G" two-step method test is very low, which has led to the test results being questioned in recent years. Finally, even the standard Granger causality test has shortcomings in some aspects (Zhao Jinwen, 2004).

Since 1978, when China implemented its reform and open policy, China's economy has grown rapidly, and energy consumption has increased rapidly, with a resulting economic form that is completely different from the circumstances that applied at the moment of reform and opening up. In this particular period, studies of the multi-variable function of production of energy consumption and economic growth in China based on the whole relationship are rare (Han Zhiyong's study and Ma Chaoqun's study are both based on two variables, missing some important variables of the study. The test conclusion is not convincing). In particular, the data used in Han Zhiyong's (2004) study is the annual sequence of the GDP and total energy consumption. In the analysis, it has no logarithmic to the original sequence to eliminate or reduce the effect of heteroscedasticity nor difference processing in order to eliminate the effect of non-stationary data of regression. For this reason, the test results are not entirely convincing. Ma Chaoqun (2004) applied annual data from1954 to 2003. In the process of inspection, the original sequence and the logarithm eliminate or reduce the effect of the heteroscedasticity of results, but the problem of first-order non-stationarity still exists, resulting in regression in the "false return" of suspects, which makes the test results somewhat less convincing.

At present, China has produced a great deal literature about changes in energy consumption that looks at two aspects of economic growth and industrialization,

and provides empirical evidence revealing the relationship among China's economic growth, industrialization and the role of energy consumption. Generally speaking, industrial energy efficiency directly decides the macroeconomic efficiency level of industry; energy consumption will provide strong support for the energy policy, which makes the goal of achieving energy-saving reasonable. However, from the perspective of research, most of the studies are based on the national or regional level. Available practical research with significance for energy-saving is inadequate. We can see that domestic and international scholars have studied much about the relationship between energy consumption and GDP after 2000, but they have not specifically studied the relationship between China's industrial economic growth and industrial energy consumption, especially with respect to the large energy consumption industry. Although some scholars have carried out preliminary studies on this issue, not only are the number of studies on industry's energy consumption not enough, but also the research methods employed could also be improved. Even though China has many studies on energy consumption and economic growth that stand alone, researching literatures comparatively is not sufficient. Based on previous studies, using a multivariate study based on production function, this paper attempts to analyse energy consumption and economic growth co-integration and Granger causality between China and South Korea, and carries out a comparative study, resulting in corresponding policy suggestions.

III. The Basic Situation of Industrial Economic Growth and Energy Consumption in China and South Korea

3.1. The general relationship between industrial energy consumption and economic growth

Combining history with current reality, we can observe the development of

energy and economy, which is especially close to the development of industrial economy. First, because energy is the main power source of modern industrial production, it is also the material basis for the sustainable development of the world. Modern industrial production involves efficient production based on mechanization, electrification, and automation. All production processes can almost be simultaneous with energy consumption, with the development of social economy; the dependence of production on energy will be greater and greater. In the following, I present two views of the relationship between industry's energy consumption and economic growth.

3.1.1. Energy consumption drives industrial economy to develop

(1) Energy consumption promotes the development of industrial economy.

In history, human society has experienced four energy periods: the firewood period, coal period, petroleum period and multiple functional complementation period. The modern period of energy consumption demand promoted a new breakthrough in energy science and technology, which caused a revolution in the industrial production technology. From one peak to another peak in the development of social productive forces, many developed countries achieved industrialization, which has radically changed the face of human society.

(2) Energy consumption input restricts industrial economic growth scale.

There must be energy to provide power in the other factor inputs, allowing many factories to run normally. Restrictions in the supply of energy can limit the size and extent of operation. Lack of investment is one of the more prominent contradictions of industrial economic growth in China. A large amount of production capacity is idle due to shortage of coal and power, which results in the loss of billions of dollars each year. This shows that, even if we had input and had developed production capacity, these would not in themselves play an effective role in promoting production absent requisite energy supplies. For example, during the first oil crisis,

Japan's energy shortage was quite serious: GDP fell by $48.5 billion. Other developed countries experienced similar drops. According to one survey, the value of the decline in GDP due to lack of energy was about 20 to 60 times.

(3) Energy consumption promotes the progress of industrial technology; it also promotes the birth and the development of emerging industries.

Throughout history, major technological leaps in industrial modes of transportation have always been implemented through an "energy revolution". The widespread use of the steam engine was effective under circumstances of a large coal supply; adoption of the motor directly depended on electricity. The use of petroleum, coal, and electrical power directly promotes the advancement of transportation. In addition, the use of energy and technological improvements also play a vital role in promoting the progress of industrial technology. The development of energy utilization techniques increase demand, and plays a promotional role in the progress of industrial technology. In the development of energy technology, every great breakthrough has an impact on production technology, promoting the productivity to a new level. Energy products, especially fossil energy, are themselves an important industrial raw material. Mineral resources, such as raw materials, petroleum chemical industry and coal not only themselves play a decisive role in industrial sector, but also lead the rapid development of a group of new industries, creating the conditions for the transformation of traditional industries.

3.1.2. The growth of the industrial economy promotes energy consumption.

(1) The industrial economy increases the demand for energy.

Energy production as well as the production of other commodities is restricted by market demand. Economic development for the growth of energy consumption and demand as well as some energy resources is relatively rare, which is the main objective reason for energy conversion. Steam engines were applied widely in the fields of traffic and industry, which greatly stimulated the development of coal

industry. The rapid development of the automobile industry and the extensive use of the gasoline engine, with most sectors using oil related products as power plant, all stimulated the demand for oil, and greatly promoted the development of the petroleum industry.

(2) The development of industrial economy, science and technology has enriched energy utilization.

The rapid development of industrial economy promotes the level of science and technologies, leading the new energy form to enter supply system of energy, which dominates the change of energy. Under the spontaneous development of both science and technology and the economy, high-quality talents are cultivated accordingly, which helps improve the method of energy, thereby improving the utilization efficiency. In addition, as energy resources are being developed and used, certain material means must be obtained, and the development of technological progress and industrial economy provides the material means for the development and utilization of energy. Therefore, the degree of development of industrial economy restricts the scale and level of the development and utilization of energy.

(3) The growth of industrial economy provides financial and material resources for energy consumption.

The growth of industrial economy provides financial and material resources for energy development; especially for the large-scale development of coal. The energy industry and long-cycle construction industry have become two of the largest areas of investment. Development of hydropower, nuclear power, energy, minerals and so on faces the same situation. The growth of industrial economy provides financial and material resources, which restrict the development and utilization of the energy level.

To sum up, the relationship between the growth of industrial economy and energy consumption can be roughly summarized as follows: the growth of industrial economy must have intrinsic demand for energy development; conversely, energy

development is a source of power for the growth of industrial economy. The growth of industrial economy creates conditions for the development of energy, while modern society is based on large amounts of energy consumption. Recognized correctly, maintaining a stable relationship between demand for energy and economic growth is crucial to energy, economic, social and sustainable development.

3.2. The basic situation of the growth of an industrial economy in China and Korea

3.2.1. The basic stages of growth in Korea's industrial economy.

Since the beginning of 1960s, the development strategy of South Korea is "growth first, export first", focusing on industrialization. From 1960s to the mid-90s, South Korea captured the world's attention, and came to be known as "the miracle on the Han River". The South Korean economy has achieved a high annual growth of more than 8%. Per capita GDP increased from 80 dollars to 15430 dollars. After 2000, due to the influence of various factors affected by domestic and foreign affairs, the South Korean economic growth rate slowed down significantly, but was still much higher than the growth rate of developed countries in the West. For example, South Korea's economic growth rate was 6.16% in 2010. A competitive industrial economy system provided strong support for "the miracle of the Han River" and "the rise after crisis" of South Korea. Looking at the objective performance of industrial structure evolution, South Korea's industrial economic development has gone through three stages:

(1) The stage of light industry (from 1960s to 1970s). In carrying out the first and the second five-year development plan for the economy, South Korea promoted the development of light industry by making full use of its abundant cheap labor force. During this period, South Korea drastically developed light industry products for export business, such as plywood, textile, clothing and so on. South Korea also switched markets from domestic

to foreign and strengthened infrastructure construction. All of these achievements provided a foundation for the next stage of development-heavy chemical industry.

(2) The stage of heavy chemical industry (from the 1970s to late 1980s). These light industrial enterprises called for small investments and yielded quick returns, but the price advantage of light industrial products vanished with the progress of society. Consequently, South Korea switched the focus of industrial development to heavy industry and chemical industry. During this time, the key industries, including chemical, synthetic, fiber, iron, steel, petrochemical, machinery, automobile, shipbuilding and so on, developed and obtained support in Korea. A series of industries accomplished rapid progress in development.

(3) The stage of post-industrialization (from late 1980s up to now). During this stage, the proportion industry occupied in the national economy gradually decreased, displaying the outstanding performance in South Korea. The proportion of the third industry is increasing continuously, and the traditional industrial development grows at a slower pace throughout the whole of South Korean industry. Because of government cultivation and support, the development of new industries has been rapid, including knowledge-intensive industries, high-tech industries, and so on, but especially the development of materials engineering, and the biochemical and electronic information industries, which have developed particularly rapidly and sustainably.

3.2.2. The stage of industrial economic growth in China.

According to the theory of industrial structure and in view of empirical facts in industrialized countries, the process of industrialization can be generally divided into three stages: light industrialization, heavy and chemical industrialization and high-level processing industrialization. According to the characteristics of changes

in industrial structure since China's reform and opening up, the period was roughly divided into two stages: One is the coordinated stage between light and heavy chemical industry from 1978 to 1997, the other is the heavy industrialization development stage since 1998.

(1) From 1978 to 1997, we observe a period of coordinated development in light and heavy industry.

Since our country adopted a special path towards industrialization in the 30 years after its founding, China's economic structure revealed large deviation at the beginning of the reform. The industrial structure at that time exhibited the prominent contradictions that "heavy industry is too heavy, and light industry is too light". Before 1978, our country's government implemented a planned economy system, by inhibiting consumption; industry subsidized agriculture, and light industry subsidized heavy industry to achieve mandatory accumulation. The government also implemented an import substitution policy and development strategy, giving heavy industry priority. Although the government successfully established a relatively complete industrial system in a relatively short period, the industrial structure of our country exhibited advanced characteristics, i.e. the proportion of industry in the national economy and the proportion of heavy industry in industrial economy greatly exceeded the required level of economic development at the time. Consequently, China paid a heavy price for economic fluctuation: people's lives rarely improved and much damage was caused to the environment. Given the tendency of heavy industry in the industrial structure of our country before the reform and opening up, during the initial period of reformation, especially during the period of 1978-1982, the new government led the way by encouraging light industry priority development in the early stage of the industrialization of developed industrial countries. In general, changes in industrial structure of this stage focused on the main line of rationalization adjustment. The main contents included the following: first, adjusting the drawbacks of emphasis on accumulation and inhibition of consumption, paying attention to

meet consumers' demands, taking the policy of compressing infrastructure construction and supporting the development of light industry in the period of 1979-1981. Second, in the period of 1982-1985, adjusting and transforming heavy industry, focusing on eliminating the defects of strong internal circulation in heavy industry, and enhancing functions of heavy industry to provide service for light industry; during this period, the machinery industry that could provide equipment for light industry developed rapidly. Third, after the mid-1980s, the durable consumer goods industry represented by household electronic appliances achieved sustainable high growth, realizing an upgrade in durable consumer goods. Fourth, in the late mid-1980s, in allusion to the clearly insufficient development of basic industry in heavy industry, and the fact that "bottleneck" limitations increasingly caused problems, the central and local governments promoted the rapid development of basic industries by increasing basic industry investment, introducing foreign investment and gradually improving the price of basic industrial products and so on. By the mid-1990s, the problem of the industrial base "bottleneck" had basically been solved.

(2) The Stage of heavy chemical industrialization development since 1998.

Due to the synergistic effects of productivity development and economic system transition since the reform and opening up, conditions developed in the late 1990s in China where the supply of industry was greater than demand, and a long-standing shortage persisted in the market over the subsequent decades. The change in the market supply and demand situation proved that an economy dominated by supply constraints had changed to one dominated by demand constraint. Facing this change in the domestic economy and the impact of the financial crisis in Southeast Asia during the same period, China executed a state-owned strategic adjustment in the economy and promoted the reform of state-owned enterprises to support the development of high-tech industries and equipment manufacturing industries. Since then, industrial structure in China began to exhibit a clear trend towards heavy

and chemical industrialization. China has experienced rapid economic development driven by investment and export, while simultaneously greatly inhibiting consumer demand. Especially in the new round of rapid economic growth since the second half of 2002, the leading role of development in heavy industry has been evident. Changes in the industrial structure of this phase mainly exhibited trends towards both heavy industrialization and high degree of processing, spontaneously. During this period, China's economic growth was mainly driven by investment; economic growth could be mainly attributed to the development of industry, especially heavy chemical industry; industrial structure transformed towards "heavy and chemical industry". In 2006, compared with 2001, the proportion of industrial added value in China's GDP increased from 39.7% to 43.1%, respectively increasing 3.6 percentage points and 3.4 percentage points. In 2006, above-scale heavy industrial added value growth was 17.9%, 4.1 percentage points higher than light industry, also 1.3 percentage points higher than total industry; the proportion of heavy industry in the industry increased by 7.4 percentage points. Meanwhile, industrial technology has developed in the direction of a high degree of processing, as the industrial structure has developed in the directly of heavy chemical industry. If the proportion of the manufacturing sector (including the general equipment manufacturing industry, the transportation equipment manufacturing industry, the electrical machinery and equipment manufacturing industry, the communications equipment, computers and other electronic equipment manufacturing industry, the communications equipment, computers and other electronic equipment manufacturing industry, the instrumentation

Table 3-1. 1998-2010 Proportion of Manufacturing Industry

Date	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
The proportion of total industrial output value	26.5	27.4	27.9	29.1	30.6	32.4	31.3	30.2	30.8	31.6	30.8	31.5	31.2
The proportion of the added value	22.8	23.1	23.7	24.3	25.7	27.3	26.5	25.6	26.1	26.5	25.7	26.8	26.2

Source: author calculated according to the "China Statistical Yearbook" calendar data.

and culture, office machinery manufacturing industries) accounted for indexes in industry that reflect the high degree of processing industry, then during 1998-201, the proportion of total industrial output value and the proportion of the added value increased by 4.7 and 3.4 percentage points respectively (Table 3-1), showing that industrial technology progress was significantly promoted in China.

3.2.3. Comparison of industrial economy growth trend in China and South Korea

(1) Comparison of general economy trends between China and South Korea

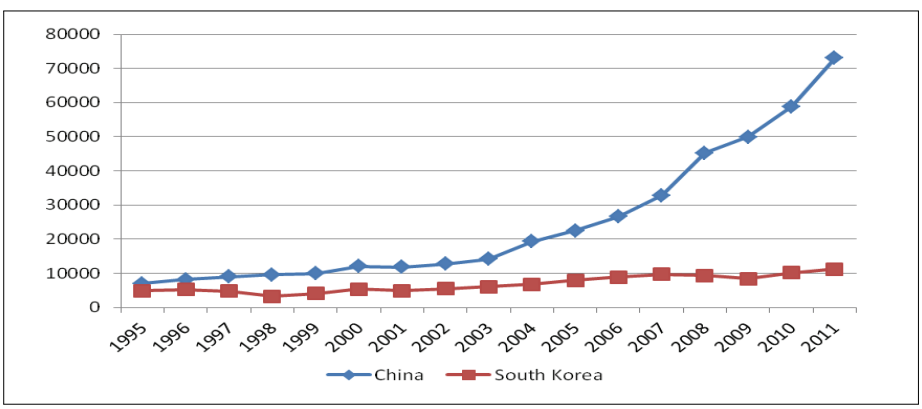
In the 1990s, South Korea entered the ranks of developed countries by industrialization, while China had just begun to transit from a planned economy to a market economy. Against this historical background, the South Korean economy growth entered into a steady growth stage; however, China began to exhibit the bonus of system transformation, meaning the overall economy is growing rapidly. Table 3-2 and Figure 3-1 reveal the changing trend of the Chinese and South Korean GDP since 1995. It is not hard to see that the Chinese GDP has grown rapidly since 1995. Growing from $700.219 billion in 1995 to $7.3011 trillion in 2011, the Chinese GDP expanded nearly 10 times over the past 17 years, with an average annual growth rate of 14.78%. Since 1995, South Korean economic development once suffered a serious setback because of the 1997 financial unrest. In less than five years, however, South Korea rose again and its economic growth rebounded to 10% in 1999. From $489.258 billion in 1995 to $1.117147 trillion in 2011, South Korea's GDP has increased nearly three times over the past 17 years, with an average annual growth of 4.98%. South Korea is still the key area of economic growth-with abundant room to grow-in Asia and the world. Figure 3-2 shows the comparative GDP growth rates of China and South Korea since 1995. From the Figure, we can see that the South Korean GDP growth rate was generally higher than 5% over most of the years, but the annual GDP growth rate decreased markedly in South Korea, because of the financial turmoil in 1997.

Table 3-2. GDP in China and South Korea (1995-2011) (100 million US$)

Year	China	South Korea
1995	7002.19	4892.58
1996	8164.93	5202.05
1997	8982.44	4764.86
1998	9590.3	3207.48
1999	9894.65	4061
2000	11985	5334
2001	11757	4820
2002	12710	5467
2003	14170	6053
2004	19316	6805
2005	22439	7914
2006	26579	8882
2007	32801	9698
2008	45218	9314
2009	49913	8341
2010	58786	10145
2011	73011	11171.47

Source: World Bank WDI Database.

Figure 3-1. GDP Trends in China and South Korea from 1995 to 2011 (100 million US$)



China's GDP growth rate is generally higher than 10% over most of the years, but the GDP growth rate decreased significantly because of the reformation and conversion of Chinese state-owned enterprises from 1999 to 2001. At the same time, the 2008 international financial crisis obviously had an impact on the GDP growth rate of both countries, so we can see the GDP growth rate of South Korea and China did suffer dramatic plunges.

The reason that we investigate overall economic development before the growth of the industrial economy is that the second industry plays an important part in GDP, according to the views of industrial classification. Industrial structure does not change in a short-term due to the effect of the stage of a country's economic development. Looking at Table 3-3, we can see that the percentage secondary industry in the Chinese GDP declined from 48.8% in 1995 to 44.6% in 2010: the trend falls slowly. In South Korea, the percentage of secondary industry in GDP fell from 43.3% in 1995 to 36.4% in 2010; the amplitude of decline was 2.7% higher than that of the Chinese over the same period. As the industrialization level improved continually both in China and South Korea, the percentage of the primary industry in the GDP and percentage of the secondary industry in GDP

Figure 3-2. The Growth Rate of GDP in China and South Korea (%)

Table 3-3. Gross Domestic Product (GDP) Industries Constitute (%)

Country	Primary Industry as Percentage of GDP				Secondary Industry as Percentage of GDP				Tertiary Industry as Percentage of GDP			
Year	1995	2000	2005	2010	1995	2000	2005	2010	1995	2000	2005	2010
China	20.5	15.1	11.9	9.5	48.8	45.9	47.0	44.6	30.7	39.0	41.1	45.9
South Korea	6.5	4.6	3.2	2.6	43.3	38.1	39.6	36.4	50.1	57.3	57.2	61.0

Source: World Bank WDI Database.

tended to decrease; tertiary industry should occupy a higher percentage in GDP. It is worth noting that in China the percentage of secondary industry in the GDP was 44.6% in 2010. This was 1.3% higher than the percentage of secondary industry in South Korea's GDP, which was 43.3% in 1995. This shows that China has been in a stage of industrialization since 1995 and that this stage should last for a quite some time into the near future.

(2) Comparison of industry value added in China and South Korea

Industry value added is what industrial enterprises contribute to the final result of industrial production activities in form of currency in a reporting period. In general, industry added value reveals the basic situation of a country's industrial economic growth. Industry encompasses all the differences in specific industries attributable to the statistical differences between countries. In China, industry generally represents the floorboard of the three industries referenced in "the international industrial division standard", which includes the mining and quarrying industry, the manufacturing industry and the electricity, gas and water supply industries. In China, manufacturing is sometimes treated as equivalent to industry in some literatures because the manufacturing industry proportionately occupies most. To ensure the comparability of the industrial growth in two countries, this paper uses data from the research foundation of the World Bank.

Table 3-4 and Figure 3-3 shows changes in industrial value added in China and South Korea. Table 3-4 reveals GDP and the proportion of industrial added value in China and South Korea from 1993 to 2011. We can indirectly calculate the industrial value added of the two countries over these years. It is relatively easy to see that Chinese industrial added value increased by almost 16.61 times in 19 years, exhibiting an average annual growth rate of 15.94%: from $207.035 billion in 1993 to $3.43969 trillion in 2011. We also find that South Korean industrial

Table 3-4. Industry Value Added in China and South Korea (1993-2011)

Year	China		South Korea	
	GDP (current US$)	Industry, value added (% of GDP)	GDP (current US$)	Industry, value added (% of GDP)
1993	440500898965.00	47	362135746945.00	42
1994	559224707281.00	47	423434190055.00	42
1995	728007199936.00	47	517118129838.00	42
1996	856084729312.00	48	557643607434.00	41
1997	952652693079.00	48	516282942110.00	41
1998	1019458585326.00	46	345432412376.00	41
1999	1083277930360.00	46	445399303511.00	40
2000	1198474934199.00	46	533384027729.00	38
2001	1324806914358.00	45	504585783004.00	37
2002	1453827554714.00	45	575928909990.00	36
2003	1640958732775.00	46	643762388701.00	37
2004	1931644331142.00	46	721975255824.00	38
2005	2256902590825.00	47	844863004335.00	38
2006	2712950886698.00	48	951773478985.00	37
2007	3494055944791.00	47	1049235951187.00	37
2008	4521827288304.00	47	931402204982.00	36
2009	4991256406735.00	46	834060441841.00	37
2010	5930529470799.00	47	1014890141871.00	39
2011	7318499269769.00	47	1116247397319.00	39

Source: World Bank WDI Database.

added value increased nearly 2.86 times in 19 years, exhibiting an average annual growth rate of 5.69%: from $152.097 billion in 1993 to $435.336 billion in 2011. Figure 3-3 shows the trend of industrial added value in China and South Korea. Through these comparisons, we see that industrial added value growth in South Korean has been relatively stable since 1993, while Chinese industrial added value grew rapidly.

Figure 3-3. Industry Value Added in China and South Korea

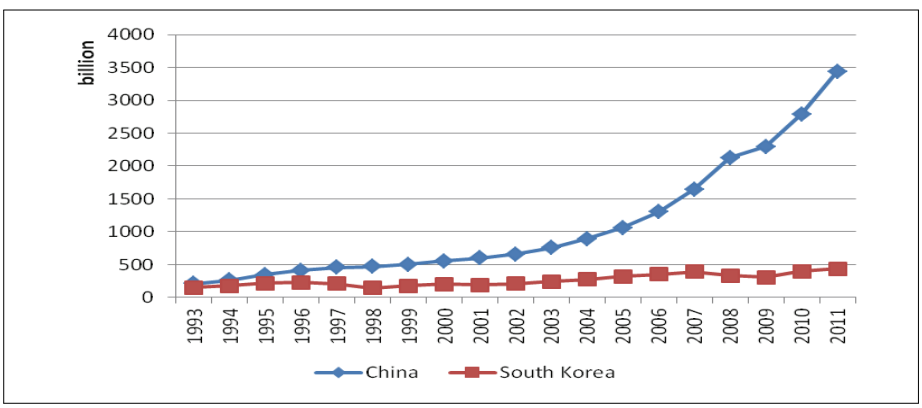


Figure 3-4. Growth Rate of Industry Value Added in China and South Korea (1993-2011)

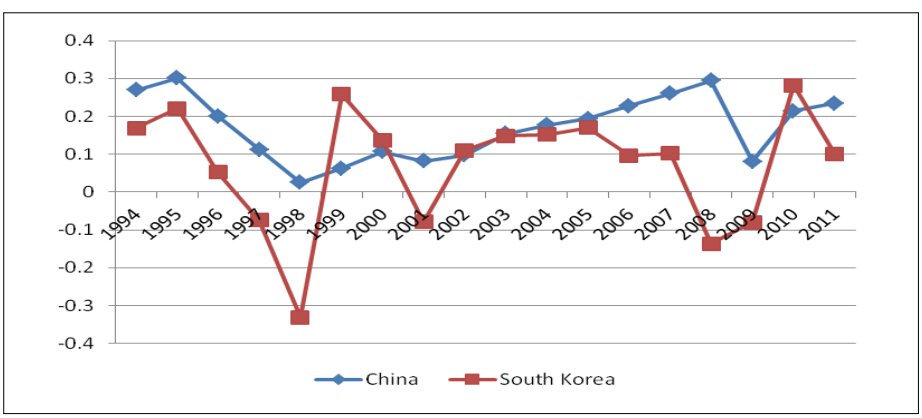


Figure 3-4 also reveals the growth rate of industrial value added in China and South Korea over these several years. We find that industrial value added in China and South Korea increased year-on-year over most of the years. Compared to South Korea, China has consistently maintained rapid growth since 1993, with an industrial value added growth rate higher than 10% in most of the years. The South Korean industrial value added growth rate clearly fluctuates. The rate even turned negative once because of the 1997 Asian financial crisis and the 2008 international financial crisis.

(3) Trend comparison of industrial economic growth in China and South Korea

Table 3-5 shows industrial economic growth data of the UN Industrial Development Organization (UNIDO) in China and South Korea. By comparing the average annual growth rate of MVA, we can see that the Chinese real annual

Table 3-5. International Comparisons of Industrial Performance

Indicator	Year Period	China	Republic of Korea	Asia	Developing Countries	Industrialized Countries
MVA average annual real growth rate (in %)	2000-2005	10.74	6.86	8.86	6.74	2.41
	2005-2010.	11.8	4.19	8.99	7.06	-1.62
Non-manufacturing GDP, average annual real growth rate (in %)	2000-2005	9.28	3.72	6.37	4.95	2.11
	2005-2010.	10.73	3.13	7.36	5.88	1.11
MVA per capita at constant (2000) US$ prices	2000	303.11	2876.32	224.77	254.20	3,399.21
	2005	480.45	3852.32	316.41	322.00	3,691.79
	2010.	820.02	4782.70	465.97	430.09	3,492.84
MVA as percentage of GDP at constant (2000) US$ prices	2000	32.12	25.23	22.5	19.47	17.62
	2005	33.05	27.76	24.24	20.57	17.59
	2010*	34.16	29.09	25.83	21.66	16.1

* UNIDO Estimate

Source: United Nations Industrial Development Organization International Yearbook of Industrial Statistics 2011.

growth rates in average during 2000-2005 and 2005-2010 were 10.74% and 11.8%, respectively, while South Korea's rates were 3.88% and 7.61%, respectively. The Chinese average annual growth rate is higher than the South Korean; however, from the perspective of MVA per capita, the Chinese MVA per capita of 2000, 2005 and 2010 are $303.11, $480.45, $820.02, respectively (at constant (2000) US$ prices). Although this increases nearly 1.5 times in ten years, it is still far less than the MVA per capita level in South Korean over the same period, compared to MVA per capita in South Korean in 2000, 2005 and 2010, which were $2876.32, $3852.32 and $4782.70, respectively. These are 9.5, 8.0 and 5.8 times higher than the Chinese is. From the percentage of MVA in GDP, we can see that the Chinese MVA percentage of GDP in 2000, 2005 and 2010 is respectively 32.12%, 33.05% and 34.16%, while the South Korean is 25.23%, 27.76% and 29.09%, respectively. Although both the MVA increased as a percentage of GDP, the Chinese MVA as percentage of GDP is relatively large for a developing country.

3.3. Comparison of energy consumption in China and South Korea

3.3.1. Comparison of trends in Energy consumption in China and South Korea

Table 3-6 and Figure 3-5 show the trends in energy consumption in China and South Korea. Chinese energy consumption was only 1.0414 billion metric tons (oil equivalent) in 2001, while it increased to 2.6132 billion tons (oil equivalent) in 2011, meaning it grew 1.5 times over 10 years. South Korean energy consumption was 193.9 million tons (oil equivalent) in 2001, and 263 million tons (oil equivalent) in 2011, meaning it only increased 35.64% over 10 years. Figure 3-5 shows that primary energy consumption in China and in the whole world all have tended to increase rapidly, while growth in primary energy consumption in South Korea and American was relatively stable. This reflects the fact that energy consumption in the United States, South Korea and other developed countries grows relatively slowly, while energy consumption-growth in developing countries such as China,

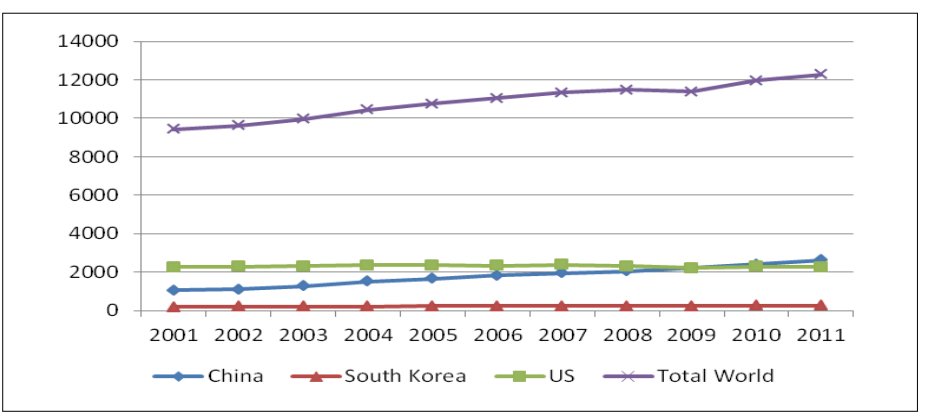
along with the rapid growth of the economy, is faster. The rapid growth of the world's total energy consumption can be mainly attributed to developing countries.

Table 3-6. Primary Energy Consumption in China and South Korea (million tons oil equivalent)

Year	China	South Korea	US	Total World
2001	1041.4	193.9	2259.7	9434.0
2002	1105.8	203.1	2295.5	9613.9
2003	1277.3	209.8	2302.3	9950.2
2004	1512.5	213.8	2348.8	10449.6
2005	1659	220.8	2351.2	10754.5
2006	1831.9	222.9	2332.7	11048.4
2007	1951	231.9	2372.7	11347.6
2008	2041.7	236.4	2320.2	11492.8
2009	2210.3	237.4	2205.9	11391.3
2010	2402.9	255.6	2277.9	11977.8
2011	2613.2	263	2269.3	12274.6
Change 2011 over 2010	8.80%	2.90%	-0.4%	2.5%
2011 share of total	21.30%	2.10%	18.5%	100.0%

Source: BP Statistical Review of World Energy 2012.

Figure 3-5. Primary Energy Consumption in China and South Korea (million tons oil equivalent)



Source: BP Statistical Review of World Energy 2012.

Figure 3-6 shows the growth rate of primary energy consumption in China, South Korea, US and total world, from which we can see the growth rate of primary energy consumption in China has stayed above 5% since 2002. This is far higher than South Korea and the Total World over the same period. The growth rate of primary energy consumption in South Korea has stayed between 0 to 5% since 2002. That means South Korea's energy consumption has been increasing slowly year-on-year. From Figure 3-6, we can also conclude that the growth rate of primary energy consumption in every country in 2009 decreased due to the 2008 financial crisis.

Figure 3-7 shows energy consumption of China and South Korea from 1993 to 2011. We can deduce that Chinese energy consumption was relatively stable from 1993 to 2001, but grew rapidly from 2001 to 2011, while South Korean energy consumption was relatively stable from 1993 to 2011. This is consistent with the trend analysis of China's and South Korea's energy consumption from 2001 to 2011 in the previous context.

Figure 3-6. The Growth Rate of Primary Energy Consumption (%)

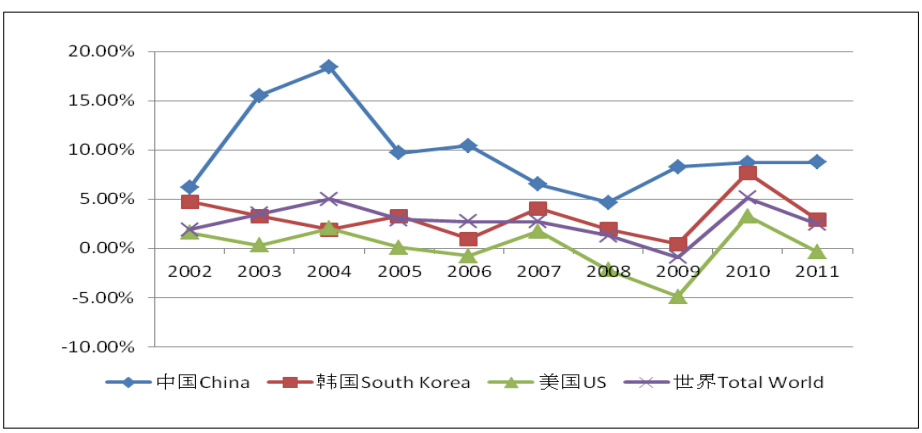
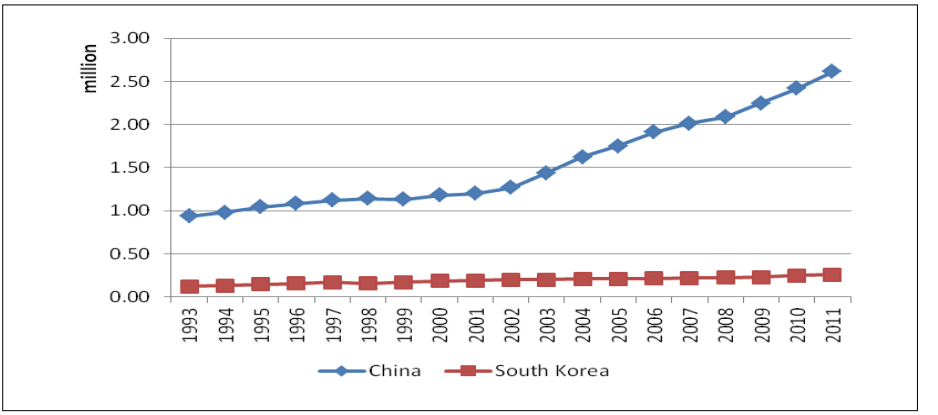


Figure 3-7. Energy Use in China and South Korea from 1993 to 2011
(kilotons of oil equivalent)



3.3.2. Analysis of the energy consumption structure in China and South Korea

Table 3-7 displays the primary energy consumption structure of the world's major energy countries in 2011. Figure 3-8 shows the primary energy consumption structure of the world's energy countries in 2011. From Table 3-7 we can see that China, the United States, Russia, India and Japan were the world's top five energy consumers during that period. Their percentage of primary energy consumption as a proportion of total world's energy consumption is 21.3%, 18.5%, 5.6%, 4.6% and 3.9%, respectively. The volume of energy consumption by the top five energy consumer accounts for 53.9% of total world consumption. As can be seen from Figure 3-8, coal occupies a large proportion of the primary energy consumption structure in China, India and South Africa. Coal consumption as a percentage of primary energy consumption structure in China is 70.39%, in India is 52.87%, and in South Africa it is 73.56%. Other countries' oil and gas consumption accounted for about 60% of primary energy consumption For example, American oil and natural gas consumption accounted for 64.32%, Japanese for 62.06%, Russian for 75.57%. The proportion of nuclear energy in the primary energy consumption structure

is generally higher than other developing countries or regions of the world for developed countries. For the total world, the proportion of oil in the world's primary energy is 33.07%, the proportion of natural gas consumption in the world's primary energy is 23.67%, the proportion of coal is 30.34%, and the proportion of nuclear energy, hydroelectricity and renewables is 33.07%.

Table 3-7 and Figure 3-8 also clearly show energy consumption and its structure in China and South Korea in 2011. From the Table and Figure, we can conclude that (1) the amounts of energy consumption in China and South Korea are significantly different. Chinese primary energy consumption was 2.6132 billion tons (oil equivalent) in 2011, while South Korean primary energy consumption was 263 million tons (oil equivalent) in 2011. The energy consumption of China and South Korea accounted for 21.3% of and 2.1% respectively of the world's total energy consumption. Chinese energy consumption is nearly 10 times the amount of South Korean energy consumption. (2) The energy consumption structures of China and South Korea are obviously different. The energy consumption structure in China is based on coal. The percentage of coal consumption accounted for a total energy consumption of 70.39% in 2011, and the percentage of oil and natural gas consumption accounted for a total energy consumption of 22.17%. However, the energy consumption structure of South Korea is based on oil, coal and natural gas. The percentage of oil consumption accounted for a total energy consumption of 40.30% in 2011, the percentage of coal consumption accounted for a total energy consumption of 30.19%, and the percentage of natural gas consumption accounted for a total energy consumption of 15.93%. Otherwise, the nuclear energy consumption of South Korea is relatively high: its percentage accounted for a total energy consumption of 12.93%, whereas in China, the percentage was only 0.75%.

Coal accounts for a large proportion of China's primary energy structure. The proportion of coal fluctuates between 65% and 75%, remaining at a high level. This is followed by oil, though the proportion of oil in China's primary energy structure is smaller and remains at a low level. There are some reasons for this. Firstly, it can be attributed to resource constraints. Chinese coal resources are rich,

while oil and gas resources are relative poor. The structure of energy consumption is basically consistent with the production structure. Secondly, it can be attributed to historical reasons. Chinese energy mainly relies on domestic production because of China's energy development strategy, which is aimed at self-sufficiency and self-reliance. Thirdly, Chinese natural gas exploration and development, as well as nuclear power development are lagging, leading to a strikingly low proportion of nuclear power and natural gas in the primary energy structure. As a result, China is one of the few countries in the world whose energy structure is based on coal; this deviates from the direction of the world's energy structure, which is based on oil or gas.

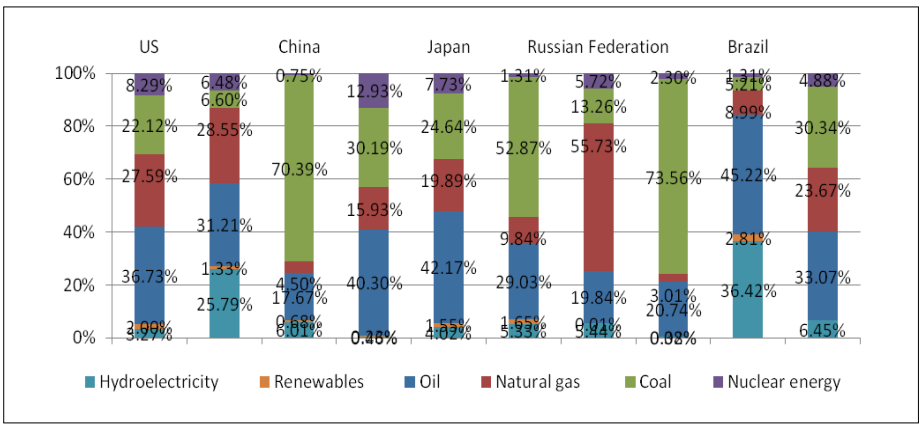
Different from China, the structure of South Korea's energy consumption is

Table 3-7. The Primary Energy Consumption Structure of the World' s Major Energy Countries in 2011 (million tons oil equivalent)

Country	Oil	Natural gas	Coal	Nuclear energy	Hydroelectricity	Renewables	Total	2011 share of total
US	833.6	626.0	501.9	188.2	74.3	45.3	2269.3	18.5%
Canada	103.1	94.3	21.8	21.4	85.2	4.4	330.3	2.7%
China	461.8	117.6	1839.4	19.5	157.0	17.7	2613.2	21.3%
South Korea	106.0	41.9	79.4	34.0	1.2	0.6	263.0	2.1%
Japan	201.4	95.0	117.7	36.9	19.2	7.4	477.6	3.9%
India	162.3	55.0	295.6	7.3	29.8	9.2	559.1	4.6%
Russian	136.0	382.1	90.9	39.2	37.3	0.1	685.6	5.6%
South Africa	26.2	3.8	92.9	2.9	0.4	0.1	126.3	1.0%
Brazil	120.7	24.0	13.9	3.5	97.2	7.5	266.9	2.2%
Total World	4059.1	2905.6	3724.3	599.3	791.5	194.8	12274.6	61.90%

Source: BP Statistical Review of World Energy 2012.

Figure 3-8. The Primary Energy Consumption Structure of the World's Major Energy Countries in 2011 (%)



based on oil, coal and natural gas. Reliance on nuclear energy and renewables is rapidly increasing. There are the reasons for this. Firstly, South Korea is a country that lacks domestic sources of energy. Its net energy imports accounts for 80% of energy consumption, which determines the structure of energy consumption. The fluctuating price of energy is another important reason affecting energy imports. Therefore, the structure of oil, coal and natural gas consumption is balanced in South Korea. Secondly, in order to ensure national energy safety, South Korea is also actively developing nuclear power and new sources of energy to reduce reliance on international energy.

3.3.3. Comparison of energy utilization efficiency between China and South Korea

Generally speaking, energy use (kg of oil equivalent) per $1000 GDP (constant 2005 PPP) most clearly reflects the economic efficiency of energy utilization. A lower index means less energy consumption per unit of GDP, while on the contrary, a higher index indicates more energy consumption in realizing a certain unit GDP.

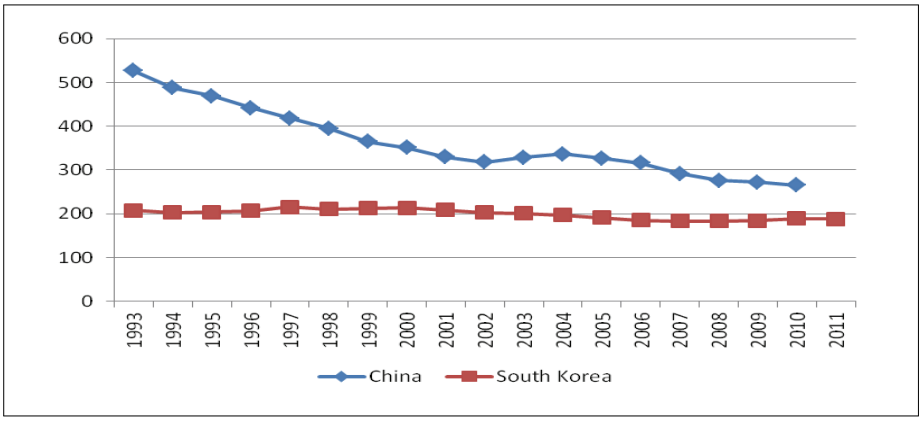
Table 3-8 and Figure 3-9 show energy use (kg of oil equivalent) per $1000 GDP in China and South Korea (constant 2005 PPP) since 1993. From Table 3-8, we observe that South Korea's energy use per $1000 GDP is 207.4 kg in 1993, whereas China's energy use per $1000 GDP is 527.1 kg-more than double that in South Korea. In 2010, South Korea's energy consumption per $1000 GDP was 189 kg compared to China's 265 kg. Although the energy consumption gap has narrowed, comparatively speaking, China's energy consumption per $1000 GDP in 2010 was still more than South Korea's in 1993. From Figure 3-9, it is evident that the trend in South Korea's energy use per $1000 GDP (constant 2005 PPP) presents a slow decline since 1993, meaning that economic growth by unit of energy is improving. The absolute value of China's energy use per $1000 GDP (constant 2005 PPP) is still higher than the level of South Korea in 1993, though it already showed a rapid decrease since 1993. This Figure indicates low energy utilization efficiency but high-energy consumption per GDP in China; the mode of China's economic growth is therefore extensive.

Table 3-8. Energy Use (kilogram of oil equivalent) per $1000 GDP in China and South Korea (constant 2005 PPP)

Year	China	South Korea	Year	China	South Korea
1993	527.1	207.4			
1994	487.3	202.9	2003	329	201
1995	469.6	203.7	2004	336.8	197.4
1996	442.1	206.8	2005	326.3	191.6
1997	418.3	215.2	2006	316.3	185.2
1998	395.4	210.9	2007	291.8	183.2
1999	364.5	213	2008	275.7	183
2000	351.1	213.7	2009	272.2	184.2
2001	329.6	208.7	2010	265	189
2002	318.1	202.5	2011	-	187.9

Source: World Bank WDI Database.

Figure 3-9. Energy Use (kilogram of oil equivalent) per $1000 GDP in China and South Korea (constant 2005 PPP)



3.3.4. Comparison of industrial energy consumption between China and South Korea

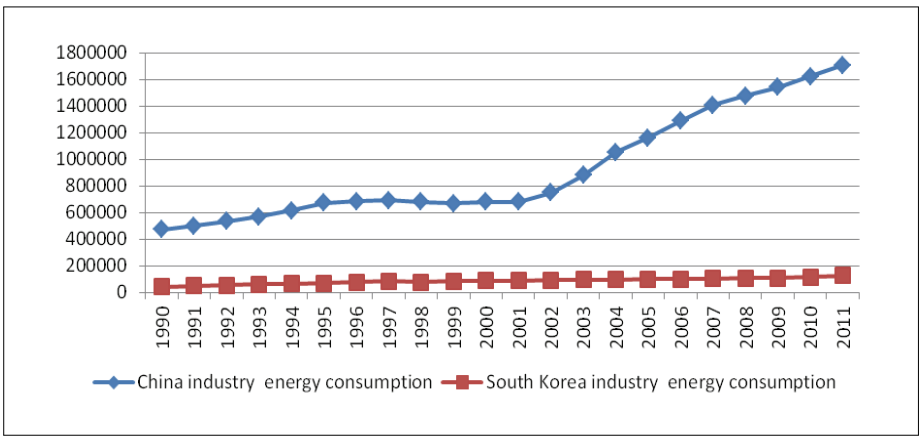
Table 3-9 and Figure 3-10 present the trend of industrial energy consumption in China and South Korea. Data from Table 3-9, indicate that Chinese industrial energy consumption was about 473.1 million tons (oil equivalent) in 1990, and increased to 1.7052 billion tons (oil equivalent) in 2011, which is nearly 3.6 times that of 1990 in 22 years with an annual growth rate of 6%. South Korean consumed about 56 million tons of industrial energy (oil equivalent) in 1990; that amount increased to 119.4 million tons (oil equivalent) in 2011, which is nearly 2.7 times that of 1990 in 22 years with an annual growth rate of 4.69%. From Figure 3-10, we can conclude that Chinese industrial energy consumption increased year-on-year from 1990 to 2011. From 1990 to 2001, the growing speed was relatively slow, whereas during 2001 to 2011, it became much faster. In comparison, South Korean industrial energy consumption years increased slowly continuously from 1990 to 2011.

Table 3-9. The Industrial Energy Consumption in China and South Korea (kilotons oil equivalent)

Year	China industry energy consumption	South Korea industry energy consumption
1990	473064.1	43776.87
1991	499881.6	48845.42
1992	533928.9	55151.97
1993	568516.7	60645.42
1994	614973.7	65400.4
1995	673326.1	71086.78
1996	683246.7	76956.76
1997	690961.1	84183.64
1998	680729.3	77012.13
1999	667520.7	83383.96
2000	678961.3	87342.75
2001	678964.2	89148.45
2002	751176	93520.48
2003	879463.9	95586.14
2004	1053085	96760.02
2005	1162144	99583.97
2006	1287767	101175.2
2007	1405878	105762.9
2008	1476009	106416.3
2009	1541177	106119
2010	1621738	116910
2011	1705176	126886

Source: Calculated by author based on China Statistical Yearbook, South Korea Statistical Yearbook and World Bank WDI Database.

Figure 3-10. Industrial Energy Consumption in China and South Korea (kilotons oil equivalent)



Otherwise, the Chinese industrial sector belongs to the energy-intensive sector. The proportion of industrial energy consumption as a percentage of whole of energy consumption was within 60% to 75% from year 1990 to 2011. This is presently maintained at around 70%. Industrial economic growth in China is the main engine driving the increase of China's energy consumption. The ratio of industrial energy consumption to total energy consumption is relatively lower in South Korea, whose industrial energy consumption as a proportion of total energy consumption was between 40% and 60% from 1990 to 2011, holding at 60% at present. The above proportion Figures are reflection of the fact that industries are important sectors of energy consumption in both China and South Korea. Changes in industrial energy consumption significantly influence the entire national energy consumption.

IV. An Empirical Study of the Relationship of Industrial Energy Consumption and Economic Growth, Comparing China and South Korea

4.1. Study of models, methods and data sources

4.1.1. Study of models

The model study of this paper refers to Lee and Chang, which explores the relationship of Korea industrial energy consumption and economic growth between China and South. Taking energy as an important factor, with Cobb-Douglas production function (C-D function) as the theoretical model, and influences in the framework of three elements of the production function, which reflect the relationship between the degree of industrial economic growth and energy consumption analysis:

$$Y=f\ (K,\ L,\ E) \tag{1}$$

Variables Y, K, L and E respectively refer to economic growth, capital stock, human capital and the energy consumption index. To avoid the impact of heteroskedasticity and multicollinearity, the logarithmic form of C-D production functions for the transformation of this model is presented as:

$$\ln Y_t = \beta_1 \ln K_t + \beta_2 \ln L_t + \beta_3 \ln E_t + \varepsilon \tag{2}$$

LY $\ln Y$, the other variables are similar, the model is as:

$$LY_t = \beta_1 LK_t + \beta_2 LL_t + \beta_3 LE_t + \varepsilon \tag{3}$$

4.1.2. Definition of variables

To study the relationship between economic growth and energy consumption,

the specific meanings of each variable above are defined as follows:

(1) Industrial economic growth index (Y). Industrial added value is a popular economic statistic in macroeconomics considered to be a measure of one of the most important indicators of a country's industrial economic development. The index is frequently used to measure the level in various countries and regions. In this paper, the industrial added value (US$ unchanged price in 2000), IVA (industry value added (constant 2000 US$), as a basic measurement of industrial economic growth, reflects the industrial economic growth in China and South Korea. In order to distinguish the data of China and South Korea, the industrial value added of China is written as IVAC, and the industrial value added of South Korea data is written as IVAK.

(2) The energy consumption index (E). In this paper, energy consumption refers to the consumption of final energy products. We choose the main energy consumption of industrial sectors (such as oil, coal, natural gas and so on) and the total energy consumption of industrial energy consumption as a summary of the variables. The unit is in thousands of tons of oil equivalent, represented by the EC energy consumption (KT of oil equivalent). In order to distinguish the data of China and South Korea, Chinese data is represented by the energy consumption of China (ECC), while South Korea data is abbreviates as ECK.

(3) The index of capital stock (K). According to the production function, the real index for capital stock, fixed assets, and capital stock is used for directing production. However, it is not able to access the statistics of all these aspects. The gross fixed capital formation (maintains unchanged price in 2000 dollars) as a proxy variable for invested capital by industrial enterprises is represented by the GFCF Gross fixed capital formation (constant 2000 US$). In order to distinguish the data of China and South Korea, Chinese data is represented by GFCFC, and South Korean data is written as GFCFK.

(4) The human capital index (L). Human capital indicators should be determined by the number of workers in the industrial sector (amount) and labor ability (quality). Considering that it is not easy to measure and acquire this data, in this paper

we determine the human capital index by the employment population (the number of employees or workers) of the industrial sector. Employment in industry is denoted by EI. In order to distinguish the data of China and South Korea, we use EIC to represent Chinese data, and EIK to represent South Korean data.

4.1.3. Source of data

This paper plans to study the relationship between economic growth and energy consumption from 1990 to 2011 in China and Korea. To obtain the data of China and Korea, and also to maintain their comparability, most of the data has been drawn from the World Bank's World Development Indicators Database (World Development Indicators Database), while some missing data has been collected from the "China Statistical Yearbook" (1990-2011), "China Energy Statistical Yearbook" (1990-2011), "Korea Statistical Yearbook" (1990-2011), the United Nations Industrial Development Organization" (United Nations Industrial Development Organization (UNIDO) website database.

4.2. The results of empirical analysis

4.2.1. The analysis of the overall trend

(1) The relation between industrial economic growth and ECC

From Figure 4-1 and Figure 4-2, we can see that the trend of the original sequence of IVAC and ECC is to increase, which seems to match with exponential growth. In order to eliminate heteroscedasticity, we take the logarithm of the original sequence before modeling. Sequence LIVAC and sequence LECC represent the logarithmic sequence of IVAC and ECC respectively. Figure 4-2 presents sample curves of the logarithmic sequence of IVAC and ECC. From Figure 4-2, it can be seen that both of the two logarithmic sequences tend to follow linear growth.

Figure 4-1. The Original Sequence Diagram of IVAC and ECC in China

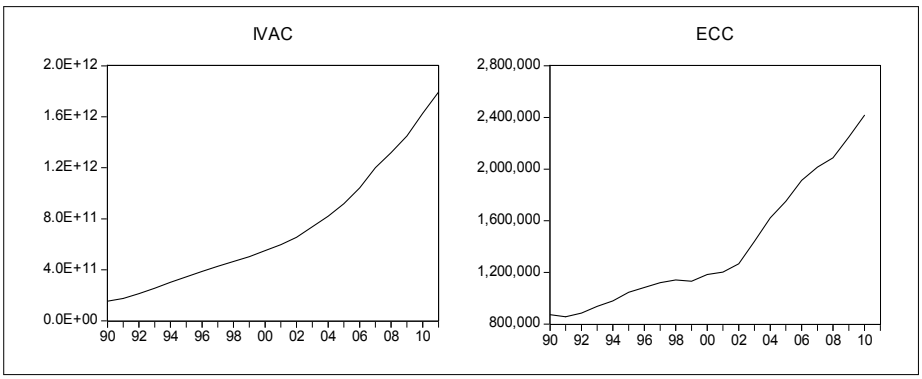
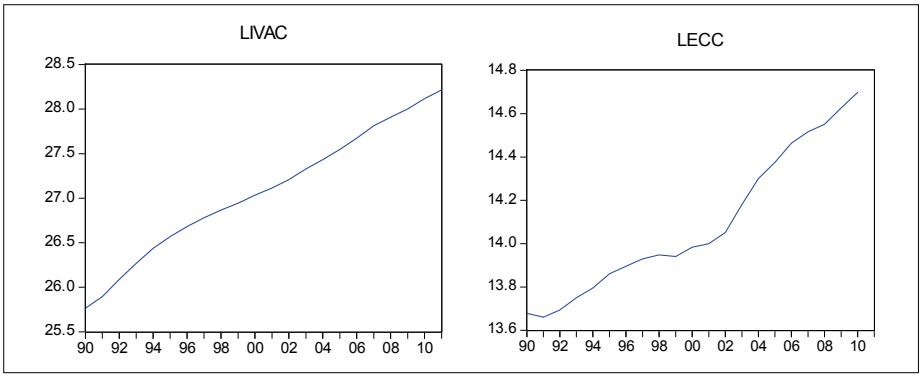
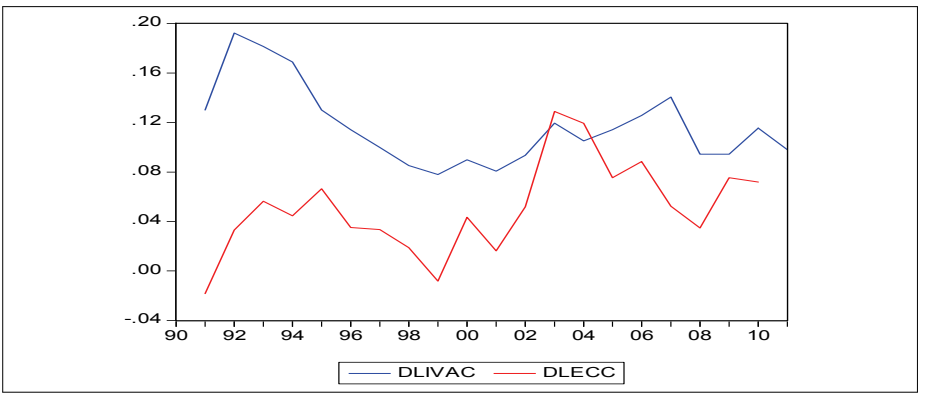


Figure 4-2. Logarithmic Sequence Diagram of LIVAC and LECC in China



From Figure 4-2, we can conclude that sequence LIVAC and sequence LECC have time trends, nonzero intercepts, and display non-stationary characteristics. However, further drawing on the logarithmic first difference sequence diagram of IVAC and ECC, which is shown in Figure 4-3, we can by way of preliminary consider them as stable sequences.

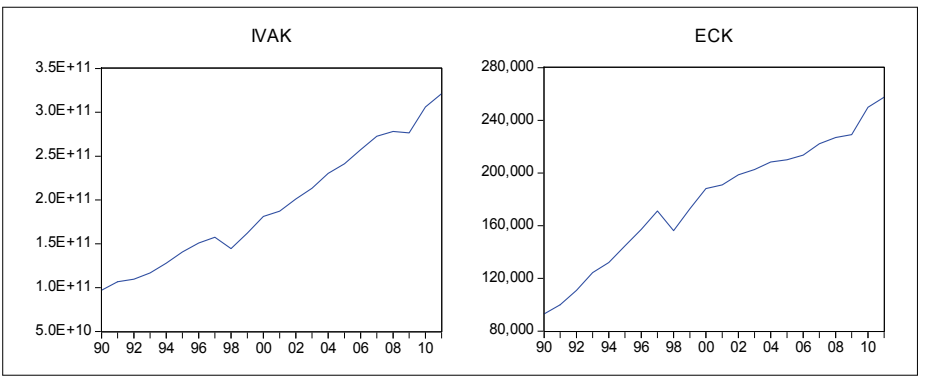
Figure 4-3. The Logarithmic First Difference Sequence Diagram of IVAC and ECC



(2) The relation between industrial economic growth and ECK

Figure 4-4 is the original sequence diagram of IVAK and ECK in South Korea. By observing and comparing the graph, it can be found that both IVAK and ECK show similar trends. Figure 4-5 is a time sequence of the logarithm of the original sequence of IVAK and ECK, which is able to eliminate the heteroscedasticity. Sequence LIVAK and sequence LECK represent the logarithmic sequence of IVAK and ECK respectively. Figure 4-5, reveals that both of the logarithmic sequences tend to follow

Figure 4-4. The Original Sequence Diagram of IVAK and ECK in South Korea



a linear growth. Moreover, it is possible to conclude that the original sequence and logarithmic sequence of IVAK and ECK is not smooth.

Figure 4-6 presents the logarithmic first difference sequence diagrams of IVAK and ECK, which show that the first difference sequence diagrams of both variables do not go against typical trends over time. This means that while inspecting the

Figure 4-5. Logarithmic Sequence Diagram of LIVAK and LECK in South Korea

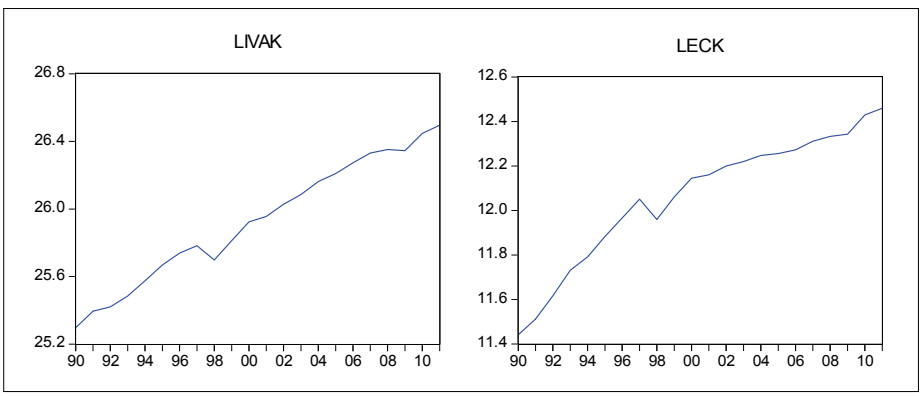


Figure 4-6. The Logarithmic First Difference Sequence Diagram of IVAK and ECK

root of unity to these sequences, we should choose inspection methods that exclude the time trend term, but only include the constant term.

4.2.2. The stationary test of variables

In order to pursue the inner structure of the compliance relationship between industrial economic growth and energy consumption objectively and scientifically,

Table 4-1. Unit Root Test Results (China)

Variable	ADF unit root testing					Inspection result
	Statistics	Critical value			Probability	
		1% level	5% level	10% level		
IVAC	3.866681	-4.4679	-3.64496	-3.26145	1.0000	unstable
ECC	1.067839	-4.66788	-3.7332	-3.31035	0.9996	unstable
EIC	-0.331805	-4.49831	-3.65845	-3.26897	0.9831	unstable
GFCFC	1.911543	-4.4679	-3.64496	-3.26145	1.0000	unstable
LIVAC	1.395392	-2.68572	-1.95907	-1.60746	0.9538	unstable
LECC	-0.350067	-4.66788	-3.7332	-3.31035	0.9798	unstable
LEIC	-2.840752	-4.66788	-3.7332	-3.31035	0.2046	unstable
LGFCFC	-2.645599	-4.4679	-3.64496	-3.26145	0.2660	unstable
ΔLIVAC	-4.088228	-4.66788	-3.7332	-3.31035	0.0273**	stable
ΔLECC	-4.252000	-4.66788	-3.7332	-3.31035	0.0206**	stable
ΔLEIC	-2.335800	-2.69236	-1.96017	-1.60705	0.0224**	stable
ΔLGFCFC	-2.803553	-4.49831	-3.65845	-3.26897	0.2119	unstable
Δ^2LIVAC	-5.269161	-2.69236	-1.96017	-1.60705	0.0000***	stable
Δ^2LECC	-4.853457	-2.69977	-1.96141	-1.60661	0.0001***	stable
Δ^2LEIC	-8.234972	-2.699769	-2.699769	-2.699769	0.0000***	stable
Δ^2LGFCFC	-5.656402	-2.69236	-1.96017	-1.60705	0.0000***	stable

Note: (1) Lag of ADF test will be automatic choice according to the SIC code; (2) Δ is a sequence of first-order difference, Δ^2 is a sequence of the second-order difference; (3) ***, **, *present a significance level of 1%, 5% and 10% respectively.

we need to confirm time series stationary first. Co-integration theory requires that related sequences must have identical stationary order; otherwise, it will generate the phenomenon of a "false return". A stationary time sequence means the mean, variance and covariance of this sequence are all stable. For example, if the mean, variance and covariance of a time sequence do not change with time, and every auto-covariance of the sequence is only associated with the order hysteresis, then the time sequence can be called stationary.

This thesis applies ADF to carry out the unit root test in examining the stationarity of the Chinese variable sequence and South Korean variable sequence, respectively, before moving on to the Granger causality test and co-integration test.

We note a nonzero mean and rising trend between logarithmic series of LIVAC, LIVAK and logarithmic series LECC and LECK (observed from Figure 4-2 and Figure 4-5), therefore this should include intercepts and a time trend when implementing the unit root test to level-value of the sequence. The time trend of the first-order difference sequence has been eliminated (from Figure 4-3 and Figure 4-6) when executing the unit root test on the level-value of the sequence, whereas the test does not contain the time trend. The choice of lag period is determined by AIC criterion. Inspection results are as follows.

From the above test results in Table 4-1, it can be concluded that the original sequence and logarithmic form of Variable IVAC, ECC are not stable, while the first-order difference sequence of LIVAC, LECC and LEIC is stationary, which means the first-order difference sequence of LGFCFC, namely I (1), is not smooth, and the second-order difference series of LGFCFC, namely I (2), is stationary. From the test results of Table 4-2, we can observe that the original sequence and their logarithmic form of the variable IVAK, ECK, EIK is not smooth, while the first-order difference sequence of LIVAK, LECK, LEIK and LGFCFK is stationary, namely I (1). Therefore, in accordance with the series data of China and South Korea, one can continue to carry out the next step of Granger causality test and co-integration test for same order stationary series.

Table 4-2. Unit Root Test Results (South Korea)

Variable	ADF unit root testing					Inspection result
	Statistics	Critical value			Probability	
		1% level	5% level	10% level		
IVAK	2.566681	-4.4679	-3.64496	-3.26145	0.666	unstable
ECK	1.767839	-4.66788	-3.7332	-3.31035	0.3121	unstable
EIK	-0.431805	-4.49831	-3.65845	-3.26897	0.1271	unstable
GFCFK	2.911543	-4.4679	-3.64496	-3.26145	0.7082	unstable
LIVAK	1.395392	-2.68572	-1.95907	-1.60746	0.1381	unstable
LECK	-0.350067	-4.66788	-3.7332	-3.31035	0.4159	unstable
LEIK	-2.640752	-4.66788	-3.7332	-3.31035	0.7102	unstable
LGFCFK	-3.045599	-4.4679	-3.64496	-3.26145	0.0581*	stable
ΔLIVAK	-5.088228	-4.66788	-3.7332	-3.31035	0.0008***	stable
ΔLECK	-5.252000	-4.66788	-3.7332	-3.31035	0.0039***	stable
ΔLEIK	-3.335800	-2.69236	-1.96017	-1.60705	0.0019***	stable
ΔLGFCFK	-5.803553	-4.49831	-3.65845	-3.26897	0.0065***	stable

Note: (1) Lag of ADF test will be the automatic choice according to the SIC code; (2) Δ is a sequence of first-order difference, Δ^2 is a sequence of the second-order difference; (3) ***, ***, *** present a significance level of 1%, 5% and 10% respectively.

4.2.3. Co-integration test of variable

Although China's time series LIVAC, LECC and LEIC are non-stationary first-order single integrated series, they may be a type of stationary linear combination. This stationary linear combination reflects the long-term stable equilibrium relationship between variables, namely the co-integration relations. Two commonly used methods of co-integration tests are the Engle-Granger test and the Johansen-Juselius test. The Engle-Granger-two step test is based on unitary variables, which are suitable for a co-integration test on two-period series. The Johansen-Juselius co-integration test is a method based on the vector autoregressive model (VAR) to test the regression coefficient, which is a good choice of method to precede the multivariate co-integration test.

This article selects the Johansen-Juselius co-integration test to check out the co-integration relationship between variables. Before the co-integration test, we need to formulate the VAR model, which should primarily consist of LIVAC, LECC, LEIC, LGFCFC, to confirm the lagging order of the co-integration test. Table 4-3 summarizes the VAR lag order number of various criteria that have been selected. According to the relevant rules in this paper, we select the VAR model whose lag order is 2.

The lag order number of the VAR model of the co-integration test is actually the lag order number of the original VAR model's first difference. Since the lag order number of the original VAR model is 2, the lag order of the co-integration test should be 1. Then we employ the Johansen-Juselius co-integration test to proceed to testing for co-integration examination between the variables. Table 4-4 and Table 4-5 report the co-integration test results.

Table 4-3. VAR Lag Length Based on Several criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	80.71374	NA	3.66e-09	-8.075130	-7.876301	-8.041481
1	200.3161	176.2561	7.06e-14	-18.98064	-17.98650	-18.81240
2	240.7581	42.57045*	7.12e-15*	-21.55348*	-19.76402*	-21.25063*

Note: (1) The log L, LR, FPE, AIC, SC and HQ present the rules when choosing lag order; (2) * indicates lag order selected by the criterion

Table 4-4. Results of Johansen-Juselius Co-integration Test (China)

Unrestricted Co-integration Rank Test (Trace):
Trace test indicates 2 co-integrating eqn(s) at the 0.05 level.

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.843811	74.44856	47.85613	0.0000
At most 1 *	0.727918	37.31481	29.79707	0.0056
At most 2	0.385711	11.28179	15.49471	0.1947
At most 3	0.073924	1.535980	3.841466	0.2152

Table 4-5. Results of Johansen-Juselius Co-integration Test (China)

Unrestricted Co-integration Rank Test (Maximum Eigenvalue): Max-eigenvalue test indicates 2 co-integrating eqn(s) at the 0.05 level.

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.843811	37.13375	27.58434	0.0022
At most 1 *	0.727918	26.03303	21.13162	0.0094
At most 2	0.385711	9.745809	14.26460	0.2292
At most 3	0.073924	1.535980	3.841466	0.2152

From the co-integration test results of Table 4-4 and Table 4-5, we can discover that there is no co-integration relationship between rejected variables of the null hypothesis ($r = 0$) when the unconstrained co-integration rank test and the maximum characteristic root co-integration test are carried out at the 1% significance level, and the co-integration relationship between rejected variable is at most, hypothesis ($r \leq 1$). Therefore, we can conclude that they are 2 co-integration equations at the 5% significant level. It is thus clear that there are at least two co-integration relationships among China's industrial economic growth, energy consumption, capital stock and human capital investment, no matter which test method is used (maximum likelihood method or trace test).

We can proceed with the co-integration test for logarithmic series of variables of South Korea's industrial economic growth, energy consumption, capital stock and human capital. Firstly, we need to set the VAR model, which consists of LIVAK, LECK, LEIK and LGFCFK, in order to confirm the lag order of the co-integration test. Table 3-15 summarizes the VAR lag order number of various criteria that are selected. We can find that, although various rules of lag order conclusions are quite consistent in China, South Korea's presents a very different situation. South Korea determines and selects the lag order number respectively according to different standards of the lag order. Based on LR, SC standards, the lag order number is 1, while on FPE, AIC and HQ standards, the lag order

number is 2. This paper considers 2 the lag order number for the VAR model.

Table 4-6. VAR Lag Length Based on Several Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	64.95740	NA	1.92e-08	-6.416568	-6.217739	-6.382918
1	151.5381	127.5927*	1.20e-11	-13.84612	-12.85197*	-13.67787
2	173.9013	23.54016	8.11e-12*	-14.51593*	-12.72646	-14.21308*

Note: (1) The log L, LR, FPE, AIC, SC and HQ present the rules when choosing lag order; (2) * indicates lag order selected by the criterion.

Table 4-7. Results of the Johansen-Juselius Co-integration Test (South Korea)

Unrestricted Co-integration Rank Test (Trace):
Trace test indicates 1 co-integrating eqn(s) at the 0.05 level.

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None*	0.804191	56.53049	47.85613	0.0037
At most 1	0.397325	17.99404	29.79707	0.5665
At most 2	0.304671	7.866501	15.49471	0.4798
At most 3	0.029511	0.599105	3.841466	0.4389

Table 4-8. Results of the Johansen-Juselius Co-integration Test (South Korea)

Unrestricted Co-integration Rank Test (Maximum Eigenvalue)
Max-eigenvalue test indicates 1 co-integrating eqn(s) at the 0.05 level.

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None*	0.704191	38.53645	27.58434	0.0451
At most 1	0.397325	10.12754	21.13162	0.7326
At most 2	0.304671	7.267397	14.26460	0.4580
At most 3	0.029511	0.599105	3.841466	0.4389

The same as in previous cases, the lag order number of the VAR model of the co-integration test is actually the lag order number of original VAR model's first difference. When the lag order number of original VAR model is 2, the lag order of the co-integration test should be 1. Then we apply the Johansen-Juselius co-integration test to proceed testing for co-integration between the variables. Table 4-7 and Table 4-8 report the results of the co-integration test.

The above co-integration test results in Table 4-7 and Table 4-8 indicate that there is no co-integration relationship between rejected variables of the null hypothesis (r=0) when the unconstrained co-integration rank test and the maximum characteristic root co-integration test are at a 1% significance level; thus, we can conclude that there is only 1 co-integration equation at the 5% significance level. It is thus clear that there is at least one type of co-integration relationship between China's industrial economic growth, energy consumption, capital stock and human capital investment no matter which test method is used (maximum likelihood method or trace test).

4.2.4. Short-term and long-term Granger causality test among variables

There are two methods for proceeding with the Granger causality test. One method is the traditional test, based on the VAR model, the other test has been recently developed, and is based on VECM. The difference between those two methods is the application range. The first method is appropriate for testing series that are not a co-integration time sequence, while the other one is suitable for a co-integration time sequence. Otherwise, the Granger causality test based on VECM investigates short-term causality among variables, which are investigated by a traditional causality test. Moreover, it may reflect long-term causality between variables that are in a co-integration relationship. The short-term Granger causality test is like the Wald weak exogenous test and examines the VECM of different dependent variables for statistics and probability; differently, the long-term Granger causality test is a Wald joint significance test of the independent variable of the lagged number for ECT and VECM. Thus, the Granger causality test based on

VECM can get not only the short-term causality between variables, but also the long-term causality of variables.

Based on the abovementioned co-integration test in China and South Korea, the existence of a long-term stable equilibrium relationship between industrial economic growth, energy consumption, capital stock and human capital has been proved. However, whether this equilibrium relationship has Granger causality or not still requires a further test. This paper uses the short-term and long-term Granger causality test suggested by Engle and Granger in 1987 based on VECM.

Based on the theory and method of Granger causality above, there proved to be a long-term co-integration relationship between LIVAC and LIVAK, LECC and LECK, LGFCFC and LGFCFK, and LEIC and LEIK, so we can take advantage of the Granger causality test based on VECM to confirm their short-term and long-term Granger causality. Test results are as presented in following Tables 4-9, 4-10, 4-11 and Table 4-12.

Table 4-9 reports the test results of the short-term Granger causal relationship between variables based on VECM. The test results show that there is Granger causality from human capital to industrial economic growth in the dynamic equation of industrial economic growth at a 10% significance level; Granger causality from capital stock to industrial economic growth at a 5% significance level has also been proved. Moreover, the test results indicate Granger causality from energy consumption to industrial economic growth in the dynamic equations of energy consumption at a 10% significance level, and Granger causality from energy consumption to capital stock at a 10% significance level. This shows that there is bidirectional Granger causality between energy consumption and capital stock in short-term and unidirectional Granger causality from human capital to capital stock; however in the short-term, there is no unidirectional or bidirectional Granger causality between energy consumption and industrial economic growth.

Table 4-9. Results of Short-term Granger Causality Tests Based on VECM (China)

	Independent variable				
Dependent variable	ΔLIVAC	ΔLECC	ΔLEIC	ΔLGFCFC	All variables
ΔLIVAC	-	0.6930 (0.7071)	0.6069 (0.0883)	3.1931 (0.0426)	3.9128 (0.0885)
ΔLECC	0.7838 (0.6758)	-	3.4310 (0.1799)	4.7759 (0.0618)	13.3631 (0.0876)
ΔLEIC	5.3806 (0.1679)	4.3870 (0.1115)	-	1.4046 (0.4954)	10.2424 (0.5148)
ΔLGFCFC	0.0147 (0.9927)	5.8472 (0.0537)	6.3041 (0.1428)	-	9.4497 (0.1498)

Note: (1) the degrees of freedom of test statistics X^2 is 2 and 6 respectively for a single explanatory variable and all explanatory variables; (2) data in brackets is a probability value.

Table 4-10 reports the test results of the long-term Granger causal relationship between variables based on the VECM. Test results show that there is Granger causality from energy consumption to industrial economic growth in dynamic equation of industrial economic growth at a 10% significance level, and Granger causality from human capital to industrial economic growth at a 5% significance level as well. Moreover, the results prove Granger causality from industrial economic growth to energy consumption in the dynamic equations of energy consumption at a 5% significance level and Granger causality from industrial economic growth to human capital at a 5% significance level. This shows that there is bidirectional Granger causality between industrial economic growth and energy consumption, industrial economic growth and human capital in China, and unidirectional Granger causality from human capital to industrial economic growth.

Table 4-10. Results of Long-term Granger Causality Tests Based on VECM (China)

	Independent variable				
Dependent variable	⊿LIVAC and ECT	⊿LECC and ECT	⊿LEIC and ECT	⊿LGFCFC and ECT	Strong exogenous test
⊿LIVAC	-	1.7010 (0.0647)	1.5868 (0.0262)	1.6468 (0.0746)	-1.7731 (0.0895)
⊿LECC	4.3630 (0.0248)	-	7.3374 (0.2034)	4.4735 (0.1229)	-2.9406 (0.0573)
⊿LEIC	3.4789 (0.0479)	3.8813 (0.1353)	-	3.5909 (0.1439)	-2.6173 (0.0754)
⊿LGFCFC	0.9546 (0.3997)	0.6029 (0.5556)	0.6273 (0.5429)	-	-1.0929 (0.2857)

Note: (1) the degrees of freedom of test statistics X^2 is 2 and 6 respectively for a single explanatory variable and all explanatory variables; (2) data in brackets is a probability value.

Table 4-11. Results of Short-term Granger Causality Tests Based on VECM (South Korea)

	Independent variable				
Dependent variable	⊿LIVAC	⊿LECC	⊿LEIC	⊿LGFCFC	All variables
⊿LIVAC	-	0.6930 (0.0771)	0.6069 (0.7383)	3.1931 (0.2026)	3.9128 (0.0885)
⊿LECC	0.7838 (0.0658)	-	3.4310 (0.1799)	4.7759 (0.1918)	13.3631 (0.0976)
⊿LEIC	5.3806 (0.0679)	4.3870 (0.1115)	-	1.4046 (0.4954)	10.2424 (0.1148)
⊿LGFCFC	0.0147 (0.9927)	5.8472 (0.1537)	6.3041 (0.4428)	-	9.4497 (0.1498)

Note: (1) the degrees of freedom of test statistics X^2 is 2 and 6 respectively for a single explanatory variable and all explanatory variables; (2) data in brackets is a probability value.

Table 4-12. Results of Long-term Granger Causality Tests Based on VECM (South Korea)

	Independent variable				
Dependent variable	⊿LIVAC and ECT	⊿LECC and ECT	⊿LEIC and ECT	⊿LGFCFC and ECT	Strong exogenous test
⊿LIVAC	-	1.7010 (0.2047)	1.5868 (0.0262)	1.6468 (0.0146)	-1.7731 (0.0995)
⊿LECC	4.3630 (0.0248)	-	7.3374 (0.2034)	4.4735 (0.3229)	-2.9406 (0.0873)
⊿LEIC	3.4789 (0.4479)	3.8813 (0.3353)	-	3.5909 (0.1439)	-2.6173 (0.2754)
⊿LGFCFC	0.9546 (0.0897)	0.6029 (0.5556)	0.6273 (0.5429)	-	-1.0929 (0.2857)

Note: (1) the degrees of freedom of test statistics X^2 is 2 and 6 respectively for a single explanatory variable and all explanatory variables; (2) data in brackets is a probability value.

Table 4-11 reports test results of the short-term Granger causal relationship between variables based on VECM. Granger causality from energy consumption to industrial economic growth in a dynamic equation of industrial economic growth at a 10% significance level, and Granger causality from industrial economic growth to energy consumption in the dynamic equation of energy consumption at a 10% significance level are indicated in the test results. Granger causality from industrial economic growth to human capital in the dynamic equations of human capital at a 10% significance level is also shown. The result shows that there is bidirectional Granger causality between industrial economic growth and energy consumption in the short-term in South Korea, and unidirectional Granger causality from industrial economic growth to human capital. In the short-term, there is no unidirectional or bidirectional Granger causality between capital stock and human capital.

Table 4-12 reports the test results of the long-term Granger causal relationship between variables based on VECM. The test results demonstrate Granger causality between human capital, capital stock to industrial economic growth in a dynamic equation of industrial economic growth at a 5% significance level, and Granger

causality from industrial economic growth to energy consumption at a 5% significance level. There is Granger causality from industrial economic growth to capital stock in the dynamic equations of capital stock at a 10% significance level. This proves unidirectional Granger causality of industrial economic growth to energy consumption in the operation of the industrial economy in the long-term in South Korea, namely economic growth results from the Granger cause of energy consumption, while energy consumption does not.

V. Conclusions and Suggestions

5.1. Conclusions

(1) No matter whether in China or South Korea, total energy consumption is not an exogenous variable of industrial economic growth, capital stock and human capital from a long-term perspective. The four important factor variables-industrial economic growth, energy consumption, capital stock and human capital-that affect the overall development of industrial economy are in an equilibrium relationship over long-term.

(2) Based on our inspection of the results of short-term Granger causality between variables, based on vector error-correction model, we conclude that:

For China, there is bidirectional Granger causality between energy consumption and capital stock, there is unidirectional Granger causality from capital stock, human capital to industrial economic growth, and there is no Granger causality between energy consumption and industrial economic growth. This indicates that an increase of energy consumption in the short-term is caused mainly by the growth of capital stock, but not y industrial economic growth. An explanation of this conclusion

could be that rapidly increasing investment in the short-term does lead to the growth in capital stock, resulting in the demand for energy consumption in basic industry; therefore, energy consumption increases significantly. Rapid increases in energy consumption in short-term also led to the formation of capital stock. At the same time, investment formed by increasing capital stock and population resulting from human capital growth are important reasons for the sustainable growth of China's industrial economy in short-term. Bidirectional Granger causality between energy consumption and capital stock clearly illustrates the situation of our country's extensive industrial economy.

For South Korea, there is bidirectional Granger causality between energy consumption and industrial economy growth and unidirectional Granger causality from industrial economy growth to human capital, and there is no Granger causality between capital stock and human capital. This means that the increase in energy consumption is mainly caused by industrial economy growth, which works as a prompt feedback expression between industrial economy growth, energy consumption and the smooth transmission mechanism of the market in the short-term. Industrial economy growth and energy consumption contribute positively to each other. On the other hand, industrial economy growth stimulates the volume of employment to increase in a short period, showing that economy growth affects employment actively.

(3) From assaying the results of long-term Granger causality:

For China, there is bidirectional Granger causality between industrial economy growth and energy consumption, which shows that the increase of energy consumption leads to industrial economy growth in China. Meanwhile, industrial economy growth also results in an increase in energy consumption. From the perspective of the long-term trend, this is behavior typical of extensive growth in industrial economy. On the other hand, there is bidirectional Granger causality between human capital and industrial economy growth, meaning that the industry sector will employ more

people as the industrial economy develops. A population increase in the industry sector, on the other hand, will promote industrial economy growth. Therefore, this indicates that the demographic dividend has a positive effect on industrial economy growth, and industrial economy growth absorbs an enormous rural population transfer. Otherwise, there is unidirectional Granger causality between capital stock and industrial economy growth. This proves that increasing investment is an important reason for industrial economy growth in China. It can be seen that Chinese industrial economy growth features clear industrialization characteristics of developing country.

For Korea, there is unidirectional Granger causality from industrial economy growth to energy consumption and no Granger causality from energy consumption to industrial economy growth. Bidirectional Granger causality between industrial economy growth and capital stock, and unidirectional Granger causality from human capital to industrial economy growth are also illustrated, revealing that energy consumption is not due to Granger causality of industrial economy growth. In the long-term development of industrial economy, increasing energy consumption cannot directly lead to industrial economy growth. The engine driving the growth of the industrial economy are increases in long-term capital investment, human capital investment, progress in science and technology, the growth of consumption, and many other factors. However, unidirectional Granger causality from industrial economic growth to energy consumption of Korea illustrates that energy consumption will increase with industrial economic growth. In addition, South Korean industrial economic growth also stimulates the investment to grow continuously and correspondingly, and promotes an increase in capital stock.

5.2. Policy suggestions

Generally speaking, economic growth will drive energy consumption, while energy consumption will promote economic growth. Since China and South Korea are in different stages of development, the relationships between industrial energy

consumption and economic growth present different characteristics. In China, the process of industrialization is still in a late stage, and industrial economic growth cannot be completely "decoupled" from energy consumption. Energy consumption is still an important factor for promoting industrial economic growth. South Korea has already completed the industrialization stage; although South Korean industrial economic growth is accompanied by an increase in energy consumption, industrial economic growth mainly depends on scientific, technological progress and technological innovation. Energy consumption is not the industry growth factor to promoting the economy. Therefore, a correct understanding of different stages of development between China and South Korea is crucial to recognizing the relationship between the economic growth of the industrial and energy consumer. In light of the above conclusions, combined with the actual situation in Chinese and South Korean industrial economic development and energy consumption, we offer the following suggestions:

5.2.1. Enhancing China-ROK industry core technology transfer, cooperation and development.

(1) Seize the opportunity presented by the transformation and upgrading of the Chinese industrial structure, and strengthen core technology transfer from South Korea to China.

South Korea and China are geographically close. Since the establishment of diplomatic ties between China and South Korea, China has been a major importer of Korean raw materials, primary products and manufactured goods in the rough machining industry, while South Korea is a major importer from China of end equipment products and consumer goods. Speaking generally, industrial relations between these two countries can be described as "low-end complementary". China's economy has been developing rapidly for many years. The energy industry is mostly dominated and promoted by heavy industry. Given future increases in energy consumption in China, the country will face the pressure of energy consumption and the need to protect the environment, increasing day-by-day. The optimization

and upgrading of the industrial transformation and structure are urgently needed.

In coming years, as China implements an industrial strategy transformation from "bigger" to "power", the policy orientation toward foreign capital in China will need to be adjusted. The basic principles of industrial transfer from South Korea to China may be as follows: one country receives key, core and cutting-edge technology, while another country earns bumper profits. Given its current level of industrial technology, South Korea is ahead of China, whose industries have an absolute competitive position in the world in areas such as electronic information hardware, automobile manufacturing, iron steel and so on. Obtaining a leading position in the electronics industry, and the cultural and creative, digital entertainment industry, but with a relatively small domestic market, South Korea should transfer the high-end manufacturing industry and cultural creative industry to China. China should formulate policy to optimize and upgrade its domestic industrial structure to attract South Korea energy (resources), saving, and intensive industries.

If South Korea transfers the latest technology to China, it can greatly improve the ability of its manufacturing enterprise, meanwhile reducing the production cost of South Korean brands and seizing market share among Chinese consumers. Therefore, a Korean company could then improve its international competitiveness, while earning huge profits at the same time. Based on China's industrial transformation and upgrading, guided by transfer and seizing the opportunity to carry out core technology transfer would be mutually beneficial to both countries in industry. This is the also direction of China's transformation with respect to South Korea in the period of a "twelfth five-year plan".

(2) Strengthening technology in the field of industrial cooperation in R&D, enhancing the technological level of Chinese and South Korean industry.

After the international financial crisis, developed countries opened up competition struggling for the choice of leading industry, carrying out strategic deployment, promoting the rapid development of energy-saving and environmental protection, new energy, information, biology and other emerging industries. Attempts to seize

strategic high ground through a new round of development exerted severe pressure on the newly industrialized countries in developing world such as China and South Korea. Viewed on the whole, Chinese industry still lags behind South Korea on technology innovation and at the technical level. However, China has scientific research institutions and university subjects for large research teams, which possess strong R&D in the fields of national defense, aerospace, chemical and biological and physical science. South Korean enterprises are the mainstay of the scientific research system and applied science was the dominant technology, forming a complementary structure. China and South Korea have complementary systems of innovation and technological advantage, allowing them to co-operate in depth in R&D in many fields, such as new ships, new energy vehicles, mobile communication and computers. Each country, respectively, can develop its own advantages, enhancing the level of bilateral technology, and realizing a great-leap-forward in the development of the level of industrial technology.

(3) China should improve the efficiency of energy use and reduce energy consumption per unit of industrial output value.

It will be a long time before the Chinese economy enters the future of development, where sustainable development overcomes the constraints of energy shortage and environmental deterioration. The key is to change the original approach to energy-extensive growth by relying on high technology and the progress of science and technology to promote the development of economy under the energy extensive consumption mode. In the past thirty years, China's industrial energy consumption per unit output value has been reduced; however, at present our country's product energy consumption per unit of output is still much higher than that of developed countries. Energy consumption per unit of output level is even far higher than South Korea. It has been recognized that China has great potential to reduce energy consumption per unit of output. At present, China is still in the period of rapid growth of economic development accompanying by energy consumption. In the short-term, the mode of economic growth is still extensive, which could form a

vicious spiral and is not conducive to transformation of the mode economic development. It is therefore necessary and urgent to exploit scientific and technological progress, to reduce energy consumption per unit of product, to improve energy efficiency and to promote the transformation of the development mode of China's economy. Currently, South Korean energy utilization efficiency is much higher than that of China; with cooperation, China and South Korea both have broad prospects for strengthening their energy efficiency in cooperation and utilization.

5.2.2. Developing a low carbon economy, realizing green economic growth between China and South Korea.

(1) China should adjust the structure of coal-based energy consumption to increase the consumption proportion of high-quality energy.

The development of a low carbon economy has become the consensus of the world. China shares this goal. A low-carbon economy based on a low energy consumption, low pollution, low emission based economic model refers to the concept of sustainable development under the guideline "through technological innovation, system innovation, industrial transformation, new energy development and other means, to reduce energy consumption as far as possible of high carbon coal, oil, to reduce greenhouse gas emissions, to achieve a win-win situation of economic and social development and ecological environmental protection at the same time. The biggest obstacle in China to achieving a low-carbon economy is the present dominant energy consumption structure in which coal occupies a high proportion. From 1980 to 2010, In China, consumption of coal per year has accounted for about 70% of total energy consumption. According to one calculation, a ton of burned coal can produce 2.6 tons of carbon dioxide gas, 30% and 70% more than per ton of oil and natural gas. In energy consumption, coal has the most carbon emission while the consumption of coal in China is also the highest. Therefore, China should adjust its coal-based energy consumption structure, avoid excessive reliance on fossil fuels, and vigorously develop renewable energy, in order to reduce

carbon emissions at the source.

(2) Strengthening the development and utilization of clean energy cooperation between China and South Korea to realize green growth of the economy.

The proportion of clean energy in China and South Korea in primary energy consumption is still low. Expanding the application of clean energy, increasing the proportion of clean energy use, reducing greenhouse gas emissions and environmental pollution are the common goals of both China and South Korea. Although the clean energy industry in South Korean started earlier than China and has a relatively higher technology level than China, the land and climatic conditions in South Korea are congenitally deficient, restricting further improvements. China started late, with a relatively backward level of technology, but the advantage of the effect is gradually emerging. Abundant natural resources and optimizing policy measures are promoting the expansion of clean energy markets. At the same time, the popularity of the use of clean energy also presents some technical problems, such as photovoltaic and wind energy storage technology. Therefore, South Korea could establish technical cooperation and exchanges with China in the solar photovoltaic and wind energy industry. China can absorb technology development and operational experience from South Korea on energy, hydrogen energy, fuel cell and other aspects. China and South Korea can complement each other and develop their respective advantages by carrying out joint research, promoting the usage of new clean energy, and cooperating to break through these technical problems. The popularization of the use of clean energy, which will drive the development of new industry, such as power generation, transmission facilities, repair, maintenance, personnel training and so on, is creating more employment opportunities for China and South Korea, and providing new impetus to economic growth.

Merging development of clean energy technology can not only ease the growth pressure of energy consumption, optimize the energy structure, but also can promote technical innovation and industrial revolution, promote industrial economy growth and development. This approach is also friendly to the environment, can bring

green economic growth, and finally results in multiple other benefits. Vigorously developing clean energy cooperation and implementing green economic growth is therefore the common goal of development.

(3) Strengthening nuclear safety cooperation and increasing the energy-saving measures offer China and Korea a huge potential for cooperation.

South Korea is a country whose fossil energy is extremely scarce; however, it is still a leading energy consumer. Under pressure of international oil prices, global climate change, domestic consumption demand growth and other factors, with South Korean energy supply and demand constantly increasing, the development of nuclear power has become an important means for Korea to alleviate the pressure of energy supply, and maintain national energy security. At present, nuclear power consumption as accounted in terms of South Korea's total energy consumption ratio has reached more than 10%. The Korean nuclear energy generation replaces traditional fossil energy consumption, and its impact on the structure of energy consumption is significant. Nuclear energy focuses on the development of China's nuclear power; however, even the most advanced countries still cannot guarantee the absolute safety of nuclear energy. The Fukushima earthquake triggered a nuclear disaster, forcing the two countries to re-examine the development and direction of nuclear energy. Nuclear safety has become a common concern of two countries. China and South Korea have an enormous range of opportunity to work together on perfecting cooperative safety supervision of nuclear power mechanisms and on developing nuclear power plant emergency preparedness, emergency response management, as well as advancing reactor development and improving the experience feedback aspects of cooperation, nuclear power equipment manufacturing, and strengthening personnel exchanges.

As the energy consumption in both two countries increases, and the energy consumed in South Korean mainly relies on import, we have huge potential for cooperation in the field of energy-saving and emissions reduction. South Korean companies have obtained advanced technologies reaching the world-level in the

energy-saving, emissions reduction, which can be transferred into the Chinese market to make a positive contribution to Chinese energy-saving, emissions reduction, while simultaneously the winning more business opportunities for themselves. Chinese companies also enjoy their own advantages in some areas. For example, ion-sieve wastewater treatment technology developed by the China Energy Conservation Investment Corporation is a leading and advanced treatment that can be applied in water polluted by nuclear radiation contamination from nuclear accidents. Considering that South Korea's nuclear energy consumption occupies a larger proportion in its energy consumption structure, such technology is relevant for the safety of Korean nuclear facilities.

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China-South Korea Financial Cooperation: Development and Prospects

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I. Introduction

1.1. Motivations of Financial Cooperation

Any country is vulnerable to financial channels of a crisis, even if the crisis is occurring elsewhere. It is no exception for East Asia. Most of the countries in East suffered from financial market collapse and economic recession in the past. Economic linkages within the region might, however, lead to the risk of crisis contagion. The Asian financial crisis in 1997-1998 provided a direct impetus for countries to recognize the need for regional financial cooperation. The global financial crisis of 2008 became a new catalyst. Having experienced the financial crisis, Asian countries reached a consensus on the need to enhance their own risk management abilities in order to prevent and resolve any future financial crises. They needed to do so by strengthening regional financial cooperation, instead of

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depending merely upon support from international financial organizations, including the International Monetary Fund (IMF) and from developed countries.

Furthermore, East Asia, including China-Japan-South Korea, is an area where real economic activities are closely linked. The brisk trade in goods and services among East Asian countries shows a well-integrated East Asian economy. Most trade by East Asian countries is cleared in U.S. dollars, and it implies that when foreign exchange shocks occur, countries in the region are highly vulnerable to financial crisis caused by foreign exchange market risks. Hence, developing an effective regional financial cooperation could be necessary.

1.2. Evolutions on China-South Korea official Financial Cooperation

In terms of specific cooperation between China and South Korea, it began with a cooperative relationship under a multilateral mechanism, rather than bilateral official links. Since the late 1990s, financial cooperation in Asia has mainly concentrated on regional financial forums, especially the Association of Southeast Asian Nations plus Three (ASEAN + 3) and the Executive Meeting of East Asia-Pacific Central Banks (EMEAP). These endeavors have achieved considerable results, albeit slowly, including the setting up of regional liquidity support arrangements through the Chiang Mai Initiative (CMI), the establishment of the Asian Bond Fund (ABF), and the progress of the Asian Bond Market Initiative (ABMI), and Chiang Mai Initiative Multilateralized (CMIM) and the recently established ASEAN+3 Macroeconomic Research Office (AMRO).

Actually, it is true that the safety net provided by Regional Financial Arrangement (RFA) plays an important role. Using the case of RFA in ASEAN+3, it is also agreed that the effectiveness of the region's RFA has been limited so far. Its accomplishment is not as originally expected. Hence, some of the member countries are trying to cooperate in a bilateral mechanism.

Under the RFA in ASEAN+3: China and South Korea have established a

bilateral currency swap agreement since 2000. And in 2011, the two central banks agreed to extend an existing won-yuan currency swap worth 64 trillion won (about $55 billion) by three years. The size of the swap, set to expire in October 2014, can be expanded if needed. And in December 2012, the two central banks introduced a currency swap scheme that allows South Korean and Chinese companies to settle trade payments in each other's currency. The agreement, which is expected to alleviate over-reliance on U.S. dollars in bilateral trade, will bring down transaction costs and prevent risks resulting from fluctuations in currency rates for companies in both countries. Meanwhile, South Korean officials still argue that the world should shift from a model where nations agree to bilateral deals, as South Korea has just done, to a more permanent swap regime that will be continuously available for solvent nations facing liquidity troubles.[2)]

In all, since 2008 China, South Korea and Japan have been operating about 50 intergovernmental consultation channels, including summit meetings, and more than a hundred cooperative projects. With the establishment of the Trilateral Cooperation Secretariat (TCS) in Seoul in 2011, financial cooperation among the three countries entered the stage of institutionalization (Lim Ho-yeol, 2012).

Indeed, compared with the economic linkage of China and South Korea, the financial cooperation is obviously lagging behind. However, along with the Sino-South Korea FTA talks re-launching, two nations face a new era of cooperation in finance. Therefore, it is essential to examine what challenges must be overcome to achieve the efficient financial cooperation. It is also important to determine the direction in improving the financial cooperative system.

In the paper, the financial cooperation mainly refers to the financial institution cooperation, the openness to each other's financial market, the settlement of trade and investment in local currency and the financial measures to support enterprises and governments for partner countries.

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2) Christian Oliver, South Korea doubles currency swap deal with China, Financial times, October 26, 2011. http://www.ft.com/intl/cms/s/0/35911e14-ffd4-11e0-89ce-00144feabdc0.html#axzz2YiKWiqNj.

II. Recent Status of Cooperation in Financial Industries

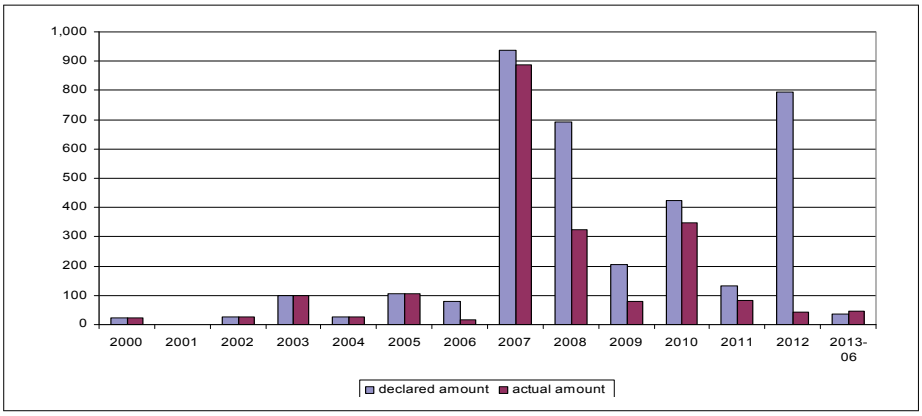
2.1. Cooperation between financial Institutions

So far there have been more than two decades since South Korean financial institutions first entered China. During these years, China has witnessed the process of its accession to the WTO and gradual opening of its financial market. From 2000 to 2011, the investment volume of South Korea in China's financial and insurance industry increased dramatically and peaked in 2007. It can be divided into two phases according to the amount of investment: the preliminary opening phase and the fully open phase (Figure 1).

From 1992 to 2006, as the openness of the financial industry was fairly limited, the declared and actual investment amounts were generally less than US $100 million. And the scale of business for foreign Banks in China was under the strict control of regulatory authorities. Therefore, there were also many limitations for South Korean commercial banks. During this phase, as spearheads of South Korean financial industry, Korean banks rushed into China and mainly established

Figure 1. South Korean investment in China's financial and insurance industry

(US$ million)



Source: Korean Eximbank, http://www.koreaexim.go.kr/en/, Statistics.

representative offices (liaison offices) or branch offices, mainly located in Beijing, Shanghai and Tianjin where trade flow were closely linked between China and South Korea. Also, they served mainly South Korean-owned enterprises in China, meeting their financial needs for international trade and investment.

In 2007, China met its commitments to fully open the banking industry; the declared and actual investment amount from South Korea in China's financial and insurance industries rocketed to $938.16 and $886.97 million respectively. Since then, foreign banks have begun to enjoy the national treatment as local banks. With an offer of a wider range of local currency business, foreign banks were finally allowed to incorporate locally. To seize the market opportunities, South Korean financial institutions rapidly transferred their branches to local subsidiaries. Until the end of 2012, the South Korean Banks have established a total of six local subsidiaries with legal person (Table 1), accounting for 1/7 of all the foreign legal person banks in China (a total of 42), a good score compared to other foreign banks in China.

As for recent business activities of South Korean financial institutions in China, it remains limited. At present, there is a dual market structure in China's banking industry, characterized by administrative monopoly of four state-owned banks and excessive competition among small and medium-sized banks. Based on the annual report of CBRC, by 2012, the market share of the assets of all foreign banks

Table 1. South Korean local subsidiaries in China with legal person

Time	Name	Location	Register Capital
2007-11	Woori Bank	Beijing	2 billion Yuan
2007-12	Hana Bank	Beijing	2 billion Yuan
2008-04	Shinhan Bank	Beijing	2 billion Yuan
2009-06	Industrial Bank of South Korea (IBK)	Tianjin	2 billion Yuan
2010-08	South Korea Exchange Bank (KEB)	Tianjin	2 billion Yuan
2012-11	Kookmin Bank	Beijing	2.5 billion Yuan

Source: CBRC (The Chinese Banking Regulatory Commission), Statistics.

continued to decline, accounting for only 1.82% of the total of commercial banks in China (a total asset of 133.6trillion yuan). With total assets of less than US $3 billion, South Korean banks have limited size and scale, compared to the Chinese banks.

Despite the removal of limitations on business and customers, the South Korean banks have generally served South Korean corporations and nationals. In addition, due to the strictly regulated loan-deposit rate (must not exceed 75%) and increasing bad debts in the wake of the global financial crisis, South Korean banks have seen their profits shrink in recent years.

In June 2010, South Korean financial industry has firstly become a strategic institutional investor, by purchasing the shares of Chinese banks. It was the Hana Bank that became involved in Jilin bank's equity participation, purchasing 1.2 billion shares ($316 million, 18% of the total share), at a price of $1.80 per share. [3] It represents a beginning of radical equity cooperation for two nations' financial institutions. As a strategic investor of Jilin Bank, Hana Bank could participate in its management and operation. Jilin bank could take advantages of Hana's experiences in such areas as credit risk management and IT technology, while enabling Hana Bank to establish a financial basis in Jilin province as well as the entire Northeast region in China. Two banks could share resources with each other and grow together.

As for the Korean insurance and securities industry, they have recently entered China in a way similar to the banking sector. In 2001, the first insurance firm in China's market, Samsung Marine Insurance Company, opened its Shanghai branch and engaged in fire insurance business in the region. On June 23 2005, it was converted to legal person institution as "Samsung Fire and Marine Insurance (China) co., LTD.",[4] and expanded its business area across China. In the same year, Samsung Life Insurance Company and Air China set up a half-half joint venture

3) http://news.hexun.com/2010-09-07/124827253.html.

4) In 2008, Samsung fire Marine insurance (China) co., LTD was renamed as Samsung property insurance (China) co., LTD.

"Zhonghang-Samsung life insurance company", in which Samsung had the right of operation. [5]Also, Hyundai Marine insurance company set up a Hyundai property insurance company in China in 2007, and signed a business cooperation agreement with China Ping An property insurance.

Recently, China's insurance industry has grown at an average annual rate of 25% since 2000 and became the world's sixth largest market in 2011. Thus, China's insurance industry has great potential for growth. However, the South Korean insurance companies that entered the Chinese market have little market share and most of their business is limited to South Korean companies and South Korean residents in Beijing, Shanghai, and Tianjin.

As for the security institutions, they have just opened 12 offices as they ventured into China's securities market, which could hardly suffice to capture a significant slice of the fast-growing securities industry in China (Table 2).

As a whole, South Korean financial institutions in China could be divided into three types: local subsidiaries (the most formal type with huge investment funds), branch offices and liaison offices. By November 2012, there were six banks and four insurance companies in the form of local subsidiaries (Table 2).

Table 2. South Korean financial institutions in China

Type	Local subsidiary	Branch office	Liaison office	Total
Bank	6	68(6)	5	79
Securities	-	-	12	12
Insurance	4(1)	10(4)	12	26
Total	10(1)	78(10)	29	117

Note: Based on data available at the end of Nov. 2012; () indicates applications for establishment in progress.
Source: Lim Ho-yeol (2012).

5) http://money.163.com/10/0423/18/64VMF1SM0025335M.html.

On the other hand, since the 1990s, the four main state-owned banks of China-Industrial and Commercial Bank of China (ICBC), China Construction Bank (CCB), Bank of China (BOC) and Bank of Communications (BC)-have opened branch offices in South Korea primarily serving Chinese clients. And the branch office of the Agricultural Bank of China (ABC) opened in Seoul in Feb.2012.

Actually, as Chinese companies in South Korea are concentrated in the service industry, the scale of companies is generally small and their financing demands are not large enough to feed the China's banking branches. To expand their market share in Korea, Chinese banks have started to diversify their customers and business activities. Taking ICBC for example, there were four branches in South Korea by 2012. The branch in Seoul has reached out to their local customers, including top conglomerates in South Korea and top500 enterprises in the world. In 2002, it played an important role in assisting BOE's (a Chinese enterprise) takeover of the Hydis panel factory that was affiliated to Hyundai.[6)]

2.2. The correlation and integration of the capital market

Based on the average daily index from June 2012 to July 2013, it can be found that since March 2013, the South Korean composite stock index (KOSPI) has been synchronized with the Shanghai stock composite index (Figure 2). According to statistical results of the South Korean financial investment industry, in June 2013, the correlation coefficient of two indexes rose to 0.4 for the first time in 2013, suggesting a "significant" association. They were also associated with exit strategies of QE policy in the United States, and the recent crash in China's stock market had a huge impact on South Korean stock market this June.

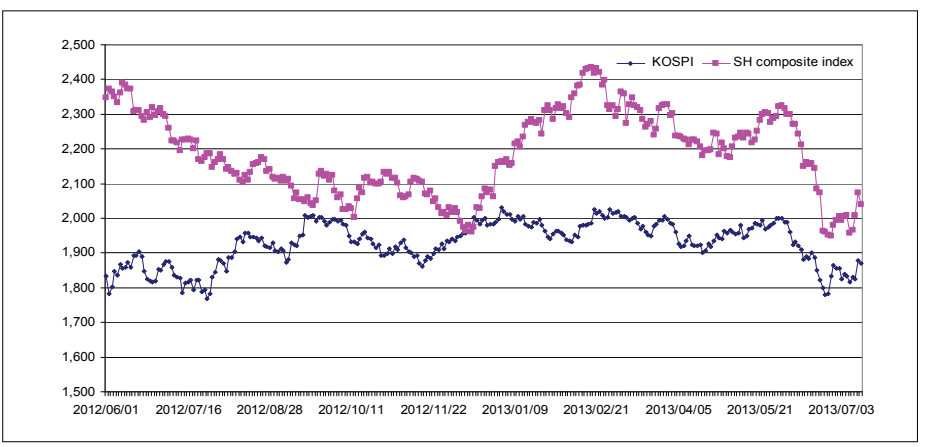
Nowadays, China has become the largest exporter for South Korea. Due to the high external dependency of the South Korean economy, it could be predicted that the degree of correlation the two indexes will be further enhanced for the

6) http://finance.people.com.cn/GB/70392/11027841.html.

foreseeable future and the U.S. impact on South Korea's index might decrease slightly. The "China concept" stocks in the South Korean market have attracted attention from investors. For example, after the financial crisis in 2008, as the Chinese government launched a 4 trillion-yuan economic stimulus package, the share price of some relevant South Korean companies increased immediately. In addition, due to the high reliance of South Korea's exports on China, China's purchasing managers' index (PMI) recently has had influence on South Korea's stock market. The factors above in all laid a more solid foundation of cooperation for two countries in capital markets.

In fact, South Korean has closer financial linkages with the United States and other industrial countries than with China, although the trend measured by either asset-return correlation or cross border financial holding has changed since the Great Recession in 2007. According to the IMF's data, South Korea's overseas securities investment has been in a state of rapid growth. It increased from US $13.5billion in1997 to the peak of US $158.6 billion in 2007, and at the end of 2011 remained at the level of US $103 billion. In terms of investment areas,

Figure 2. 2012/6/1-2013/7/12 KOSPI and Shanghai composite index (Daily)



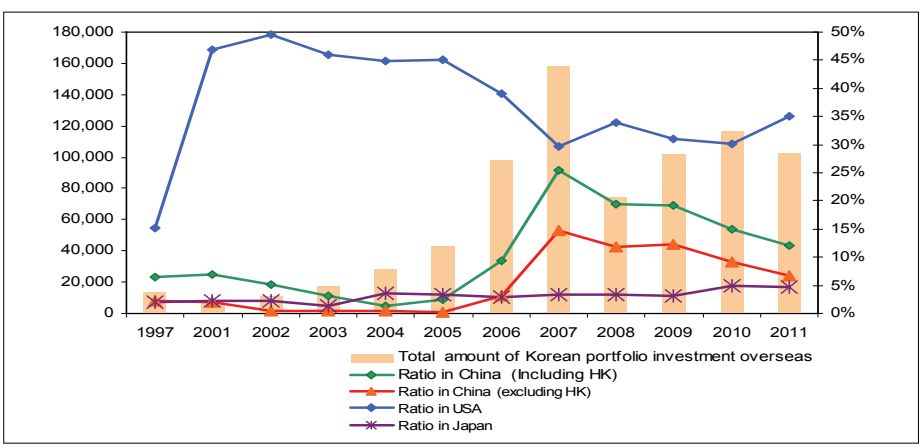
Source: CEIC Statistics.

its investment in United States generally accounts for 30-50%, much higher than the ratio for China (less than 5% before the year of 2006). Despite the increase of Korean investment in mainland China to 15% in 2007, but after the financial crisis in 2008, it was gradually receded back to below 7% in 2011 although the total investment was rising again (Figure 3).

In terms of the volume and structure of portfolio investment in mainland China, it is generally seen that the investment amount of Korean investment in China has been growing fast, increasing from $42 million in 2002 to $6.894 billion in 2011, by more than one hundred times. However, compared with Japan and the US, the amount for South Korea remains low, both in equity and debt investments.

One notable fact is that, for three countries above, compared to debt investment, their equity investment accounts for the vast majority. Moreover, the percentage of long-term bonds is far higher than short-term bonds. In South Korea's case, from 2006 to 2011, the proportion of equity investment was maintained between 93-98% of the total investment, whereas the debt investment was usually less than 5%. By the end of 2011, the amount of Korean debt investment in China was

Figure 3. South Korean overseas portfolio investment



Source: Reported Portfolio Investment Assets by Economy of Nonresident Issuer, IMF, 2013 http://cpis.imf.org/.

only US $232 million, half of that of Japan and 1/10 of the United States, respectively. And the short-term bonds investment only accounted for 1% in the debt investment in most available years.

Since China adopted the strategy of "going out" in 2000, China's overseas portfolio investments have also been rising year by year. However, China's investment in South Korea totaled KRW 4.6 trillion at the end of October 2012, accounting for only 1% of the total foreign investment in South Korea. China's investment in South Korea is relatively small compared to its trade volume with South Korea. The reasons were not difficult to find.

Table 3. Portfolio Investment in Mainland of China (South Korea, Japan and US)

(US $, Millions)

	1997	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
South Korea in total	295	157	42	72	122	101	3,086	23,268	8,923	12,576	10,806	6,894
Equity Securities	7	15	4	34	53	15	2,888	23,066	8,770	12,428	10,639	6,662
Debt Securities	288	142	38	38	69	86	198	202	153	148	167	232
Long Term Debt	278	118	38	38	69	86	198	202	146	141	146	218
Short Term Debt	10	24	...	0	...	...	0	0	8	7	21	14
Japan in total	4,492	1,669	1,458	2,518	4,723	4,074	10,267	15,501	5,994	13,122	13,975	10,650
Equity Securities	335	789	880	2,094	4,195	3,650	9,853	15,043	5,499	12,600	13,481	10,113
Debt Securities	4,157	880	578	423	529	425	414	458	496	521	494	537
Long Term Debt	4,157	880	578	422	529	425	414	458	496	521	494	516
Short Term Debt	0	0	0	1	0	0	0	0	0	0	0	22
U.S. in total	5,394	3,004	4,963	13,738	12,723	28,443	75,314	97,240	54,902	102,303	102,226	76,799
Equity Securities	2,255	2,370	3,948	13,064	11,645	26,888	73,912	95,658	53,269	101,616	100,624	74,727
Debt Securities	3,139	634	1,015	674	1,077	1,555	1,402	1,582	1,633	687	1,602	2,072
Long Term Debt	3,139	634	651	667	1,065	1,544	1,305	1,457	1,606	670	1,572	1,949
Short Term Debt	0	0	364	7	12	11	97	125	27	17	30	123

Note: (...) Indicates data are unavailable
Source: Coordinated Portfolio Investment Survey (CPIS), IMF, http://cpis.imf.org/.

On one hand, in order to strengthen resource allocation functions and strengthen the connection with international capital markets, the South Korean government introduced the capital market internationalization plan in 1981. After the 1990s, the South Korean capital markets headed completely towards liberalization and internationalization. Foreign companies and investors can usually enjoy complete national treatment, making the most to attract foreign capital. Currently, the foreign investors have outnumbered domestic individual investors and institutional investors, as the first major player in the market, with a market share increase from 3% in 1999 to 38% in 2012. Particularly in some representative South Korean enterprises, like Samsung Electronics and POSCO, the share of foreign investors have already reached 50%.[7)]

On the other hand, China started its overseas securities investment relatively late. Similar to South Korea and other East Asian countries, China has large-scale investment in the securities market in the United States and other western countries. It cannot be ignored that China has become the largest creditor for the US. China has recently became the top foreign holder of US treasury bonds, with holdings of 1.3159 trillion dollars bonds as of May 2013. As a result, the roportion of Chinese securities investment in South Korea is almost negligible.[8)]

Nonetheless, with the help of intergovernmental cooperation, South Korea, China and Japan agreed to boost cross-border investment in government bonds in May 2012. Only three years after entering South Korea's bond market, China has become the third largest holder of South Korean bonds. Holdings of South Korean bonds in China's central bank amounted to KRW 10.9 trillion at the end of October 2012 (12% of total investment) (Lim Ho-yeol, 2012).

Indeed, the case is not limited to South Korea and China. Asia's financial sector has been growing steadily and has become more resilient than before. But judging by the volume of cross border holdings of assets, it is still far from full

7) KSE, Statistics.

8) http://www.treasury.gov/Pages/default.aspx.

financial integration. Why is there a lack of regional bias? What is the most critical criteria regional investors use in their investment decision? A number of studies tried to analyze the intraregional flows of financial assets. Kim, Lee, and Shin (2006) assessed the East Asian financial integration by linking it with the degree of risk sharing, attempting to find the explanations as to why the region's level of integration is low. Borensztein and Loungani (2011) looked at the cross-country dispersion in equity returns and interest rates in Asia to evaluate the degree of financial integration in the region. That the integration of the bond market is lagging behind equity market seems to be a "normal" pattern as it also happens in other emerging economies (Adarov & Tchaidze, 2011)

All of these studies suggest that the cross border holding of financial assets in Asia is indeed low, albeit increasing in some cases. Results of the econometric study point to financial market and economic size, market liquidity and stability, and financial openness as important determinants of investment decision. (See Azis, 2012) To be specific, compared to the Asian market, the U.S. financial market so far has had the greatest appeal to investors.

First, the US dollar is the key currency in the world, so investing in the U.S. dollar back towards the American market is considered more normal. Also, U.S. has a most advanced financial market with a highest degree of liquidity in the whole world. However, in Asia, many developing countries, like China, have financial markets with a short history as well as strict capital control. Furthermore, as the U.S. is the biggest economy and has the strongest national defense capabilities, the outlooks for its government bonds are considered stable with low risk. Hence, U.S treasury bonds are regarded as the most safety investment choice for most foreign investors, including China and South Korea.

As a whole, the cross border holding of financial assets in Asia is indeed low, lagging behind trade integration.

2.3. The openness to each other's capital market

As mentioned above, since the 1990s, the South Korean capital markets has been completely opened to the world, allowing foreign companies listed in the stock market in South Korea and South Korean companies to list abroad. Yet, even in such circumstances, the openness of the capital markets between China and South Korea, especially the stock market, is still in its infancy. In March 2003 the KSE signed the memorandum of cooperation, with Shanghai and Shenzhen stock exchange respectively. The main contents of the MOU include: the mechanism of high-level visits, platforms for sharing information, personnel training and academic exchange activities.

Since 2007, there are 12 Chinese companies listed in Korea, with 3 listed in the Korea stock exchange market and 9 listed in KOSDAQ, accounting for 80% of the numbers of all foreign companies. Among them, most companies belong to traditional manufacturing and textile industry from China's eastern region, with 6 companies from Fujian province and 3 from Jiangsu province (Table 4).

However, various financial problems have been revealed in some of the listed enterprises, thus slowing down the pace of listing of new Chinese enterprises in South Korea. For example, in March 2011, China high-fiber (중국고섬) has been suspended but two months after it was listed due to financial problems. As a result, it caused negative repercussions for the market, especially led to great loss for individual investors. Since then, the South Korea's financial authority has greatly strengthened listing standards for foreign companies with stricter conditions. As a result, no more Chinese companies were listed in South Korea since then.

On the other hand, China's capital market is under tight control for an extended period, with restrictions on the movement of assets in and out of the country. Only prestigious foreign companies and red chips (mainland Chinese companies incorporated internationally and listed on the Hong Kong Stock Exchange) are allowed to have an IPO in China's stock market. Recently, to make China's capital market more competitive, the Shanghai Stock Exchange is in the process of launching

an international board for foreign company listing. Although the Chinese government has promised a speedy launch several times in the past, the establishment of the international board has been delayed for legislative, accounting and supervisory reasons.

In addition, China's stock market had previously been closed off to foreign investors. Since a decade ago, China has tried to permit capital flow under control.

Table 4. China's listed companies in South Korea

	Company listed (South Korean)	Method	Region in China	Industry	Time of Listing	underwriter
Korean Stock Exchange Market	華豐集團 화풍집단	DR	Fujian	textile	2007.11.26	대우증권
	中國遠洋資源 중국원양자원	IPO	Fujian	pelagic fishery	2009.05.22	현대증권
	中國高纖 중국고섬	DR	Jiangsu	textile	2011.01.25	대우증권
KOSDAQ	中國食品包裝 중국식품포장	IPO	Hebei	food packaging	2009.03.27	신한증권
	鴻興沃登卡 차이나그레이트	IPO	Fujian	Sports shoes	2009.05.29	NH투자증권
	中國動力 중국엔진집단	IPO	Fujian	machinery	2009.12.04	신한증권
	首爾金屬 글로벌에스엠	IPO	Guangdong	precision-parts	2009.12.23	미래에셋
	中國浩然 차이나하오란	IPO	Jiangsu	papermaking	2010.02.05	신한증권
	金山大道 차이나킹	IPO	Fujian	healthcare products	2010.03.31	우리투자
	東亞體育 이스트아시아	IPO	Fujian	Sports shoes	2010.04.23	교보증권
	亞特電器 웨이포트	IPO	Zhejiang	Power tools	2010.07.23	메리츠증권
	萬利國際 완리국제	IPO	Jiangsu	tiles	2011.06.13	삼성증권

Source: South Korean Stock Exchange.

The Qualified Foreign Institutional Investor (QFII; 合格境外機構投資者) is a program that was launched in 2002 in China to allow licensed foreign investors to buy and sell yuan-denominated "A" shares in China's mainland stock exchanges (in Shanghai and Shenzhen). According to "Regulations on Domestic Securities Investment by Qualified Foreign Institutional Investor", to qualify as a QFII, the candidates must:

- have stable finances, good credibility, meet the minimum asset scale set by China Securities Regulatory Commission (CSRC);
- have sufficient staff to meet the requirement set by the authority in its own country or area;
- have a healthy governing structure and complete internal control system, and no record of significant legal sanction or punishment in the last 3 years;
- be from a home country with a complete legal and supervision system, and its home country or home area has signed Memorandum of Understanding (MOU) with CSRC, and maintains effective supervision cooperation;
- Other requirements set by CSRC based on prudence.

By June 23rd 2013, as a whole, 207 licensed QFII investors were granted a combined quota of $43.463 billion to invest in China's capital markets under the QFII program. 18 South Korean financial institutions have already been approved with a quota of $2.978 billion, holding 6.9% of the total amount. Samsung Investment Trust Management has the largest portion of the approved quota ($45million) in the South Korean QFII list, as the top 5 in all the QFII. It should be noted that the Bank of South Korea has become the first QFII as a foreign central bank. (Table 5)

Up to date, the QFII has entered China's capital market for more than a decade. According to the data of China's state administration of foreign exchange, since 2003, 121.3 billion yuan in net capital flowed into China, reaching 265.6 billion yuan by 2012 in QFII account total assets. The total profit is 144.3 billion yuan, close to 120% of the overall rate of return, which significantly outperformed the Shanghai composite index during the same period. QFII companies' surprisingly

good performance was mainly due to their investment strategy in the past ten years, which allowed them to reap the dividends of China's economic growth miracle.[9)]

As RMB was not fully convertible and capital account has not been open,

Table 5. the list of South Korean QFII with its quota approved by China

(Unit: US $ Millions)

No.	Institution	Custody Banks	Cumulative approved amount	Qualification approved date
1	Samsung Investment Trust Management Co., Ltd.	BOC	450	8/25/2008
2	South Korea Investment Corporation	HSBC	400	12/28/2011
3	Mirae Asset Global Investments Co., Ltd.	ICBC	350	7/25/2008
4	The Bank of Korea	HSBC	300	12/21/2011
5	Hanwha Investment Trust Management Co., Ltd.	CITI BANK	238	2/5/2009
6	South Korea Investment Trust Management Co., Ltd	ICBC	200	7/21/2009
7	KB Asset Management Co., Ltd.	CITI BANK	200	8/9/2010
8	The South Korea Development Bank	CCB	150	4/23/2009
9	KTB Asset Management Co.,Ltd	CCB	100	12/28/2010
10	HI Asset Management Co., Limited.	ICBC	100	12/31/2011
11	Shinhan BNP Paribas Asset Management Co., Ltd.	HSBC	100	1/5/2012
12	National Pension Service	CITI BANK	100	1/5/2012
13	Hana Daetoo Securities Co,Ltd	CITI BANK	100	3/29/2012
14	Tongyang Asset Management Corp.	CITI BANK	70	12/11/2009
15	Dongbu Asset Management Co.,Ltd.	CCB	70	4/20/2012
16	Woori Bank Co., Ltd	ICBC	50	5/4/2009
17	Prudential Asset Management Co.,Ltd.	CCB	0*	4/7/2008
18	Hyundai Securities Co., Ltd	CCB	n.a**	3/22/2013
	Total Amount		2978	

Note: * Its approved amount was given as 75 million US dollar in 2008, but was canceled in 2012.
**The most recently-approved institution; has yet to receive the approved amount by CSRC yet.
Source: China Securities Regulatory Commission (CSRC); State Administration of Foreign Exchange (SAFE).

9) http://finance.sina.com.cn/stock/zldx/20130709/032116055704.shtml.

QFII has brought the advanced investment philosophies to China, and has gradually begun to affect Chinese investors' investment strategy. More importantly, it has played an important role in promoting China's capital market towards a more open and healthier market.

On the other hand, Qualified Domestic Institutional Investor (合格境內機構投資者), also known as QDII, is a scheme in created 2007 to allow China's financial institutions to invest in financial products overseas, with measures to ease pressure on yuan appreciation. Similar to QFII, it is a transitional arrangement which provides limited opportunities for domestic investors to access foreign markets. Up to date, the net value of a QDII product investing in overseas stocks must not exceed 50%.

QDII entry into the South Korean security market was approved by Chinese Banking Regulation Commission (CBRC) in June2008. Since then, South Korea has become the seventh QDII destination market for investment, after the United States, Japan, Britain, Australia, Singapore and Hong Kong. By the third quarter of 2012, QDII funds investing were given a priority in the United States market with 39 QDII funds, with 37 funds in Hong Kong and 19 in the UK. And QDII has set up 10 funds in South Korea, the same as in Singapore and Thailand.[10)]

III. Financial Cooperation Based on RMB Internationalization

3.1. Cross trade settlement by RMB

As a measure indispensable for promoting the internationalization of the RMB, China began to promote the yuan as a "settlement currency" in international trade since 2009. Nowadays, RMB settlement in current account has been fully open to all enterprises in China engaged in import and export of goods and services

10) http://funds.hexun.com/2012-10-31/147456827.html.

that could choose to bargain, invoice and settle in RMB. In 2011, China formally allowed the use of the yuan to settle Chinese outbound direct investment (ODI) and foreign direct investment (FDI) in China. Currently, cross-border trade RMB settlement business has mainly taken place in Asian countries and regions that have close economic linkage with China, and some of the European and American enterprises are also increasingly tending toward RMB settlement. Latest data released by the PBOC shows that in 2012 the cumulative amount of RMB settlement business in China's cross-border trade was 2.94 trillion yuan (trade in goods was 2.06 trillion), increasing by 41.4% over the past year, while foreign direct investment was 251 billion yuan RMB.[11)]

In the case of China and South Korea, 95% of bilateral trade is valued and cleared in U.S. dollars. Despite close economic links, trade settlement in yuan or won is limited by the partial internationalization of both currencies. Take Shandong province for example, Shandong is a key area in the China-South Korea economic and trade cooperation. In 2012, however, in Shandong, the cross-border RMB settlement amount was 3.1 billion yuan with South Korea, accounting for only 1.28% of the total trade volume of 39.54 billion US dollars.[12)]

The reasons for the local currency settlement lagging far behind are as follows: firstly, the currency exchange between KRW and RMB is costly, 2% higher than won against the US dollar; second, the lack of effective hedging tools against RMB exchange rate risk leads to a low degree of liquidity of yuan, and a small trading volume in the market; third, due to the strict investment constraints of RMB, there is little demand for South Korean enterprises and investors to hold a low-yielding asset.

As part of its efforts to internationalize the yuan, China is in the process of expanding cross-border trade settlement in the yuan. As mentioned above, two countries have opened an account in each other's central bank with deposits in

11) The People's bank of China, statistics, http://www.pbc.gov.cn/.
12) http://qingdao.customs.gov.cn/publish/portal105/tab1626/info413714.htm.

its own currency, which has established a good foundation for local currency settlement. Through an agreement with the People's Bank of China, the Bank of Korea introduced the South Korea-China Currency Swap-Financed Trade Settlement Facility in December 2012, aiming to utilize a portion of the won/yuan currency swap proceeds for bilateral trade settlement. Under this scheme, South Korean firms are able to use yuan currency swap funds provided by the Bank of South Korea for their yuan payments in trade settlements with China, while Chinese firms may use won currency swap proceeds provided by the PBOC for their won payments in trade settlements with South Korea.

In order to enhance the convenience of the use of this facility, the Bank of Korea accepts yuan loan applications from domestic banks at any time and allows early redemption according to domestic firms' actual period of trade settlement. Table 6 shows the eligible transactions and institutions for currency swap-financed

Table 6. Summary of South Korea-China currency swap-financed trade settlement facility

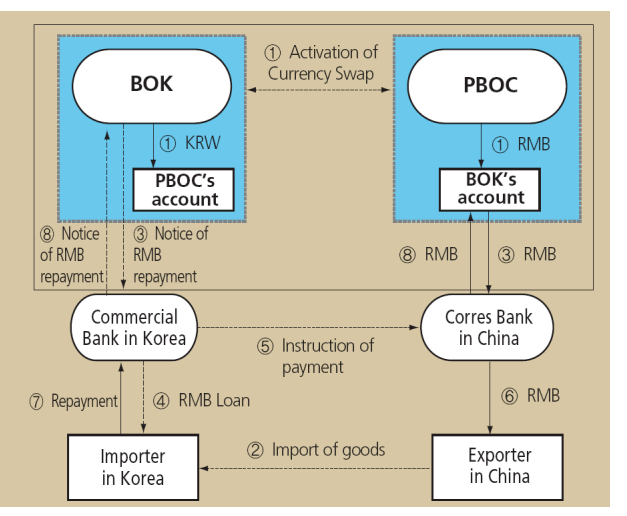
Eligible transactions for Loans	Transactions in which eligible institutions advance RMB export proceeds to exporters in South Korea, or provide importers in South Korea with term loans for payment for imports
Institutions eligible for Loans	Banks as defined by the Banking Act-including foreign bank branches, foreign-affiliated domestic loans banks and the credit business division of the National Federation of Fisheries Cooperatives, South Korea Development Bank, Industrial Bank of South Korea.
Loan amount	The amounts are those applied for by the eligible institutions, but the BOK can decide their minimum
Loan period	Either three or six months, but early redemption is allowed at the request of the eligible institution.
Loan interest rate	SHIBOR, the Shanghai Interbank Offered Rate
Collateral	Eligible institutions are to provide the BOK with collateral corresponding to 110% of the KRW-translated values of their RMB loans.
Repayment	The eligible institution repays the loan principal plus interest in RMB to the BOK on the maturity date.

Source: The annual report of 2012, the Bank of Korea, p. 93.

trade settlement facility. The loan interest rate is SHIBOR, the Shanghai Interbank Offered Rate, and the loan period is either three or six months.

Through the introduction of this scheme, enterprises in both countries can have access a more stable supply of won/yuan and are expected to reduce their foreign exchange risks and transaction costs associated with trade settlement (Figure 4). At the national level, the system is beneficial in terms of the further promotion of bilateral trade, the alleviation of external vulnerabilities due to reduced dollar dependence and the development of international use of both countries' currencies. Furthermore, the promotion of the use of won/yuan in trade settlement will lead to greater financial integration between the two countries and the South Korea-China currency swap arrangement will become naturally become permanent in fact

Figure 4. Illustration of the South Korea-China currency swap-financed trade settlement facility (From perspective of importers in South Korea)



Source: The annual report of 2012, the Bank of Korea, p. 92.

3.2. Offshore RMB bond market in Hong Kong

The offshore RMB bond is also playing an important role in RMB internationalization, which are issued outside of China but denominated in Chinese RMB, rather than the local currency. In Hong Kong, it is called a Dim sum bond, which is derived from a popular Chinese dish that involves serving a variety of small delicacies.

Until July 2010, only Chinese and Hong Kong banks could issue RMB-denominated bonds. The tendency of deregulation has led to the development of an offshore market in RMB and the internationalization of dim sum bonds. Along with the appreciation of the RMB and its advancement of internationalization, the size of dim sum bond market continues to expand, and the number of issuers from South Korea is growing (Table 7). There are three banks, including Export-import Bank of South Korea, South Korea Development Bank and Shinhan Bank, and one enterprise - Lotte Shopping. It entered the dim sum bond market on February 3, 2012, as the first consumer company issuer from South Korea. When it raised 750 million yuan ($119 million), with its three-year coupon rate at 4.0%, Moody gave this bond a 3A rating, with a stable outlook. Lotte said its issuance proceeds would be used for general corporate purposes.[13)]

Table 7. South Korean issuers in Hong Kong bond market

Issuance Date	Issuer	Amount (million yuan)	Coupon (%)	Maturity (year)
2011.9	KOREA DEV BANK	121	1.35	1
2011.10	EXPORT-IMPORT BANK OF KOREA	160	2.2	1
2011.11	EXPORT-IMPORT BANK OF KOREA	400	2	1
2012.2	LOTTE SHOPPING BUSINESS MANAGEMENT (HONG KONG) LTD	750	4	3
2012.2	SHINHAN BANK	625	3.5	2
2012.6	KOREA DEVELOPMENT BANK	160	3.30	3

Source: List of CMUS Instruments, the Hong Kong Monetary Authority (HKMA).

13) http://cn.reuters.com/article/hkBizNews/idCNSB136766020120203.

Theoretically, all enterprises, financial institutions, international organizations and sovereign governments in the world are able to issue RMB bonds in Hong Kong. For foreign enterprises and institutions, including South Korean, issuing offshore yuan bonds (dim sum bonds) in Hong Kong has the following benefits:

First, the cost of issuing dim sum bonds is advantageous; with an interest rate 1-2% lower than the cost of financing in mainland China. It is mainly because that there are large amount of RMB deposits that Hong Kong accumulated over the years, and few investment channels for holders of RMB waiting for its appreciation.

Second, the dim sum bond is not subject to any restrictions, no matter for issuers or pricing. Under permission given by China's regulator, the fund could be appropriated into mainland China, rather than leave money idle outside China's market.

Third, it could automatically hedge the currency exposure of assets and liabilities for local subsidiaries in China. That is to say, the parent company could use the principal of the bonds to invest in yuan instead of US dollars. In this way, regardless of the exchange rate of yuan against the dollar, the assets and liabilities of the local subsidiaries could remain unaffected and the companies are able to concentrate more on business operations.

However, for dim sum bond issuers, it is currently not easy to send RMB fund back directly to mainland China. There are only two methods: one is through the cross-border trade, settlement in RMB with qualified pilot export enterprises in China; the other one is to exchange RMB principal into US dollars, then through FDI investing to the local enterprises by capital injection or shareholders' loans.

IV. Prospects of Cooperation in Finance

South Korea should strengthen its financial cooperation with China, as their real economies are growing more and more intertwined. In the future, the two countries could improve cooperation in various fields.

4.1. New opportunities for localization of South Korean banks in China

If South Korean banks are to localize successfully, they should actively pursue various measures including:

- Merger and acquisition of local small- and medium-sized banks:
  Since 2006, foreign banks were permitted to open "village banks" (村鎮銀行), by purchasing China's rural credit cooperatives and rural commercial banks. Presently, 16 village banks have been set up by HSBC and 54 joint funded village banks opened by Bank of China and Temasek (Singapore's sovereign-wealth fund). South Korean banks could consider seeking new opportunities in rural areas in response to the urbanization policy in China.
- Equity investment and business alliances with commercial banks in urban and rural areas:
  South Korean banks could invest in the equity of China's local commercial banks. Just as Hana Bank has become a strategic investor in Jilin bank, other Korean banks could consider the similar measures to share management skills, customer resources and market shares in China.
- Expansion of business networks to central and western China and expansion of the private banking service and credit card business operation in response to income growth in China.

4.2. Potential markets created by deregulation in China' financial industry

China's financial market has recently been opening up faster than at any other time in the past. The trend of deregulation in China's financial industry is obvious.

As for the banking industry, interest rate liberalization and reform has been making steady progress and China's banking industry will take this opportunity to break the original market structure and profit model. Up to July 20 2013, the lower bound of lending rates has been relieved. [14]In the future, it will be seen that the saving rate would gradually diminish, eventually the traditional profit model

led by the high spreads income will come to an end. By then, the big banks' absolute advantage in terms of customers and the market will no longer exist. The banking industry in China will gradually enter into a fairer and healthier environment, which could benefit all foreign banks including Korean banks. So Korean banks should aim to compete on service quality rather than background and resources. Korean banks should develop its advantages in risk management, internet financial technology, and personal bank services, etc.

Meanwhile, China's insurance industry has a high growth rate but a low level of market penetration. With China's economic development and the enhancement of the residents' awareness of insurance, the outlook of the insurance industry is immensely positive. For example, China opened compulsory traffic accident insurance to foreign insurers in May 2012.[15] At present, the number of cars in South Korean is approximately 19 million, an average of one car for 2.7 people, and its automobile market has long been saturated. Considering that China has a population of 1.3 billion and but only about 100 million cars, China's auto insurance market has huge potential. South Korean insurance giants could make efforts to seize market opportunities by taking advantage of their expertise in auto insurance.

China also has accelerated the deregulation of securities firms jointly owned by domestic and foreign investors. Up to date, South Korea has not radically entered China's securities industry yet, with only a few overseas branches. Under such circumstances, South Korean securities firms should immediately devise measures to gain "first-mover advantage" and capture a larger share of the Chinese markets.

4.3. Lubricating the capital flow into each other

In terms of capital flow between two countries, there is still much more room for progress. First, it is necessary to help Chinese enterprises restart their listing

14) http://money.163.com/special/view389/.

15) http://finance.ifeng.com/money/insurance/hydt/20121212/7421803.shtml.

plans in South Korea. Actually, the advantages for Chinese firms of listing in South Korea still exist:

- China and South Korea have similar industrial structures, with a high proportion of manufacturing;
- The key industries for investment in South Korea include semiconductor, electronic communication, shipbuilding, automobile, steel, chemical industry, etc., therefore Chinese companies in these industries are more appropriate in terms of entering South Korea.
- Compared with Hong Kong and Singapore, the Korean market is more liquid, the IPO price is higher and the procedure of listing is simpler.
  However, the financial problems in some previously listed firms have undermined the credit of Chinese enterprises; there are several Chinese companies have recently postponed or abandoned listing plan in South Korea.
  Under such circumstances, it is imperative that both sides join their efforts. Chinese companies need to be more fully prepared for overseas listing, e.g. establish better communications with South Korean brokers, provide reliable information and listing plans and follow the regulations in South Korean listing system. Meanwhile, to rebuild the enterprise image, the trust of public is a great challenge for Chinese companies.

Also, the brokers in South Korea should fully convey the information on regulations to Chinese enterprises and reduce the degree of information asymmetry. They need to give appropriate recommendations with the analysis regarding feasibility and existing problems, based on conditions of each specific enterprise.

Also, both of two sides should make good use of increasingly deregulated QFII and QDII scheme. Indeed, China's capital market is opening relatively slowly, given that QFII investment only accounts for 1.6% of the country's stock market. However, regulations of QFII are increasingly relaxed: not only the scope has been widened but also the approval procedures simplified.

As for QDII, The China's securities regulator (China Securities Regulatory

Commission, CSRC) will lower the threshold for applicants and expand the scope of outbound securities investment as part of its efforts to expedite capital market reform. QDII investors will be allowed to invest in derivatives listed on foreign exchanges that have signed memorandums of understanding with CSRC, increasing the number of foreign investment outlets from the current approved list.

Therefore, South Korean institutional investors should make good use of these two schemes. On one hand, QFII from South Korea could seek more investment opportunities in China. As the Bank of Korea becomes a QFII investor, it helps to expand the diversity of South Korea's foreign exchange reserves, although current investment quota of BOK accounted for a rather paltry share of South Korean foreign exchange reserves. On the other hand, as an international and open capital market, South Korea should absorb more Chinese capital into South Korean stock and bond market to promote the recovery of the South Korean capital market.

4.4. Taking advantage of RMB internationalization

In order to strengthen the Regional Financial Safety Nets, South Korea and China should reduce their high dependence on the dollar by expanding trade settlement in their own currencies. Trade settlement in the local currency should be expanded simultaneously with the opening of the capital market and currency internationalization. The central banks of both countries have been active in collecting suggestions for improvement of facilities for supporting trade settlement. South Korea and China should bolster policy efforts to promote the use of their currencies in a settlement by establishing the necessary system and opening the won-yuan foreign exchange markets over the long term.

If RMB comes to the currency settlement, the Bank of Korea must raise the proportion of the yuan in foreign exchange reserves and reduce the proportion of the dollar. As China currently has the largest trade deficit vis-à-vis South Korea, it is convenient for South Korean export enterprises to receive and accumulate

RMB. But it also needs China to open its capital account to a higher degree with a free-flow RMB. In this way, the yuan might enhance its level of safety in the market. Meanwhile, it is essential for South Korean companies to consider how to deal with more volatility of RMB exchange rate and other challenges in the future, after increasing the proportion of the yuan in currency settlement and in foreign exchange reserves.

In addition to Hong Kong, there are other offshore RMB bond markets, not only in other Asian countries and region, like in Taipei since March 2013 (called as "Treasure island Bond") and in Singapore since May 2013, but also outside of Asia, like in London since April 2012. The internationalization of the offshore RMB bond markets is seen by economists as a key step in a policy initiated by China to facilitate greater use of the RMB for trade.

In Table 8, there are four Asian cities which might become the offshore RMB markets in the future. Hong Kong, as the premier offshore RMB business location

Table 8. Comparison on four Asian cities to be Offshore RMB markets

	Hong Kong	Singapore	Taipei	Seoul
Currency Swap Amount	40 billion Yuan	30billion Yuan	In Discussing	36billion Yuan
RMB Deposit	837 billion Yuan (up to 2013.4)	60 billion Yuan (up to 2012.6)	40.3 billion Yuan (up to 2013.3)	----
RMB offshore bond	HK Dim Sun Bond (Since 2007 issued by domestic and foreign institutions & firms)	Singapore Dim Sun Bond (since 2013.5, issued by HSBC & Standard Charted)	Treasure island Bond(寶島債) (since 2013.3, issues by China trust Commercial Bank & Deutsche Bank)	Gimchi bonds (not yet)
Competition Advantages	Pioneers; Geography; Political support	Golden Key to ASEAN; Asia's biggest financial derivatives and commodity market	Allowing their manufacturers to settle with RMB with mainland China; Substitute of Hong Kong	Swap amount as the second; close links in real economy

Source: HKMA and other pubic news and reports.

with an eight-year history, has great support from central government of China as well as the geographical and time zone advantages. Singapore is a key to helping RMB extend its range of usage in ASEAN countries; and Taipei has just allowed their manufacturers to settle with RMB with the mainland of China. These two cities have just begun to issue RMB bond this year in their own market.

As for South Korea, the size of its currency swap is now just behind Hong Kong, and there seems to be great potential to develop the RMB settlement and RMB bond insurance. If RMB bond could be issued in South Korea, called Gimchi RMB bonds, there undoubtedly will be many positive implications. First, Gimchi RMB bonds will provide more impetus to hold and invest the yuan for South Korean companies and investors, and thus increase the liquidity of RMB. It also will lay a broader market base for RMB settlement between two nations. In addition, South Korean enterprises could have more financing channels of yuan for investment in China. After all, it is known that the offshore RMB bond market remains in a nascent stage, with significant growth potential over the medium to long term.

V. Conclusions

1) China and South Korea have a very close relationship both in trade and investment. Over the past decade, bilateral trade had increased steadily. On the other hand, China and South Korea have limited contact and cooperation in in the realm of finance. The recent currency swap between the two central banks, laid a solid foundation for improving financial cooperation between two countries.
2) South Korean investment in China's financial industry grew rapidly, especially in banking and insurance industries. Due to policy limitations and financial market monopoly in China, services provided by South Korean banks were generally limited to South Korean corporations and nationals.
3) To succeed in localization, Korean banks should find new measures for cooperation.

Such as, opening "village banks" in rural areas is a new choice in response to urbanization policy in China. And becoming strategic investors by purchasing large amount of shares of China's small-to medium-banks.

4) Both South Korea and China have greatly increased their overseas securities investment. But both of them have closer financial linkages with the United States and other industrial countries than each other. And the integration of bond market lags far behind the equity market. However, South Korea, China and Japan agreed to boost cross-border investment in government bonds in 2012, thus have greatly improved official investment in each other's Treasury bond.
5) As South Korea has an internationalized capital market whereas China has not yet opened its capital account, the degree of openness of the respective capital markets to each other is still in its infancy. There have been several Chinese firms listed in the South Korean stock market, and many South Korean institutions have become QFII firms to invest in China's debt and stock market.
6) There is much more room for progress in capital flow. It is very urgent to help Chinese enterprises restart their listing plans in Korea. Both sides should make efforts in this regard. Also, we should make good use of QFII and QDII schemes to benefit investors from both sides.
7) RMB and KRW are seldom used in the trade and investment between China and South Korea. Instead, USD is used as an intermediate currency. Both countries are trying to expand the range of RMB or KRW as valuation and settlement currencies for trade and investment between them, which will reduce exchange rate risks for enterprises of both countries, and will be helpful in promoting bilateral trade and investment.
8) When promoting RMB internationalization, it is important to allow overseas investors to hold RMB assets. Meanwhile, the restriction on domestic investors holding overseas assets should be relaxed too. These changes will provide more opportunities for investors in official and private departments of China and South Korea.
9) RMB internationalization provides new financing opportunity for South Korean

enterprises for investment in China. Currently, Hong Kong offshore RMB bond (dim-sum bond) is gaining widespread popularity. The financing cost is quite advantageous. If the fund could be appropriated into mainland China, it could substitute domestic, high-cost RMB financing. In the future, we can envisage offshore RMB bonds issued in the South Korean market further benefitting South Korean investors as well as enterprises.

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4

China's Position on Economic Integration in Northeast Asia: Political Economy Perspective[1)]

You-il Lee[2)]

I. Introduction

One of the most striking features of today's global economic geography is the shift in countries' traditional policy from an orientation based on market-driven multilateralism to what we refer to as regional economic clustering or integration. Until the awakening of the People's Republic of China (hereafter China) as a global economic powerhouse in the early 21st century, global economic clustering or regional integration worldwide had been led and dominated by Europe (the European Union) and North America. Among the most noticeable features of the

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new global development is the stepping up of economic regionalism efforts towards integration and cooperation in Asia since the early 1990s, pioneered by the Association of Southeast Asian Nations (ASEAN) in 1992, when it initiated the ASEAN free trade agreement (FTA). By 2011, 93 FTAs involving Asian countries were in effect, up from 25 in 2000 (Kastner 2011). As of 2013, the World Trade Organization (WTO) had recorded 218 FTAs in the world and of these, 56 were FTAs wherein one of the signatories was an East Asian country (Choi 2013). In particular, it is noteworthy that the strong push towards economic integration in Northeast Asia[3] strengthened considerably in recent years. The launch of the CJK (China, Japan, Korea) FTA negotiations was announced at the CJK Economic and Trade Ministers' Meeting held in Phnom Penh, Cambodia on November 20, 2012. Negotiations between the three countries took over a decade to reach this stage. Subsequently, there have been two official FTA negotiations held in 2013 (March and August) and one to be held in December 2013. The most fundamental and obvious rationale behind this claim, despite the Sino-Japanese rivalry, differences in political systems, current territorial and historical disputes, and lack of shared community consciousness (Choi 2013:105), are the economic benefits from deepening regional economic interdependence in recent years. These include geographic and psychic (cultural) proximity, complementary endowments of production factors, and increasing economic ties. During 2012, China was the largest trading partner of Korea and Japan, and the two countries were regarded as the second largest trading partners of China. In 2012, Japan was Korea's second largest trading partner and Korea was Japan's third largest trading partner (Korean Ministry of Foreign Affairs and Trade 2013).

One particular feature to be noted is China's aggressive move towards the regional FTA formation. China has shown a keen interest in realising the CJK-FTA.

3) Though the precise area of Northeast Asia varies, it normally includes China, Japan, Korea, Mongolia and the eastern part of Russia. In terms of economic strength, China, Japan and Korea comprise the core of the region. As such, throughout this paper, Northeast Asia refers to China, Japan, and Korea.

In general, from China's perspective, a CJK-FTA would give China a foothold for further integration in Asia; free up production supply chains (concentration on manufacturing); offer enhanced economic security for the new Chinese leadership; enable China to expand the use of the Renminbi, so the country could internationalize this currency, reducing their reliance on the U.S. dollar; see more higher quality products exported to China; and offer improved market opportunities for both state-owned enterprises (SOEs) and private companies. Despite the significance of economic and political arrangements in Northeast Asia for new changes and advancement, much of the literature on FTAs seems to be within the field of economics focusing on the welfare implications of FTAs, both for members and the world as a whole (Choi 2013). This paper argues that, though Northeast Asian economic cooperation has only been achieved sporadically and its future remains uncertain (primarily due to the historical, cultural, political and economic characteristics of the region and strong resistance from interest groups in each nation), not only are there economic benefits to be gained from implementing the CJK-FTA, but there are also strong political and economic pressures and expectations motivating China to push for the CJK-FTA. In other words, resumption of the CJK-FTA is a response to the rapidly changing internal and external political-economic environment rather than a simple calculation based on economic optimality. This move towards regionalism presents a wide range of economic and political challenges and opportunities to its neighbouring countries.

It is not possible in this paper to assess comprehensively the diverse, complex and sensitive issues primarily related to the historical, cultural, political and economic characteristics of the region. This paper addresses a number of critical issues and challenges (socio-economic and political) for CJK-FTA, including how well it (CJK-FTA) will work; whether it can continue to work in the future; who benefits most among CJK from this new form of economic integration; what the major factors were that contributed to China's policy shift from multilateralism to bilateral/regional FTA negotiations in years; what the motivations are behind the China's recent speedup of CJK-FTA; and whether China's progressive approach

to the new Asian regionalism will reduce the influence of the U.S.'s preferred Asian regional architecture (Trans-Pacific Partnership Agreement (TPP)). The paper then examines China's attitude towards the proposed CJK-FTA, while the penultimate section analyses the policy implication for China and its political-economic impact on the member countries (Japan and Korea).

II. Northeast Asia and Regionalism

Regional institution-building or regional integration should be a part of regionalism, where collective decision-making is central in facilitating regional arrangements (Katana 2009). This paper adopts Lindberg's concept of 'integration,' which is 'the development of devices and processes for arriving at collective decisions by means other than autonomous action by national governments' (Lindberg 1963:5). In the case of economic integration, this can begin with a simple preferential trade area agreement (e.g. the development of free trade and factor mobility). As integration increases between states, their agreements may develop towards a common market and eventual complete economic and monetary union, such as in happening in various stages with the European Union, the North American Free Trade Agreement (NAFTA) and Andean Community and Mercosur (trading blocs of South America)[4].

4) An FTA is widely defined as an economic agreement between two countries or regional groupings to eliminate tariffs and other trade barriers. An FTA is a different level of trade agreement towards economic integration, which consists of four different stages of trade agreements among member states. The lowest level of integration is known as a *Preferential Trade Agreement* or *Preferential Trade Arrangement* (PTA), which allows member states to grant the other participants preferential access to select segments of their markets. The next level of integration is a *Free Trade Agreement (FTA)*. A FTA is a PTA in which member countries do not impose *any* trade barriers (zero tariffs) on goods produced within the union. However, each country keeps its own tariff barriers to trade with non-members. In the form of customs union (CU), barriers are not only eliminated, but a common external tariff is erected vis-à-vis third parties; then, a common market adds more criteria to a CU, such as implementing similar product regulations and permitting the free flow of factors of production between member countries.

In the case of political integration, this may involve a process 'whereby nations forgo the desire and ability to conduct foreign and key domestic policies independently of each other, seeking instead to make joint decisions or to delegate the decision-making process to new central organs' (Lindberg 1963: 6). Put simply, economic and political cooperation are necessary for integration to continue to deepen. As integration goes beyond trade, it will result in the formation of regional institutions, increased interaction between both states and societies, and a mutual desire for security. These new steps towards deepening regional cooperation do not mean there were

Table 1. Northeast Asia: Intra-regional Trade 1990-1999

(Unit: US$ billion)

	1990	1995	1999
Intra-regional 2-Way Trade:			
Korea-Japan	29.2	48.2	38.8
Japan-China	18.1	58.0	66.1
China-Korea	2.8	16.5	22.6
Total, NE Asia	50.1	112.7	127.5
Total Exports			
Korea	65.0	125.1	144.7
Japan	287.6	443.1	419.4
China	62.1	148.8	195.1
Total, NE Asia	414.7	717.0	759.2
Total Trade:			
Korea	134.8	260.2	264.5
Japan	523.0	779.0	730.7
China	115.4	280.9	360.9
Intra-regional Trade/ Total Exports	12.1%	15.7%	16.8%

Source: Schott and Goodrich 2001.

Most of the regional trade agreements that Asian countries, including China, Japan, and Korea (CJK), have established can be considered FTAs.

no previous market-based regional cooperative or rationalization[5] efforts attempted among the members of Northeast Asia.

Tables 1 and Tables 2 provide data on intra-regional trade in Northeast Asia over the 1990s. The share of intra-regional trade among the three countries has increased steadily: from 12.3% in 1990 to 19.0% in 1996, just prior to the Asian financial crisis of 1997. The outbreak of the 1997 Asian financial crisis, the expansion of the EU into central and eastern Europe, and the success of NAFTA have created much interest in regional economic and monetary cooperation in East Asia (Aminian 2005; Kawai and Wignaraja 2010). During 2010, China was the largest trading partner of Korea and Japan, and the two countries were the second largest trading partners of China. In the same year, Japan was Korea's second largest trading partner and Korea was Japan's third largest trading partner (see also Table 3).

Table 2. Northeast Asia: Intra-regional Trade 2000-2010

(Unit: US$ billion and ¥100 million on Japan trade)

Country	To	2000			2010		
		Export	Import	Total	Export	Import	Total
Korea trade	China	18.5	12.8	31.3	116.8	71.6	188.4
	Japan	20.5	31.8	52.3	28.2	64.3	92.5
China trade	Korea	11.3	23.2	34.5	68.8	138.0	206.8
	Japan	41.6	41.5	83.1	120.3	176.3	296.6
Japan trade	Korea	33,088	22,047	55,135	54,609	250,234	79,632
	China	32,744	59,414	92,158	130,867	134,087	264,954

Source: Lee, Oh *et al.* (2012:2)

5) Saori Katada defines this market-based economic cooperation as 'regionalization,' which is a 'bottom-up approach of the regional integration led by private sector business activities and subnational communication through people's activities such as migration' (Katada 2009). In this bottom-up process or functionalist approach, the integration is seen as a function of actors cooperating across state borders in order to better achieve necessary tasks.

Table 3. Trade and Investment among CJK in 2011

(Unit: US$ billion)

	Korea-China		Korea-Japan		China-Japan	
	Kor→Chi	Chi→Kor	Kor→Jap	Jap→Kor	Chi→Jap	Jap→Chi
Export	134.2	86.4	39.7	68.3	147.3	194.4
Investment	4.88	0.65	0.42	2.29	0.11	12.65

Source: Ahn and Jung (2012:41).

While Northeast Asian economic integration is being achieved informally due to the political and economic characteristics of the region, the new millenium has brought about an increase in deliberate Northeast Asian economic integration, regional trade and investment relations, financial cooperation, environmental cooperation, science and technology cooperation and industrial cooperation (Cheong 2003; De Santis 2005; Chia 2010; Kawai and Wignaraja 2010; Estrada, Park *et al.* 2011; Naoko 2011). The tariff barriers among the three countries in Northeast Asia are steadily decreasing: the weighted average tariff in 2004 of the three economies was less than 6 per cent, as compared to more than 20 per cent in 1991 (De 2006:2). As shown in Table 4, in 2010, aggregate GDP (Gross Domestic Product) of CJK accounted for 19.7 per cent (US$12,352 billion) of the world's total, and their trade volume accounted for 18.5 per cent of the world's exports and 16.3% of the world's imports in 2010. This volume increased again, amounting to 24.1% in 2004 (Lee, Oh *et al.* 2012). More recently, in 2012, the combined GDP of CJK accounted for 21% of global GDP, and the combined volume of CJK's trade in 2012 accounted for 18% of the global total (Choi 2013:101). Therefore, if established, a trade agreement among CJK would significantly influence the regional as well as the global economy.

CJK is presently a major global manufacturing centre. CJK's export-driven growth approach, demonstrating a similar layout of industries engaging in exports and imports, has accelerated the current intra-trade boom, a trend driven largely by the development of regional production networks (Kastner 2011; Nicolas 2012).

Table 4. GDP Major Economies

(Unit: US$ billion, % to world total)

Major economies	2000	2010
World	32,217	62,911
United States	9,951(30.9)	14,527(23.1)
European Union	8,496(16.4)	16,242(25.8)
China	1,198(3.7)	5,878(9.3)
Japan	4,667(14.5)	5,459(8.7)
Korea	534(1.7)	1,015(1.7)

Source: Lee, Oh *et al.* (2012:1).

The current division of labour between CJK has boosted intra-regional trade; Japan and Korea have developed sophisticated technology, while China is the world's factory, due to its low labour and production costs. China produces and processes final products with parts and pieces provided by Japan and Korea. These final products are then exported, mostly to the United States and the EU.

From 1992 to 2012, the exports and imports of the three countries increased rapidly. In 2012, CJK accounted for 11.2 percent, 4.4 percent and 3.0 percent of the world's total exports, respectively, and represented 9.8 percent, 4.8 percent and 2.8 per cent of the world's total imports, respectively. Table 5 demonstrates the economic importance of CJK in the world and shows how its position has changed over the last 10 years (2002 to 2012).

The share of intra-regional trade among the three countries has also increased steadily. It increased from 12.3 per cent in 1990 to 19.0 per cent in 1996 and further increased to 24.1 per cent in 2004. During 2012, China was the largest trading partner of Korea and Japan, and the two countries were regarded as the second largest trading partners of China. In 2012, Japan was Korea's second largest trading partner and Korea was Japan's third largest trading partner (Korean Ministry of Foreign Affairs and Trade 2013). As shown in Table 6, CJK's intra-regional trade exhibited the highest increase. This may be due to China's rapid economic

growth as well as CJK's having realised the need for regional economic cooperation and subsequent changes in their trade pattern from extra- to intra-regional (Choi 2013:103). In short, there seem to be economic clusters[6] emerging within the Northeast Asian region.

Northeast Asia (CJK) is the only remaining region without a formal economic integration structure (Lee and Bang 2011), despite CJK's important role in world trade and the consensus among the member nations that economic power and competitiveness as a result of the economic clustering would be enhanced, and despite the multiplicity of FTAs among Asian countries, including ASEAN+1 FTAs (i.e. ASEAN and China/Japan/Korea). This reluctance to form bilateral trade

Table 5. Global Share of GDP and Trade of CJK (2002 and 2012)

(Unit: %)

	GDP		Trade		Export		Import	
	2002	2012	2002	2012	2002	2012	2002	2012
China	4.3	11.3	4.7	10.5	5.0	11.2	4.4	9.8
Japan	11.9	8.3	5.7	4.5	6.4	4.4	5.1	4.8
Korea	1.7	1.6	2.4	2.9	2.5	3.0	2.3	2.8
Total	17.9	21.2	12.8	18.0	14.0	18.5	11.8	17.5

Source: Choi (2013:102).

Table 6. Main Economic Blocs' Share of Intra-regional Trade

(Unit: %)

	EU		NAFTA		ASEAN		MERCOSUR		CJK	
	2002	2012	2002	2012	2002	2012	2002	2012	2002	2012
Intra	67.1	62.8	56.1	48.5	22.7	25.8	11.4	14.5	12.8	18.0
Rest	32.9	37.2	43.9	51.5	77.3	74.2	88.6	85.5	87.2	82.0

Source: Choi (2013:103).

6) The term 'clusters' as 'geographic concentrations of interconnected companies and institutions in and encompassing an array of linked industries and other entities important to competition.' (Porter 1998).

agreements among CJK can be attributed to a number of domestic and international political conditions; thus, one can see the recent shift as a response to changed political and economic circumstances rather than economic optimalism. The stalemate of multilateralism of the WTO, the emergence of regional trade blocs (i.e. US-led Trans Pacific Partnership, China-led Regional Comprehensive Economic Partnership (RCEP)), and the aftermath of the Asian financial and economic crisis in 1997-98 were among the key driving forces accelerating CJK-FTA talks.

III. Roadmap to Regionalism?

Some significant progress recently has been made:

- November 1999, Manila: At the ASEAN+3 Summit Meeting, the leaders of CJK met over trade for the first time; since then, the Trilateral Summit Meeting has gathered annually.
- November 2000 (ASEAN-China Summit, Singapore): The first proposal for ASEAN-China bilateral FTA was made by then Chinese Premier Zhu Rongji; Japan also made a proposal for a bilateral FTA with ASEAN.
- 2001: The ten ASEAN countries launched the Chaing Mai Initiative[7] with China, Japan and South Korea (the so-called ASEAN+3), which committed these states

7) In order to prevent the spread of crisis from one country to another, East Asian countries felt the need to reinforce regional economic cooperation. At present, there has been more action in the area of financial cooperation rather than trade cooperation through the creation of an economic cooperative body. Bilateral Swap Agreements (BSAs) are now in force in East Asian countries through the Chiang Mai Initiative (CMI). Ahn and Cheng (2007) argue that the CMI triggered by the 97 Asian financial crisis should be a turning point towards regional integration as there is a critical need for CJK to establish a formal institution that would allow 'mutual consultation regarding exchange rates, interest rates and foreign exchange reserves' (Ahn and Cheong 2007:178). A key function of CMI is to promptly provide liquidity assistance such as monitoring, surveillance and exchange rate coordination to regional countries showing signs of a currency crisis by equipping and strengthening liquidity assistance facility (Kawai 2005).

to monetary cooperation, steps towards financial liberalization, and monitoring each other's economic and financial situation.

- 2001: China's entry into the WTO and China's progressive approach to regionalism.
- December 2008, Fukuoka: The first independent Trilateral Summit Meeting took place outside of the ASEAN+3 framework, and the independent Trilateral Summit Meeting has now become an annual event.
- October 2009, Hua Hin, Thailand: The Trilateral Economic and Trade Ministers' Meeting was held, where the three countries agreed to launch an Official Tripartite Joint Study for a CJK-FTA at the Trilateral Summit Meeting.
- May 2010: Following a preparatory meeting held in January 2010, the Joint Study Committee (JSC) for a CJK-FTA was launched; its first meeting was held in Seoul, Korea on May 6 and 7, 2010.
- May 2011 to December 2011: Seven meetings of the JSC for a CJK-FTA were held.
- September 2011: Establishment of CJK Trilateral Cooperation Secretariat in Seoul Korea.
- May 13, 2012, Beijing: Premier Wen Jiabao (China), Prime Minister Yoshihiko Noda (Japan), and President Lee Myung-bak (Korea) announced their intention to begin negotiating a trilateral FTA.
- November 2012, Phnom Penh, Cambodia: The CJK Economic and Trade Ministers' Meeting launched FTA negotiations among CJK.
- December 2012[8]: The CJK Joint Study Committee's report submitted to the leaders at the Trilateral Summit Meeting.
- March 26-28, 2013, Seoul: First round of CJK-FTA negotiations held.
- July 30-August 2, 2013, Shanghai: Second round of CJK-FTA negotiations held.

8) This report was based on a Trilateral Joint Research Project on a Free Trade Agreement (FTA) among China, Japan and Korea (CJK-FTA); the Development Research Centre (DRC) of the State Council of China, the National Institute for Research Advancement (NIRA) of Japan, and the Korea Institute for International Economic Policy (KIEP) conducted research jointly between 2003 and 2009.

- Third round of CJK-FTA negotiations is to be held in Japan at the end of 2013.

The following conditions underpin these developments towards the deepening economic ties and integration: The outbreak of 1997 Asian financial crisis, the intensification of economic integration of EU and NAFTA, China's WTO accession in 2001 and its increasing global economic power, and the global financial and the European fiscal crises. These conditions brought about a consensus among the key policy makers of CJK that they need to reduce their dependence on exports from outside the region (the US and EU in particular) and base their economic growth more firmly on domestic or regional demand in order to stabilize the global as well as regional economy (Ahn and Park 2007). This seemed a powerful rationale for a CJK-FTA and may be regarded as part of a supporting policy framework for deepening production networks and supply chains formed by global multinational corporations (MNCs) and emerging Asian firms (Kawai and Wignaraja 2009).

CJK are now increasingly the leading players in the spread of economic clustering in the form of Free Trade Agreements (FTAs). China has 10 FTAs in force with Hong Kong, Macao, New Zealand, ASEAN, Chile, Singapore, Peru, Pakistan and Costa Rica and Taiwan. China is currently negotiating FTAs with the GCC (Gulf Cooperation Council), the SACU (Southern African Customs Union), Australia, Switzerland, Norway, CJK and Iceland.

Japan has 12 Economic Partnership Agreements (EPAs), namely those with Singapore, Mexico, Malaysia, Chile, Thailand, Indonesia, Brunei, ASEAN, the Philippines, Switzerland, Vietnam and India. Japan is also very active in pursuing EPAs. In addition to these agreements, Japan has recently signed an FTA with Peru, and is negotiating EPAs with the GCC and Australia. Consultations are underway between Korea and Japan to resume bilateral EPA negotiations and FTA discussions, which have been suspended since 2004 (Korean Ministry of Foreign Affairs and Trade 2011).

Korea has also been very determined since the 1997 Asian financial crisis

to become a regional FTA hub nation in order to overcome its relatively small domestic market and to participate actively in a rapidly regionalized world. Currently, Korea has 8 FTAs in force, namely those with Chile, Singapore, EFTA (European FTA), ASEAN, India, the EU, Peru, and the United States and has recently concluded FTA negotiations and signed agreements with Colombia and Turkey. In addition, Korea is now negotiating with Australia, New Zealand, the GCC, Canada, China, Vietnam, Indonesia, Mexico, CJK, and Japan for FTAs (refer to Table 7) (Korean Ministry of Foreign Affairs and Trade 2013). Equally important, four preliminary discussions have been held between China and Korea prior to formal bilateral FTA negotiations. Currently, more than 30 FTAs are in the process of being negotiated for CJK economies.

The governments of CJK have declared that there is much to be gained from a CJK-FTA which would eliminate both tariff and non-tariff barriers and ultimately lead to a common market (Korean Ministry of Foreign Affairs and Trade 2011).

Table 7. Bilateral and Plurilateral FTAs (status by economy), As of March 2013

	ASEAN	Japan	China	Korea	India	Australia		New Zealand	CJK
ASEAN	◎	◎	◎	◎	◎		◎		X
Japan	◎	—	△	○	○	○		X	○
China	◎	△	—	△	△	○		◎	○
Korea	◎	○	○	—	◎	○		○	○
India	◎	○	△	◎	—	△		△	X
Australia	◎	○	○	○	△	—		◎	X
New Zealand	◎	X	◎	○	△	◎		—	X

◎ = FTA in place or FTA negotiation signed, ○ = official negotiation under way, △ = feasibility study of FTA under way,
X = no official move taken.
Notes: Australia and New Zealand jointly have an FTA with ASEAN. In 2012, the territorial sovereignty disputes among the CJK froze Japan's bilateral ties with China and Korea; the negotiation of the CJK-FTA was suspended in 2012 and resumed in February 2013.
Source: Modified and updated from (Kawai and Wignaraja 2010a:24).

The most fundamental and obvious rationale behind this claim are the benefits from the deepening of regional economic interdependence. These include geographic and psychic (cultural) proximity, complementary endowments of production factors, and increasing economic ties. From China's perspective, a CJK-FTA would bring economic benefits from institutional agreements such as i) increased market access to goods, services, skills, and technology; (ii) increased market size, permitting specialization and realisation of economies of scale; (iii) facilitation of the foreign direct investment (FDI) activities and technology transfer of MNCs; and (iv) permission to simply tariff schedules, rules, and standards (Kawai and W 2010a:20). In addition, a CJK-FTA would give China a foothold for further integration in Asia; free up production supply chains (concentration on manufacturing); offer enhanced economic security for the new Chinese leadership; enable China to expand the use of the Renminbi, internationalizing the Renminbi and reducing the country's reliance on the U.S. dollar; see more and higher quality products exported to China; and offer improved market opportunities for both SOEs and private companies. These strong political and economic pressures and expectations have motivated China to push for realisation of the CJK-FTA.

For Korea, the main advantage of a CJK-FTA is that China's eagerness in seeking a FTA with Korea provides an opportunity to seek strong economic returns, which would allow Korea to enhance its position in CJK. A CJK-FTA would also offer critical strategic value in providing enhanced leverage over North Korea. To Korea, the CJK-FTA and a bilateral FTA with China represents a heavily focused political-security and economy-driven model. For Japan, although interest in a CJK-FTA was not visible until recently, Prime Minister Abe has claimed to be pursuing both a CJK-FTA and a TPP. Japan has also recently resumed negotiations on the FTA with China and Korea.

For Japan and Korea, the CJK-FTA would bring improved markets for Japanese companies and Korean *Chaebol*s (a South Korean form of business conglomerate), increase the market for capital goods and offer increased investment opportunities. Equally important, the realisation of such an FTA would incorporate Korean companies

into the region's economic power structure. The increased competitiveness would bring significant benefits, not only to the region but also to the world[9]. The recently published report (December 2012) by the CJK-FTA task force foresees that a CJK-FTA and subsequently East Asia FTA (EAFTA) will open a new era for East Asia, enabling the region to maintain its economic dominance, enlarge internal markets and create a stable international political and security environment. This new economic clustering will make progress in the ongoing process of economic integration in East Asia, such as ASEAN+3, ASEAN+6 (ASEAN + CJK+ Australia, India and New Zealand), as well as the Asia Pacific region by providing a comprehensive and institutional framework in which a wide range of trilateral cooperation would evolve.

East Asia's policymakers are increasingly of the view that a CJK-FTA could provide a strong foundation for a possible EAFTA, ASEAN's RCEP and eventually a Japanese-led proposal for a Comprehensive Economic Partnership of East Asia (CEPEA), involving Australia, New Zealand and India. This new centre of Northeast Asian economic power will undoubtedly rival that of the North America FTA and recently, the US-led TPP. The proposed CJK-FTA would most likely have a similar impact on Europe, namely decreased trade and investment with the three member countries. Currently, the EU has a FTA with Korea, but not with China or Japan. Also, with the exception of Norway, none of the European countries

9) The most compelling evidence gathered from our interviews conducted in CJK in 2012 was that all parties recognise and understand the economic inter-dependency among CJK. A number of in-depth interviews with government officials, scholars, and industries, who are closely associated with the CJK-FTA proposal, were conducted in 2012. During April 2012, we visited Korea (Seoul) for interviews with the Australian Embassy in Korea, the Korean Ministry of Foreign Affairs and Trade, KOTRA (Korea Trade and Investment Promotion Agency), the Korea Institute of International Economic Policy (KIEP), and the Korea Institute for Industrial Economics and Trade (KIET). In September 2012, we revisited those institutions in Korea. In October 2012, we visited and conducted interviews with scholars and policymakers in Japan (Tokyo) and China (Beijing), including the Australian Embassy in Tokyo, Tokyo Denki University, Meiji University, Tsukuba University (Tokyo), the National Institute for Research Advancement (NIRA) in Tokyo and the Chinese Academy of Social Sciences in Beijing.

is in FTA talks with China. Switzerland is the only European country with an FTA with Japan. Equally important, CJK do not have bilateral FTAs with Australia, although Australia is negotiating an FTA with each of those three countries. While the economic reality of increased interdependence came later for Europe, in the case of CJK, the intensity of current economic interaction has provided the basis for considering greater integration (Yap 2007).

IV. China's FTA Strategy: RCEP, CJK-FTA and TPP?

One of the most striking features of today's global economic geography is the shift, since China's accession to WTO, in China's earlier strong belief in multilateralism to what we refer to as regional economic integration or regionalism

Table 8. China's FTAs by Status and Geographical Orientation as of September 2008

	Intra East Asia-15	Extra East Asia-15
Under implementation	China-ASEAN CECAb/ China-Hong Kong CEPA China-Macao CEPA China-Thailand FTA	Asia Pacific Trade Agreement (APTA) China-Chile FTA China-Pakistan FTA
Signed		China-New Zealand FTA
Framework Agreement Signed/FTA Under negotiation		China-Australia FTA China-Iceland FTA
Under negotiation	China-Singapore FTA	China-South African Customs Union FTA China-Gulf Cooperation Council FTA
Proposed/Under consultation and study	ASEAN+3 FTA China-Japan-Korea FTA	ASEAN+6 FTA Shanghai Cooperation Organization FTA China-India RTA China-Costa Rica FTA China-Norway FTA China-Peru FTA

based on FTAs. In particular, it is noteworthy that China's strong push towards regional economic clustering strengthened considerably after the 1997 Asian financial crisis. China officially proposed its first FTA negotiation with ASEAN members in November 2000. Since then, China has entered into a number of regional and bilateral trade agreements. China currently has 10 FTAs in force with Hong Kong (2004), Macao (2004), New Zealand (2008), ASEAN (2004), Chile (2006), Singapore (2008), Peru (2009), Pakistan (2007) and Costa Rica (2010), and Taiwan (2010), and two were recently signed with Iceland (2013) and Switzerland (2013). China is currently negotiating FTAs with the GCC, the Southern African Customs Union (SACU) (including Botswana, Lesotho, Namibia), Australia, Norway, CJK and Iceland (Nakagawa and Liang 2011).

According to Nugroho (2008:18-9), four economic and political motivations lead to China's FTA strategy to ensure the sustainability of its economic growth and development, and to become a regional pole in East Asia.

1. Similar to what is being pursued in the WTO accession, by establishing FTAs, China wants to widen market access for its quickly growing export industry.
2. The creation of FTAs can quell China's perception of being under threat, facilitate economic and political cooperation with other countries and increase China's influence around the globe.
3. Establishing FTAs helps China in meeting its needs for key mineral and energy resources.
4. The creation of FTAs demonstrates China's commitment to trade liberalization and encourages further domestic economic reforms, which in the long-term will allow China's economy to grow based on efficiency and comparative advantage.

In other words, strong political and economic incentives and expectations have motivated China to push for the realisation of the CJK-FTA:

- A foothold for further integration in Asia, thus freeing up production supply chains (concentration on manufacturing);
- Enhancing economic security for the new Chinese leadership, and enabling China

to expand the use of the Renminbi so the country can internationalize the currency; and

- Reducing China's reliance on the U.S. dollar. A CJK-FTA would also mean higher quality products would be exported to China and offer improved market opportunities for China's state-owned enterprises and private companies.

China's strategies of competitive liberalization are based the following priorities and should be viewed in a political-economic framework[10]:

- Completion of a Chinese (overseas) economic zone and economic dominance in the Asian region;
- Stability in the region (e.g. Pakistan and ASEAN);
- Acquiring energy for its economic growth (Chile, GCC);
- Political and economic stability in Northeast Asia (Japan and Korea);
- Expansion and diversification of markets (for example, Australia, New Zealand, and Switzerland);
- The final stage of unification of China (Hong Kong, Macao and Taiwan, or *Greater China*);
- Overall, part of China's *Peaceful Rise strategy.*

V. Political-economic Dilemma

Although seemingly based purely on economic considerations and functional integration has shown considerable progress in the market sector, in the final analysis political factors influence trade arrangements more than economic factors (Katana 2009; Yap 2005). Cases of regional integration such as the EU and NAFTA demonstrate

10) This information was gathered while I visited and discussed with members of Chinese Academy of Social Sciences in Beijing, China in October 2012.

that political security plays a crucial role in establishing regional integration. Therefore, a range of political or non-economic factors should accompany the economic case for Northeast Asian regional integration. The regional institution-building or economic integration between the three countries is in its very early stages and considerable uncertainty surrounds such an FTA:

- Uncertain prospects for stability in Northeast Asia due to historical and cultural animosities that still persist in the region, which aggravate numerous territorial and maritime disputes; different types of government and political systems between CJK; the intensification of North Korean nuclear tension;
- Transition from a competitive to a cooperative framework among CJK members;
- CJK's political stability and their new relationships under the newly started leaderships in the three countries;
- The newly emerged US-led FTA initiative, TPP, which places Japan and Korea in a dilemma, as they are being asked to pursue integration compatible with the interests of the US, which may run contrary to those of China (e.g. TPP will exclude China); and
- Strong resistance from domestic pressure groups (e.g. farmers, SMEs).

Historical animosity (Japan's Pacific War with China and its annexation of Korea between 1910 and 1945) and territorial disputes between CJK will be the greatest challenge to both the FTA negotiation and its vision for regional integration. Korea has recently suspended the signing of agreements on military cooperation with Japan because of public opposition, particularly from older generations who have bitter memories of Japan's colonial rule. On 10 August, 2012, Korea's then President Lee Myung-bak visited the disputed set of remote islands called Dokdo in Korea and Takeshima in Japan, which are controlled by Korea but also claimed by Japan. This angered Japan and consequently, Japan temporarily recalled its ambassador from Seoul, Korea and said it will be submitting the Takeshima/Dokdo dispute for consideration by the International Court of Justice. The then Japanese Prime Minister Yoshihiko Noda went further and cancelled a planned meeting

with President Lee at the APEC Summit in Vladivostok, Russia, in October 2012 (Spitzer 2012). In recent months, the Japanese Abe government has decided to set up an exclusive department within its cabinet secretariat to deal with territorial issues, including its claims over Dokdo (Lee, February 9, 2013).[11] These developments will aggravate the already-strained Korea-Japan relations and exercise their control over the Japanese leadership. As such, Korea's main concern now with the CJK-FTA has become how to manage public sentiment against Japan.

Similarly, Japan and China have also long been in dispute over territorial claims in the uninhabited islands in the East China Sea, known as Senkaku in Japan and Diaoyu in China. China's claim to sovereignty over Manchuria during the 1930s and over the Senkaku/Diaoyu Islands is now overwhelmingly more important in driving its foreign policy than any stress on physical control, which is more common to the West (Lee 2011).

The territorial sovereignty disputes among the three countries have frozen Japan's bilateral ties with China and Korea until very recently and seriously affected regional trade. As indicated earlier, the negotiation of the CJK-FTA was suspended in 2012 and just resumed in March 2013. This clearly indicates that the stability of economic relations among the three countries will primarily rest on sound political relations in the region. As the widening discrepancy between the territorial status quo and the political and economic balance of power, including the wide disparity in development among countries, becomes more glaring in Northeast Asia (as evidenced in recent months), it is predicted the conflict will intensify (Lee 2011). As discussed in the case of Dokdo or Takeshima, mutual distrust among these countries still represents the greatest impediment to a decision regarding Northeast Asian regional integration (CJK-FTA) based on considerations of political economy.

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11) On 22 February 2013, Japan's central government dispatched a vice-ministerial official to a ceremony aimed at promoting its territorial claims over Korea's easternmost islets of Dokdo. This is the first time that Tokyo has sent a government official to the so-called 'Takeshima Day,' annually hosted by the Shimane prefectural government (*The Korea Times*, 23 February 2013).

As one Japanese commentator pointed out 'building mutual trust among the people of CJK, rather than presenting empirical evidence of economic benefit, is the necessary step to realising CJK-FTA' (Ohnishi quoted in Ahn and Cheong 2007:187).

Secondly, the US has now returned to Asia with a new free trade concept, '*Competitive Liberalization,*' (Bergsten 1996), referred to as the TPP, which appears to challenge the underpinnings of the CJK-FTA. The TPP, also known as the Pacific Four (P4) agreement, is a plurilateral FTA among Brunei Darussalam, Chile, New Zealand, and Singapore that came into force in May 2006. In fact, it is the political implications of being part of this 'higher level' of integration (high politics) that has the potential to affect the political-economic geography of Northeast Asia. The TPP will be a major challenge to China's ambition to achieve a *Peaceful Rise,* which aims at:

- Gaining leadership and control over the global economic and trade order and forming a counter power comparable to the US and Europe by unifying Asian countries;
- Achieving political objectives through economic approaches.

Japan's containment against China in attempting to secure a leadership position via recent entry to a TPP negotiation and Korea's recent announcement of its willingness to join in negotiations could delay China's achievement of *Peaceful Rise.* Japan has also proposed a CEPEA, involving Australia, New Zealand and India that will certainly lower China's influence on ASEAN and ASEAN's position on free trade in Asia. ASEAN has proposed the RCEP. In broad terms, the TPP and RCEP may lead to a new form of geo-political power game between the US, China and Japan, which inevitably carries political and security implications. Each will be trying to shape economic cooperation groupings in Southeast and Northeast Asia and in the wider Asia Pacific region to promote their respective economic interests. This may have unpredictable, unproductive and even dangerous political consequences for the CJK-FTA or Northeast Asian economic integration in the near future.

China has responded to the US-led TPP pact in a number of ways, especially with members of the TPP. Firstly, China has strengthened the China-ASEAN FTA by launching sector-level dialogue mechanisms in the hope of further integrating China and ASEAN across a broad range of industrial sectors. Second, China has signed the Foreign Investment Protection Agreement (FIPA) with Canada in February 2012. Third, China continues negotiation with Australia on an FTA. Fourth, and most importantly, China has now sped up the process of CJK-FTA and launched the China-Korea FTA discussions in May 2012 (Tso 2012). China believes that a key to propelling Northeast Asian integration could be the establishment of separate bilateral FTAs between China and Japan, China and Korea, and Japan and Korea. Such a move would establish mutual trust. Given that the Korea-US FTA is now in force, this option for bilateral FTA (China-Korea/Japan-Korea) is also critical for Korea, which will bring a positive effect on the security of the Korean peninsula. In short, political-economic considerations impinge on the move towards a CJK-FTA. Kawai and Wignaraja (2010) argued that 'Due to a rise in the number of players in official negotiations for FTAs, creating an encompassing FTA in Asia could become more complicated. This suggests that forming a CEPEA would be more complex than forming an EAFTA and that forming an FTAAP would be even more complex than forming a CEPEA' (Kawai and Wignaraja 2010:24). In addition, political rivalry over FTA leadership in Asia may hinder any such economic integration. As discussed, each of the three economies has been a strong supporter of different economic blocs (e.g. China for an EAFTA, Japan for a CEPEA, TPP, and Korea for a Korea-China FTA). As Hoffmann argued in the case of European Community (neo-functionalist view), 'Every international system owes its inner logic and its unfolding to the diversity of domestic determinants, geo-historical situations, and outside aims among its units' (Hoffmann 1966:864). This is why strong and focused political leadership may be required in those complex, multi-party negotiations.

VI. Concluding remarks

A new economic cluster such as the CJK-FTA is based on a variety of factors that extend beyond any long-standing differences. Five factors stand out. First, CJK is the major global manufacturing region and will continue to be so in the foreseeable future. Second, a FTA between these three countries is seen as a necessary response to the other free trade proposals, such as the TPP, and barriers being put up by others. An export-oriented developmental model has helped CJK accumulate more than half of the world's foreign exchange reserves. The complimentary CJK endowments of production factors have boosted intra-regional trade: Japan and Korea provide sophisticated technology and capital goods while China manufactures a large percentage of the world's consumer products. Third, CJK economic integration is an essential first step in the formation of a regional FTA that would help promote an East Asian era. Fourth, the perception towards each other among CJK members is changing. Given an unpredictable global economic future, a dependant economic partnership among CJK is becoming a shared priority for each of these nations. A more formal level of economic cooperation such as a trilateral FTA is now seen as a necessity by the political and industrial leadership within each country. Fifth, China's progressive approach to the new Asian regionalism aims to reduce the influence of the TPP, the U.S.'s preferred Asian regional architecture. In short, a consensus is now emerging among CJK leaders that-despite political, historical and cultural barriers- there is much to be gained from a CJK-FTA, which could eventually lead to the formation of a region-wide FTA, most probably a CJK-ASEAN FTA.

As for the way forward, the emergence of this Northeast Asian community and the nascent political and economic cooperation among CJK will require a strategic repositioning of other economic partners in the Asia Pacific region, including the US and Australia, given they have a strong economic interest in this region. The future trend of regional economic integration could be developed along two competing parallel trajectories: one is the establishment of the China-led CJK economic

cluster first, then expanding to a CJK+ASEAN Free Trade Area, and at a later stage a further expansion to an ASEAN + 6 Free Trade Area which will cover a large part of Asia Pacific region, including Australia, New Zealand and India. However, this development and formation of regional integration will most likely exclude the US. Therefore, it is in the US interests to form a competing regional economic group by promoting and strengthening the formation of the TPP, which includes the major partners of the US, but excludes China. Given the higher threshold requirement for getting into the TPP membership, many developing countries as well as some developed economies such as Japan and Korea could find it difficult to concede key interests in order to become TPP members. The possible formation of the TPP based regional integration may be realised among some key advanced economies first, and then following further negotiation, could be expanded to cover other relevant countries. As the later countries would probably not meet all the conditions for membership, the real operation of an FTA among these members could take a much longer period. These competing regional economic integration models reflect the reality that such issues are not just related to economic and trade matters, but geo-political struggles between major players (i.e. the U.S. vs. China) in the region and the development of both trends could lead to a very different outcome in terms of geo-political and economic relationships in the Asia Pacific region.

Further development along the lines of CJK integration is possible, but it is premature to expect China, Japan and Korea's political and economic systems will soon to be more fully incorporated. Such integration will certainly require joint political commitment from the governments of all three countries. The requisite political leadership to realise the regional integration is the key development to ensure economic prosperity and political stability. An interdisciplinary approach combining three sectors, namely the state, society and the market needs to be adopted in discussions of Northeast Asian regional integration (Ahn and Park 2007). It is highly likely that political-economic considerations will weigh heavily on the final outcome of the new vision on the trilateral FTA. While the motivation for

the integration is based on economic calculations, the process of integration is clearly political. As was the case of European integration, coalition formation and leadership are now central aspects in the Northeast Asian integration (Laursen 2008: 5). While widening the membership of any agreement merely involves the extension of the cooperation to more actors, deepening it can be more complex and controversial, and will depend on whether the individual CJK countries seek to expand economic ties or whether they would want to secure the political gains from closer integration and cooperation.

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5

Comparative Study on Green Growth Strategy in China and Korea

LU WEI[1)]

Green growth can be seen as a way for pursuing economic growth and development, while preventing environmental degradation, biodiversity loss, and unsustainable natural resource use. Nearly all countries are looking to achieve green growth development and are formulating appropriate strategies. The 1997 Asian financial crisis and the worldwide economic downturn since 2008 prompted China and Korea to actively explore a new path of economic restructuring and accelerate the pace of strategic transformation. In accordance with these changes, Korean government began the implementation of a "low-carbon green growth strategy", published a "Green Growth and the Five-year National Strategic Plan" and instituted relevant regulations that detailed strategic plans to promote long-term planning, strategic objectives, implementation plans, policies and measures. In 2011, China released its first-ever plan including green development in the form of the 12th Five-Year Plan. This marked the beginning of China's process of green modernization in the first half of the 21st century. The process of green modernization is a new

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type of interpretation of the Chinese road. Green development is has been identified as a way to open up an era of eco-friendly culture, a new path to be explored and led by China, thus creating new values and developing ideas and promoting scientific developments. This study prepares to compare the background, content, experience, existing problems and policy effectiveness of the low-carbon/ green growth strategies in China and Korea.

I. Why Green Development Strategy is So Important for China?

"Green Growth"is a relatively new term that has become the focus of much interest and considerable debate among policy makers and other stakeholders concerned with enhancing both nearer-term economic progress and longer-term environmental sustainability. China's development has previously resulted not only in high emissions, excessive resource consumption, and environmental destruction, but also external, social, and regional imbalances. The traditional modes of economic growth, urbanization, industrialization, household consumption and foreign trade are no longer feasible for China due to a series of anomalies resulting from environmental pollution such as smog in 2013. As income levels increase, the Chinese people are demanding improved welfare, a cleaner environment, and higher quality of life-without the recurring risks of environment-related disasters.

1.1. The Traditional Mode of Economy Growth Is No Longer Feasible

In 2010, the amount of direct material input (DMI) per unit of GDP was 14.5 tons in China, while the Figure was only 5.9 tons in EU-15 in 2000 and 4 tons in 2006 in Japan. In 2009, electricity consumption per unit of GDP was 0.424 kWh in China, or 1.6 times that of Japan and 1.9 times of that of the EU-15. In 2007, GDP per square kilometer of construction land was 21.1 million dollars in China, and it was 72.2% of that of USA and 16.7% of the numbers for Japan. In 2009, SO_2 emissions per unit of GDP were 22.68 g, while the Figure was only 0.216 g in the EU-15.

Figure 1. Direct Material Input per Unit of GDP

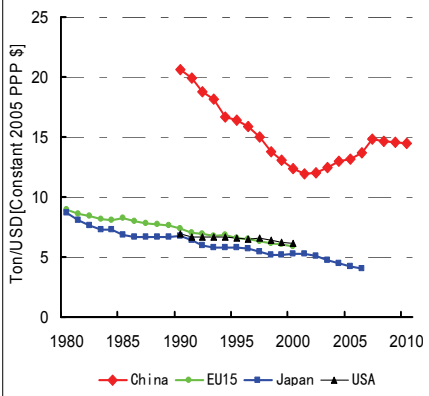


Figure 2. Electricity Consumption per Unit of GDP

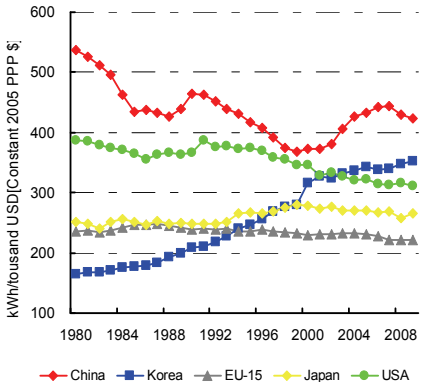


Figure 3. GDP per Square Kilometer of Construction Land

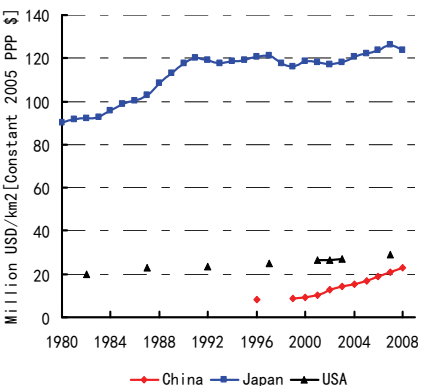
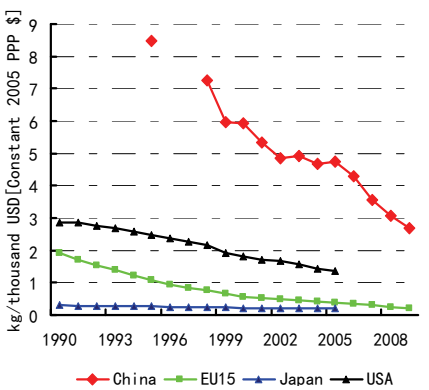
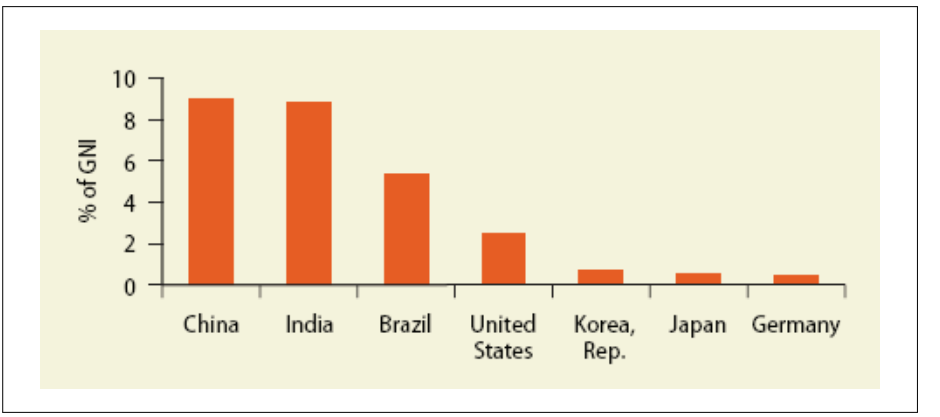


Figure 4. SO2 Emissions per Unit of GDP



Source: Direct material input includes biomass, fossil fuels, minerals and imported raw materials, semi-finished and finished products. PPP GDP is the gross domestic product converted to 2005 constant international dollars using purchasing power parity rates. The data sources of EU-15 `Japan and USA are from Matthews *et al.* (2000), Wuppertal Institute (2007, Eurostat, OECD Statistic Database, the Statistics Bureau and the Director-General for Policy Planning of Japan and World Bank Open Data.

Figure 5. Environmental and Natural Resource Degradation and Depletion in 2008



Source: The World Bank; Development Research Center of the State Council, PR China; China 2030: Building a Modern, Harmonious, and Creative Society 2013.

Meanwhile, at China's current level of development, the environmental degradation and resource depletion in the country is valued at approximately 9 percent of gross national income (GNI), more than 10 times higher than Korea and also Japan, in which air pollution accounts for 6.5 percent, water pollution 2.1 percent, and soil degradation 1.1 percent. A successful path of green development would reduce this number, by 2030, to the much lower level of 2.7 percent of GNI a year (comparable to current levels in the United States)-at an estimated additional cost of 0.5-1.0 percent of GNI/year beyond current spending on environmental protection, according to the estimation by the World Bank.

1.2. The Traditional Mode of Industrialization Is No Longer Feasible

Overall, China's industrial growth continues to show declines in technical efficiency trends. At the national level, technical inefficiency value increased from 0.413 (1985-1990) to 0.502 (2004-2009). Although the technical efficiency of the

Eastern Region during the past 25 years has improved, it is still difficult to offset the impact of declines in the technical efficiency of the Central, the Western and the Northeast Regions. Given the worsening conditions of technical efficiency, investment-driven industrialization model spawned much excess capacity. In 2010, the capacity utilization rates of cement, steel, flat glass, coke, PVC, calcium carbide and polysilicon were only 72%, 80.2%, 70.8%, 67.2%, 49.1%, 60.7% and 60%. These products were more concentrated in high energy consumption and high pollution industries, which not only exacerbated the disorganized development of the industry and the low level of competition, but also incurred excess costs in terms of resources and energy.

Economic growth influence exploitation of natural resources and environment through the scale effect, structure effect and technology effect; and the structural effect is subject to technical effects. During the transitional period of imitation and independent R&D from 1993 to 2009, the share of the contribution of technological progress to economic growth was only 20.7% and the elasticity coefficient was only 0.13 in China. This suggests that many technological achievements had little impact in terms of economic benefits. And it was still the improvement in technical efficiency rather than technological progress that dominated in the China's industrial restructuring. Technological innovation has not yet become the main mode of technological development. From the investment point of view of independent

Table 1. Technical Efficiency Deterioration of Industrialization in China from 1985–2009

Time period	The Nation	The Eastern Region	The Central Region	The Western Region	The Northeast Region
1985-1990	0.413	0.256	0.494	0.483	0.488
1991-1997	0.44	0.194	0.536	0.57	0.549
1998-2003	0.492	0.218	0.608	0.651	0.586
2004-2009	0.502	0.213	0.621	0.669	0.621

Source: Pang Ruizhi, Li Peng. Regional Disparity and Dynamic Evolution with respect to China's New Industrialization Growth Performance, 2011.

innovation, the R&D expenditure of high-tech industries in China as a percentage of industrial added value level (6%) was far behind that of the United States (36.8%), Japan (28.9%) and other developed countries. During the "Eleventh Five-Year" period, total factor productivity did make a major contribution to improvements in energy saving, carbon dioxide emissions of major industrial pollutants and agricultural nonpoint source pollution control in China. The rate of contribution by technological progress in some areas such as pollutant emissions even reached 66%. But as the more easily attainable energy saving technologies from the early days saw extensive use, the marginal cost of energy conservation in enterprises increased fast. However, the disparity in the level of energy consumption and pollution emissions between China and international advanced level is still large. Therefore, China needs to take more forceful and effective measures to promote advances in technologies related to production, pollution control and resource recycling in the next decade.

1.3. The Traditional Mode of Urbanization Is No Longer Feasible

From 1978 to 2011, the proportion of urban population increased from 17.92% to 51.3% in China. The average annual urbanization rate increased 1.2 percent per year. Urbanization has entered of rapid growth. During this process of rapid urbanization, the problem of low quality of urbanization has become increasingly prominent. From 1991 to 2010, built-up urban areas in China expanded 2.12 times, while the urban population grew by only 0.89 times. The rate of land expansion was 2.38 times of the rate of urban population growth.[2] In 2010, the population density of built-up urban areas in China was 16615 capita / sq. km, a decrease of 29.3% compared to 1990. In 2005, the average floor-area ratio of all cities was only 0.5 and the ratio of all towns less than 0.2, while the floor-area ratio of cities in some neighboring countries or areas was usually between 1 and 2.

2) Niu Wenyuan. The report on new urbanization in China[M]. Beijing: Science Press, 2012.

Energy consumption from buildings is on the rise in Chinese cities. From 2007 to 2009, energy consumed by buildings, both residential and commercial, represented more than one-quarter of total energy consumption. Actual annual-average building-energy consumption grew from 309 million TOE over the period 2000-02 to 391 million TOE over the period 2007-09. From 1996 to 2010, with the growth of every percentage in the urbanization rate, an additional 49.4 million tons of standard coal, 6.45 million tons of steel and 21.9 million tons of cement increased in average. The average annual growth rate of urbanization was 3.12% from 2001 to 2010, far below the average annual growth rate of built-up area (5.84%) and the growth rate of urban electric power consumption (12.62%). It was also lower than the growth rate of urban solid waste generation (5.64%) and the growth rate of urban sewage emissions (5.72%) in China.

1.4. The Traditional Mode of Urban Household Consumption Is No Longer Feasible

First, the proportion of plant food consumption per capita in food consumption per capita overall was 82.9% in China in 2007, which was still much higher than that of U.S. (59.3%), Germany (60.3%), and other developed countries. With the advance of urbanization and the improvement of rural household's living standards, it can be expected that the proportion of plant food consumption per capita will decrease, while the proportion of animal food consumption per capita will gradually rise. Because the virtual water content, land use and pollutant emissions per unit mass animal food are much higher than those of plant food, the steady increase of animal food consumption will increase the pressure on the environment and nature resources such as water and arable land. Second, Chinese society transitioned from an era of necessities into an era of consumer durables over the past two decades. The rapid growth of PC and private car ownership led the energy used by urban households in China to increase from 207 kg of standard coal per capita

in 2001 to 315 kg of standard coal per capita in 2010. In 2007, a government-funded project aimed to expand sales of household electric appliances in the country's vast rural areas at prices 13 percent lower than those in cities. It was part of the government's plan to battle the global recession by stimulating the flagging domestic manufacturing industry, which faced dwindling external demand. This project increased the number of TV owned per 100 rural households from 94.4 in 2007 to 111.79 in 2010, close to the number of TV owned per 100 urban households (137.4). However, compared to the number of TV, the disparity in the numbers of air conditioners, refrigerators, washing machines, computers and automobiles owned by rural households and urban households is still large.

Among all consumption domains of urban household expenditure in China in 2007, the top 4 highest domains in aggregate environmental impact were *Household equipment and services* (27.6%), *Food and nonalcoholic* (19.9%), *Transport (private)* (10.2%), *Recreation and culture* (9.2%). In EU-25, the top 4 highest domains in aggregate environmental impact were *Food and nonalcoholic* (31.8%), *Transport (private)* (17.1), *Furnishing, household equipment and routine maintenance of residences* (13.9%), and *Restaurants/ hotels* (9.4%). In 2007, the expenditure in

Figure 6. Food Consumption Structure in Different Countries

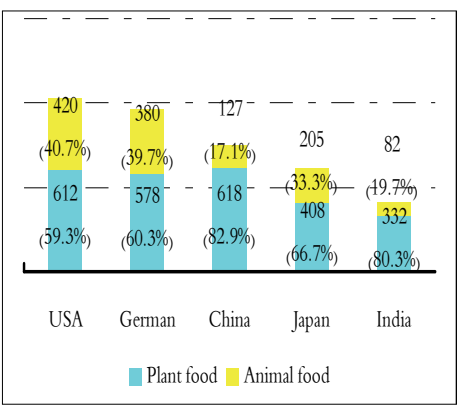
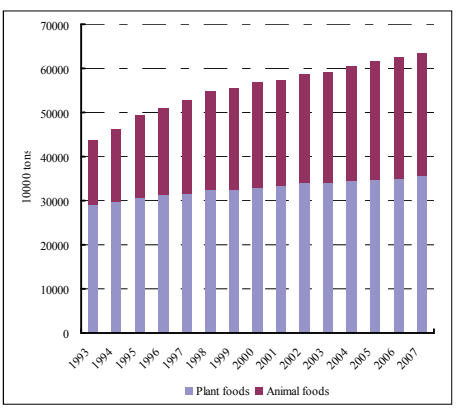


Figure 7. The Trend of Food Consumption in China



Household equipment and services accounted for 6.02 percent of urban household expenditure in China, but the cumulative environmental impact accounted for 27.6% of the total impacts. While in 2005 the expenditure in *Furnishing, household equipment and routine maintenance of residences* accounted for 12% of urban household expenditure in EU-25, the cumulative environmental impact was only 13.9% of the total. First, it shows that energy and material consumption throughout the life cycle of consumer durables is still high,[3] it is necessary to popularize energy and material saving consumer durables. Second, although the aggregate environmental impact of unit expenditure in the *Service* domain is far less than those in *Household equipment and services*, *Housing* and *Food and nonalcoholic*, the proportions of urban and rural household expenditures in the *Service* domain were 29.6% and 25.8% in 2009, roughly equivalent to the level of Japan in 1990 and the level

Figure 8. Energy Consumption by Urban and Rural Residents in China

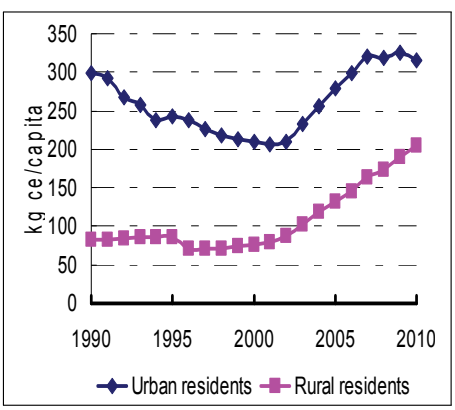
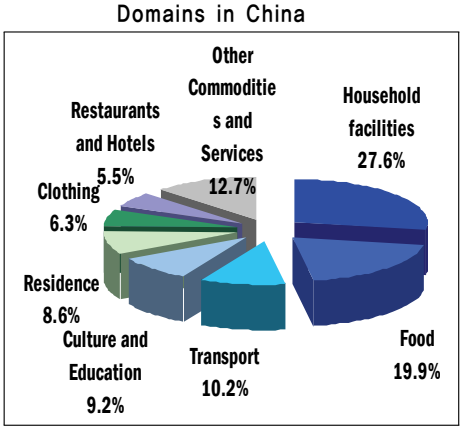


Figure 9. The Structure of Aggregate Environmental Impact Caused by Different Consumption Domains in China



3) According to our calculations, the aggregate environmental impacts per unit household consumption expenditure in Housing, Household equipment and service, Transport (private) were 7.40, 5.75, 1.59 times higher than those of EU-25.

of Korea in 2000. Low in the proportions of urban and rural household expenditures in the *Service* domain not only led to a high aggregate environmental impact of household consumption in China, but also reduced the pulling effect on the level of household consumption growth.

1.5. The Traditional Pattern of Foreign Trade Is No Longer Feasible

Subjected to financial and technical constraints, China is still at the lower levels in the international division of labor. Export products mainly rely on low labor and production costs to gain a competitive edge in the international market. The product structure of exports overall looks does not accord with logic. The primary products, especially high energy and resource-intensive products, account for a high proportion in the product structure of exports. The export of these products is synonymous with much exports of energy, directly or indirectly. In 2007, CO_2 emissions embodied in net exports of China reached 1.129 billion tons, accounting for 20.3% of total domestic CO_2 emissions. And 33.8 percent of total domestic

Figure 10. CO2 Emissions Embodied in Export and Import Trade

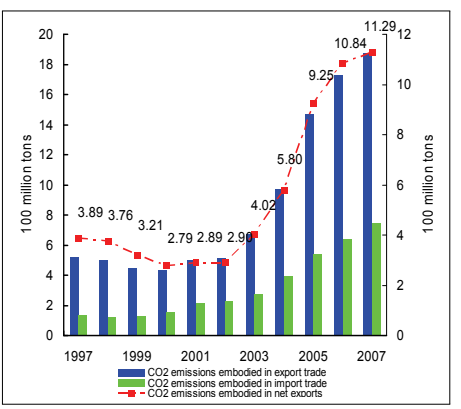
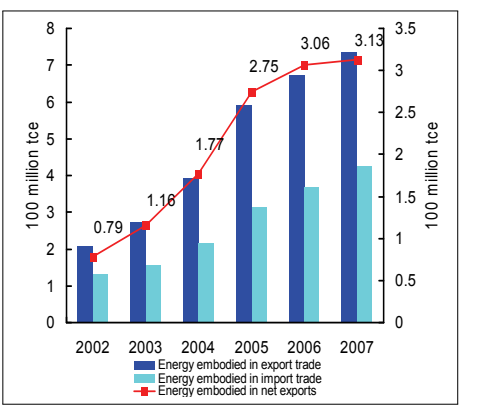


Figure 11. Energy Embodied in Export and Import Trade



CO_2 emissions were produced by export commodities in China. In 2007, energy embodied in net export trade in China reached 313 million tons of standard coal. In 2002, 13.1 percent of China's total energy consumption was caused by exports. And this proportion increased to 26.3% in 2007, which indicated that 1/4 energy of all consumption in China was caused by the consumption of other countries and regions. In 2007, SO_2 emissions resulting from exports accounted for 56.1% of the total SO_2 emissions in China. The proportion of SO_2 emissions caused by net exports also reached 24.4%. The growth in exports has become one of the very important sources of SO_2 emissions in China.

II. Experience of South Korea: Revelation to China

To implement the National Strategy for Green Growth, which covers the years up to 2050, the Korean government announced in July 2009 the Five-Year Plan for Green Growth. The Five-Year Plan (2009-13) contains about 600 projects with a total cost of 108.7 trillion won (10% of 2009 GDP). In addition, each of Korea's 16 provinces and metropolitan cities has a "Green Growth Execution Plan", which includes specific goals and programmes. The government estimated that the plan will lead to production worth 182-206 trillion won (around 20% of 2009 GDP) and create 1.6 to 1.8 million jobs (a 10% rise in employment) by 2013. Meanwhile, the Korean government also planned to increase the preference rate of new and renewable energy from 2.24% in 2006 to 11% in 2020, increase the share of new and renewable energy in the world market from 0.7% in 2007 to 15% in 2020, and increase the output value of new and renewable energy from $500 million in 2007 to $130 billion in 2020. It also put forward plans to promote the level of energy technologies from the current level of 60% of developed countries to the advanced world levels in 2020, and increase the proportion of national controllable energy from 27% in 2007 to 65% in 2020, transforming Korea into a global energy powerhouse.

2.1. Foster Green Sources of Growth

2.1.1. Green Transformation of Traditional Sectors

A large number of extant conventional techniques and management models does not only reduce energy use and emissions but also improve the level of corporate profitability. Although the greening of traditional sectors may seem less dramatic and revolutionary than the development of cutting-edge new technologies, it is clear that with information and financing, many energy-efficient investments are also cost-effective and will yield high economic returns.

Korea's objectives for energy efficiency, which was established in its Basic National Energy Plan 2008-2030, is to reduce energy intensity by 46 percent between 2007 and 2030. The overall energy savings goal for 2030 is nearly 38 Mtoe, 44 percent of which should be achieved in industry (17 Mtoe), 32 percent in the residential and commercial sector (12 Mtoe), 19 percent in the transport sector (7 Mtoe), and 5 percent in the public sector (1.9 Mtoe). Korea's energy efficiency strategy includes building codes for new buildings over a certain size and a certification system; businesses with buildings that consume more than 2 ktoe/year can participate in Energy Saving Partnerships or enter into voluntary agreements. Businesses and individuals who invest in energy-saving facilities are entitled to tax reductions (up to 20 percent of investment costs for a year) or low-interest loans. Three labeling programs have been launched to promote high-efficiency appliances: the Energy Efficiency Standards and Labeling Program (1992), the High efficiency Appliances Certification Program (1996) and the E-Standby Program (1999). Energy service companies (ESCOs) have been operating since 1992.

Despite the unprecedented progress China has made in reducing the energy intensity of its economy over the past three decades, a large gap between China and the high-income countries remain in energy productivity. During the "Eleventh Five Year" period, new green technologies have been implemented to improve the energy efficiency in traditional sectors in China. Let us take the ten major energy conservation projects as an example. From 2006 to 2010, the central budget

Table 2. Energy Productivity of China and Korea

(Unit: US$ per ktoe)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
China	1.45	2.13	3.08	3.16	3.26	3.52	3.57	3.61	3.71	3.82
Korea	5.02	4.72	4.68	5.22	5.40	5.46	5.47	5.43	5.29	5.32
USA	4.20	4.40	4.93	5.44	5.64	5.65	5.78	5.87	5.90	6.04
Japan	7.45	7.08	7.07	7.47	7.61	7.84	8.07	8.00	7.94	8.55
OECD	5.35	5.50	5.99	6.40	6.61	6.74	6.85	6.90	6.88	7.14

Source: OECD Statistic Database, http://new.sourceoecd.org/.

for investment and the special funds for energy conservation was arranged by the central government amounted to 30.5 billion Yuan, which was aimed at implementing 5100 individual projects comprising in the ten major energy conservation projects, which represented an energy-saving capacity of 160 million tons standard coal. Over the past five years, China's steel industry promoted the use of complementary energy such as blast furnace gas, coke oven gas and converter gas. The self-generating capacity increased from 6.8 million kilowatts in 2005 to 16.8 million kilowatts in 2009. It saved 13.63 million tons of standard coal and reduced 34 million tons and 300,000 tons of carbon dioxide emissions and sulfur dioxide emissions, and cut down about $ 20 billion in purchase costs.

2.1.2. Expansion of Emerging Green Industries

Emerging industries are green if they emit low levels of pollution and greenhouse gases. The most concrete example of emerging green industries is clean energy, and some industries such as solar power, wind power, biomass, and hydropower have already been commercialized on a large scale. Take the development of new and renewable energy industry as an example. In 2011, Korea's energy consumption structure was still largely based on oil, coal, and natural gas. These three traditional types of energy accounted for 86% of total energy consumption in Korea, among which the proportion of oil, coal and natural gas consumption reached 40%, 30%

and 16% respectively. Nuclear energy accounted for 13% of total consumption and hydropower less than 0.5%. And the proportion of consumption of other types of clean energy, including wind, geothermal, solar, biomass and biofuels, was only 0.2%, which could almost be negligible.

Of the total supply of NRE, waste energy contributed the largest proportion with 67.54 percent, following by hydropower with 12.73 percent, and other types of energy such as photovoltaic (PV) with 19.73 percent. NRE power generation has increased rapidly in particular, PV and Wind area, thanks to the introduction of the FIT and RPS systems. In terms of PV, power generation has increased nearly 30 times to 917198 MWh in 2011 from 31,022MWh in 2006, and Wind increased to 862,884MWh from 238,911MWh. NRE generation accounted for 17345GWh (1.24%) of total 501527009GWh of electricity generated in 2011 (Waste power generation accounted for 58.8%).

According to the long-term target for NRE deployment in Korea, the annual rate of increase for new and renewable energy supply is 7.8% from 2010 to 2030. The fastest growth of NRE supply comes from Marine sources. And the proportion

Table 3. The status of Energy Consumption in Korea

(Unit: Million toe)

	2003	2004	2005	2006	2007	2008	2009	2010	2011	Portion(%) by 2011
Coal	51.1	53.1	54.8	56.7	59.7	66.1	68.6	77.1	83.6	30.3
Oil	102.4	100.6	101.5	101.8	105.5	100.2	102.3	104.3	105.1	38.2
LNG	24.2	28.4	30.4	32.0	34.7	35.7	33.9	43.0	46.3	16.8
Nuclear	32.4	32.7	36.7	37.2	30.7	32.5	31.8	31.9	32.3	11.7
Hydro	1.7	1.5	1.3	1.3	1.1	1.2	1.2	1.4	1.7	0.6
Others	3.2	4.0	4.0	4.4	4.8	5.2	5.5	6.1	6.6	2.4
Total	215.1	220.2	228.6	233.4	236.5	240.8	243.3	263.8	275.7	100

Source: Korea Energy Management Corporation, Overview of New and Renewable Energy in Korea 2013, 2013.

Table 4. Energy Supplied by New and Renewable Sources in Korea from 2000 to 2010

	2000	2005	2006	2007	2008	2009	2010
Supply amount	2127.40	4879.20	5225.20	5608.80	5858.50	6086.20	6856.30
(Share,%)	1.6	2.1	2.2	2.4	2.4	2.5	2.6
Solar heat energy	41.7	34.7	33	29.4	28	30.7	29.3
Photovoltaic energy	1.3	3.6	7.8	15.3	61.1	121.7	166.2
Biomass	82	181.3	274.5	370.2	426.8	580.4	754.6
Waste	1977.7	3705.5	3975.3	4319.3	4568.6	4558.1	4862.3
Hydraulic power	20.5	918.5	867.1	780.9	660.1	606.6	792.3
Wind power	4.2	32.5	59.7	80.8	93.7	147.4	175.6
Geothermal energy	-	2.6	6.2	11.1	15.7	22.1	33.4
Hydrogen and fuel cell	-	0.5	1.7	1.8	4.4	19.2	42.3

Source: Korea Energy Management Corporation, Overview of New and Renewable Energy in Korea 2013, 2013.

of waste energy supply will steadily decline from 67.4% in 2010 to 33.4% in 2030, with a maximum degree of growth occurring in bio-energy, increasing from 13% in 2010 to 31.4% in 2030.

To achieve these targets, Korean government issued many programs to popularize NRE. One example is the creation of a subsidy program. The objective of the subsidy program is to create an initial market for new technologies and systems developed domestically, and to establish and activate the deployment infrastructure of commercialized technologies and equipments. These subsidies are classified into two categories which are the test-period deployment subsidy and the general deployment subsidy. The total subsidies provided from 1993 to 2012 amounts to 195 billion KRW. Another example is the regional deployment subsidy program. The government promoted this program since 1996 to support various projects carried out by local governments. Depending on the support ratio of the government subsidy and the nature of project, subsidies can be classified into two categories until 2010: for building the infrastructure and for installing NRE systems.[4)]

The seven strategic industries targeted by China, including new energy, next generation information technology, biotechnology, high-end manufacturing, clean-energy vehicles, and high-tech materials, are environmental protection and energy

Table 5. NRE Deployment Projections (by Sources)

(Unit: 1000 toe, %)

	2010	2015	2020	2030	Annual increase(%)
Solar thermal	40	63	342	1882	20.2
	(0.5)	(0.5)	(2.0)	(5.7)	
PV	138	313	552	1364	15.3
	(1.8)	(2.7)	(3.2)	(4.1)	
Wind	220	1084	2035	4155	18.1
	(2.9)	(9.2)	(11.6)	(12.6)	
Bioenergy	987	2210	4211	10357	14.6
	(13.0)	(18.8)	(24.0)	(31.4)	
Hydro	972	1071	1165	1447	1.9
	(12.8)	(9.1)	(6.6)	(4.4)	
Geothermal	43	280	544	1261	25.5
	(0.6)	(2.4)	(3.1)	(3.8)	
Marine	70	393	907	1540	49.6
	(0.9)	(3.3)	(5.2)	(4.7)	
Waste	5097	6316	7764	11021	4
	(67.4)	(53.8)	(44.3)	(33.4)	
Total	7566	11731	17520	33027	7.8
Primary Energy (Mtoe)	253	270	287	300	0.9
Share	2.98%	4.33%	6.08%	11.00%	

Source: Korea Energy Management Corporation, Overview of New and Renewable Energy in Korea 2013, 2013.

4) But government has been promoting regional deployment subsidy program for only installing NRE systems from 2011.

efficiency. In 2010, the added value of strategic emerging industries in China 2551.37 billion Yuan, accounting for a proportion of 6.36% in GDP. Compared to the proportion of 5.82% in 2008, it increased 0.54 percentage points. China is now the world leader in renewable energy investment, surpassing all other countries. The wind power industry alone accounts for more than RMB 161 billion ($25 billion) a year in investment, with 20 gigawatts installed per year. And the strategic emerging industries in the industrial sector accounted for 4.03% of the GDP, an increase of 0.7 percentage points compared to 2008. And the strategic emerging industries in the industrial sector accounted for 2.33% of GDP, an increase of 0.16 percentage points compared to 2008. Furthermore, if the State Council targets are met, the contribution of emerging green industries to China's GDP will be 15 percent by 2020.

Since 2005, implementation of green growth strategy fostered development of huge markets in China. Let us take the market of energy-saving equipment as an example. In 2010, the market size for ground source heat pump was about

Table 6. Industrial Added Value of China's Strategic Emerging Industry in 2010

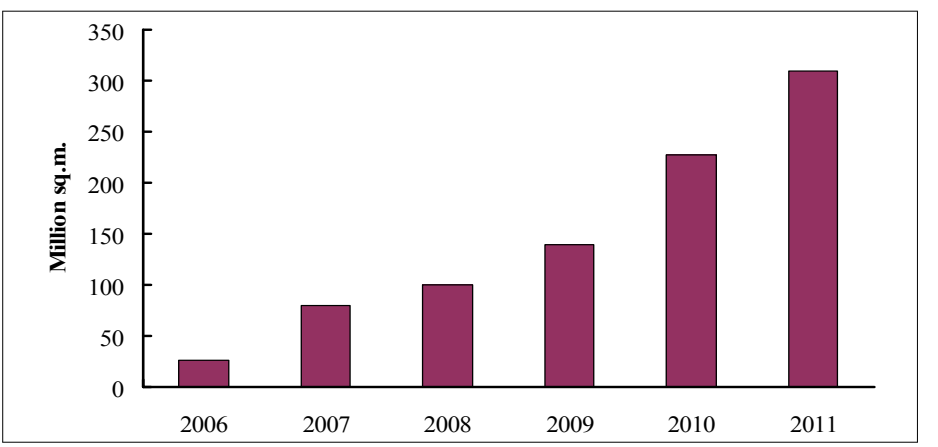
Strategic Emerging Industry	Value Added (billion yuan)	Value Added as a sharp of GDP (%)	Value Added as a sharp of total strategic emerging industry (%)
Environmental Protection and Energy Efficiency	73.9	0.184	2.897
Next Generation Information Technology	1636.98	4.08	64.161
Biotechnology	45.55	0.114	1.785
High-end Manufacturing	502.71	1.253	19.704
New Energy	189.2	0.472	7.416
High-tech Materials	102.11	0.255	4.002
Clean-energy Vehicles	0.93	0.002	0.004
Total	2551.37	6.359	100

Source: Zhoujing. Development and Distribution of Strategic Emerging Industries in China. Statistical Research. Vol. 29. No. 9. 2012.

25 billion Yuan, an increase of about 31%, the largest increase in recent years. Till 2011, the market size reached 3.1 billion Yuan. During "Eleventh Five-Year" period, the gross output value of energy service industry increased from 4.73 billion Yuan to 83.629 billion Yuan, with an annual growth rate above 40%. By the end of 2011, the gross output value of China's energy service industry reached 125 billion Yuan, of which the gross output value of energy performance contracting (EPC) accounted for 41.2 billion Yuan, almost one-third of the total for China's entire energy service industry. In August 2013, the State Council of China issued an document named "Views on Accelerating the Development of Energy-saving and Environmental Protection Industry". This document put forward a goal to promote faster development of energy-saving and environmental protection industry from 2013 to 2015: in 2015, the gross output value of this industry will reach 4.5 trillion Yuan, and become a new pillar for the national economy.

In China, subsidy programs have also been implemented to promote development of energy-saving and renewable energy industries. Starting in 2011, the Ministry of Finance, the Ministry of Housing and Urban-Rural Development launched a series of demonstrations for energy-saving in public buildings of key cities. The

Figure 12. GSHP (Ground Source Heat Pump) Cumulative Application Area in China



first group of cities, including Shenzhen, Tianjin and Chongqing, received a total of 240 million yuan in financial subsidy from central government funds. At least 12 million square meters in public buildings will be allotted for energy-saving activities in these three cities. By 2015, public building energy consumption per unit area of key cities should be reduced by more than 20%, of which energy consumption per unit area in large public buildings should be reduced by 30%.

2.1.3. Expansion of the Service Sector

The green transformation will impact the service sector in two ways. First, it will give birth to new green service industries, such as ecosystem services, carbon asset management services, carbon trading, and contract energy management. Second, it will support the country's intended economic rebalancing away from heavy manufacturing and toward a larger service sector. Both trends are important for reducing not only China's but also Korea's carbon footprint.

In Korea, energy-intensive industries, such as steel, petrochemicals and cement, accounted for 12% of total value-added in 2008, the highest in the OECD area and well above the OECD average of 8%. While per capita energy use in the transport, residential and commercial sectors was below the OECD average, the figures for industry was almost 50% above the OECD average in industry. In

Table 7. The Share of the Service Sector in Total Value Added in Several Countries

(Unit: %)

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
China	31.5	32.9	39.0	40.5	40.9	41.9	41.8	43.4	43.2	43.3
Korea	49.5	51.8	57.3	59.0	59.7	60.0	60.8	60.4	58.5	58.1
Japan	60.4	65.4	67.4	70.7	70.8	70.7	71.4	72.9	71.5	
USA	70.1	72.1	75.4	76.6	76.7	76.9	77.6	79.3	78.8	
Germany	61.2	66.6	68.2	69.7	69.1	68.6	69.4	72.4	71.2	
OECD	65.1	68.3	70.8	72.7	72.7	72.9	73.5	75.4	74.4	

Source: OECD Statistic Database, http://new.sourceoecd.org/.

contrast to the high share of energy-intensive industry in GDP, the share of the service sector in Korea is one of the lowest at 60% of value added. Energy intensity in services in Korea is less than one third of that of manufacturing. One of the benefits of developing the service sector would be to reduce energy-intensity. Such an approach would help achieve the government's target of reducing energy intensity by one-third of the 2006 level by 2020, or at levels similar to the OECD average.

In China, the emerging green service sector is already important. According to a trade association of energy conservation service providers in China, at the end of 2012, the total value of China's energy conservation service industry was RMB 165 billion ($25 billion). Compared with Korea, the share of services in total value added was much lower. And according to estimates by the DRC, the energy intensity of output (value added) by services was one-fifth of secondary industries in 2009. Every percentage point increase in the share of services in GDP is associated with a decline in energy consumption of 1.4 percentage points in China.

2.2. Promotion of environmental tax

Revenue from environmental taxes in Korea increased from 2.16% of GDP in 1995 to 2.86% in 2007, and then decreased to 2.42% in 2011. In China, the ratio of revenue from environmental taxes to GDP was 1.36% in 2011, which was lower than that of Korea. However, the growth rate of this ratio increased rapidly since 2000 in China. Given Korea's low overall tax burden, environmental taxes accounted for 9.5% of total tax revenue, well above the OECD average of 5.4%. The rising share in Korea reflects tax reforms to encourage energy conservation and protect the environment. Between 2001 and 2007, the government raised the tax on diesel by 2.4 times in real terms and the tax on LPG butane by 6.8 times.

Table 8. The Ratio of Revenue from Environmental Taxes[5] to GDP in Several Countries

(Unit: %)

	1995	2000	2005	2006	2007	2008	2009	2010	2011
China	0.00	0.39	0.76	0.77	0.78	0.76	1.27	1.42	1.36
Korea	2.16	2.79	2.72	2.68	2.86	2.75	2.45	2.78	2.42
Japan	1.69	1.73	1.75	1.72	1.68	1.61	1.68	1.60	1.59
USA	1.12	1.00	0.89	0.88	0.84	0.81	0.82	0.80	0.46
Germany	2.35	2.36	2.49	2.42	2.24	2.21	2.29	2.18	2.24
OECD	1.93	1.80	1.78	1.72	1.71	1.62	1.68	1.65	1.43

Source: OECD Statistic Database, http://new.sourceoecd.org/.

Korea has three types of taxes and charges: (1) on the import of petroleum and coal, (2) on transportation fuel such as gasoline and light oil, and (3) on the sale of electricity. There are also the tax levied on the purchase and ownership of an automobile. The share of these taxes in the national tax revenue is 16.1%. In addition to these taxes, Korea has implemented many environmental charges based on the polluters-pay principle. If these charges are included, Korea would be ranked high among the OECD members in terms of their share in the GDP.

At present, China mainly takes measures such as administrative penalties and pollution charges to control environmental pollution. Because the amount of penalty fees is less than the costs of reducing pollution by enterprises, enterprises lack the motivation to cut emissions and simply choose to accept the punishment. So the effect of the implementation of the policy is not obvious. The scheme to levy environmental tax has been submitted to the State Council of the Chinese government in 2013. Though the estimates are far from complete, if the above mentioned

5) **Environmentally related tax revenues** are expressed in percentage of GDP. Environmentally related taxes include (i) energy products for transport purposes (petrol and diesel) and for stationary purposes (fossil fuels and electricity); (ii) motor vehicles and transport (one-off import or sales taxes, recurrent taxes on registration or road use and other transport taxes); (iii) waste management (final disposal, packaging and other waste-related product taxes); (iv) ozone-depleting substances and (v) other taxes.

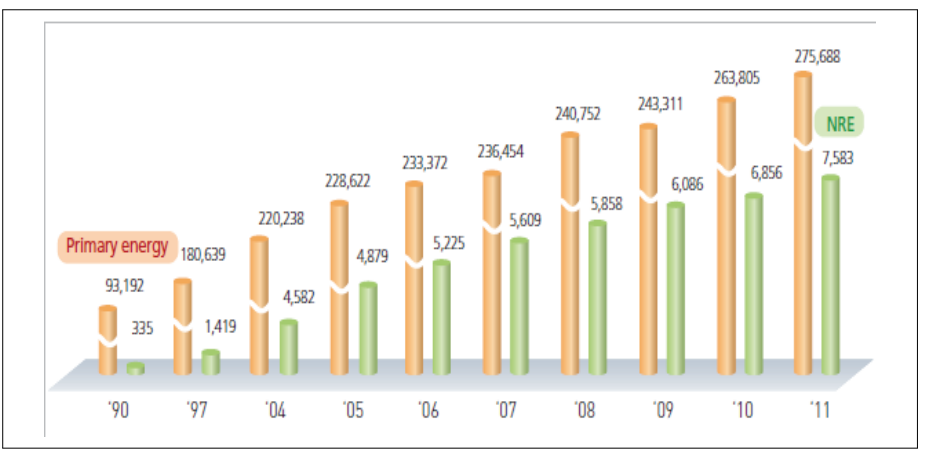
environmental taxes are fully implemented and collected, then it is estimated, based on the tax base of 2006, the gross national environmental tax revenue would reach 233 billion Yuan, which would represent 6.0% of the total government fiscal revenue and 6.7% of the tax revenue respectively. It also makes up 1.1% of the GDP for 2006.

2.3. Make Subsidies More Greener

2.3.1. How to subsidize Renewable Energy industry

In 2002, Korea established a Feed-In-Tariff (FIT) system to expand the market for renewable energy. The feed-in tariff (FIT) system compensated for differences between costs of generating electricity from renewable energy and baseline generation costs. With the promotion of the FIT system, the share of renewable energy in total primary energy supply (TPES) increased from 1.4% to 2.75% in 2011, leading to a large increase in the number of firms in this sector and their exports.

Figure 13. Share of Renewable Energy in Korea



Source: Korea Energy Management Corporation, New and renewable energy statistics.

In 2012, the government replaced the FIT with a quantity-based instrument named Renewable Portfolio Standard (RPS), which obliges electric power companies to produce or buy a specified share of their electricity from renewable sources. The RPS target for renewable energy is 2% of total electricity supply in 2012, rising to 10% by 2022. An important reason for shifting from a price-based instrument to a quantity-based instrument is that it can reduce the financial burden on the government as it no longer has to provide subsidies.

And this is just the problem the Chinese government is faced with. Renewable energy tariff standard increased from 0.1 cent/kWh to 0.8 cent/kWh at the end of 2011. According to the published plan, China's subsidies for electricity from renewable sources are no less than 100 billion Yuan in 2015. According to the estimation at the current level of 0.8 cent per kWh, about 48 billion Yuan may be levied for funding renewable energy tariff subsidies in 2015. But there are still over 500 million gap in funding. Until then, the government will face a dilemma, either to default subsidies, or to raise the price of electricity. At present, since the downward pressure on China's economy is increasing, the rise in electricity prices will greatly affect the competitiveness of enterprises and offset the bonus from structural tax cuts and other measures.

Meanwhile, disadvantages of government subsidies continue to appear in 2013. The "Gold Sun" demonstration project, which gives 50% to 70% of construction end subsidies to the solar roof project included in the list, was started in 2009 by the Ministry of Finance, the National Energy Board and the Ministry of Science and Technology in China. A total of more than 900 projects have been included in the list of subsidies, for which the central government subsidies amounted to more than 200 billion Yuan. However, according to the National Audit Office's audit results in 2013, a number of companies and units defrauded the central government for subsidies of about 260 million Yuan by fabricating false application materials.

Relevant departments in China have begun to realize that subsidies are not a permanent solution. It can only cope with a relatively low price of wind power. But once the scale of photovoltaic power generation (with higher prices) grows

as quickly as that of wind power, subsidies will not work. Tradable certificate systems tend to be more effective in promoting renewable energy if they use long-term contracts, thus reducing the risk associated with the short-run volatility of certificate prices. It provides an alternative choice for the Chinese government to substitute the existing subsidy policy.

2.3.2. Remove environmentally harmful energy subsidies

The International Energy Agency (IEA) estimated that in 2010, fossil fuel consumption subsidies reached $409 billion. According to the IEA's analysis, if subsidies can be gradually phased out by 2020, then global primary energy demand would decrease by 3.9 percent and CO_2 emissions from energy by 4.6 percent by that year, compared with a baseline in which subsidies are unchanged.

In Korea, there are few explicit subsidies for fossil fuels and they do not protect any important domestic industries. The main subsidy is for the production of coal and its use in the form of charcoal briquettes by low-income households. Despite the gradual decline in the subsidy, it still amounted to 267 billion won in 2009, equivalent to around 5% of total environment-related spending by the central government.

In China, according to the estimation of the IEA, fossil fuel subsidies reached $18.6 billion and the average subsidy rate is 4%. According to research by Huang (2010) and others, undervaluing China's labor, capital, land, energy, and environment is tantamount to offering subsidies to resource-intensive industries. For example, in 2009, subsidies embodied in artificially low energy prices were equal to about 0.7 percent of GDP. H. Li (2011), based on 2007 data, stated that eliminating fossil fuel subsidies would reduce China's emissions by 6.21 billion tons of CO_2.

2.4. R&D in Green Technologies

To avoid government failure, policies to promote green industries should be

as neutral as possible, focusing on basic and long-term R&D in technologies that are still too far from commercial viability to attract private investment. Table 8 compiles R&D investment schedules for green technologies. It shows the current status of technology development with actual investment and future mid-term targets. Compared to the total national R&D investment increase from USD 10.26 to USD 11.37 billion (10.8%) over the same period, the increase in green technology R&D (40.0% for overall green technology and 35.1% for 27 core green technologies) confirms the remarkable change in policy priorities since the launch of the Korean Green Growth Initiative. In 2012 an investment of USD 2.98 billion is expected which is much higher than the proposed target of USD 2.59 billion. All told, green technology investment represents about 25% of total government R&D investment.

In 2011, the government assessed progress in these technologies, based on patent data and appraisal by experts. It was found that Korea's overall level of technology had increased from about one-half of the most advanced countries in 2009 to around two-thirds in 2011. In the six technologies including CO2 capture and storage, smart grid and green cars, the gap had been reduced by more than 20 percentage points. Moreover, Korea's development of five technologies including LED and green IT, silicon-based solar cells and light-water reactors, reached at

Table 9. Green Technology Investment Schedule (2008–2012)

(Unit: billion USD)

Category		2008	2009	2010	2011	2012	Note
National R&D	Target	10.26	11.37	12.66	13.77	15.34	
Green Technology R&D	Target	1.29	1.76	2.03	2.31	2.59	19% (annual growth rate)
	(Weight, %)	(12.60)	(15.40)	(16.10)	(16.80)	(16.90)	
	Planned	1.35	1.89	2.14	2.43	2.75	
Core Green Technology R&D (27)	Target	0.92	1.29	1.57	1.85	2.13	23.4% (annual growth rate)
	(Weight, %)	(71.70)	(72.00)	(77.30)	(80.00)	(82.10)	
	Planned	0.97	1.31	1.65	1.94	2.26	

Source: MEST (2010).

least 80% of the cutting-edge technologies in advanced countries.

In China, the most serious problems in terms of development of strategic emerging industry are the lack of R&D capabilities and core technology, and also inadequate control of intellectual property. Although in recent years, China's manufacturing industry is developing at an alarming rate, it is still in the low-end position in the global industry value chain, which is mainly due to the lack of advanced technology. The technical decision-making power of three core technologies in manufacturing of new energy automobiles including batteries, motors and electric control system lay with foreign auto giants. In 2010, the ratio of R&D investment to GDP reached 1.76% in China, but there were still some gaps with the average level of 2.5% in developed countries. Although R&D investment by enterprises increased gradually since 2000 and has presently reached 73% of total R&D investment, the ratio of enterprises with R&D activities accounted for only about 10% of all enterprises in 2010. And R&D activities were unstable in 49.25% of enterprises with R&D activities.

2.5. Provide Strong Market Stimuli

2.5.1. Channel Funds to Green Business

In Korea, the government is using various channels to supply money to green businesses. Because of the high risk of green finance and its long investment horizon, credit guarantees are used to activate green lending. During the first half of the Five-Year Plan (2009 to mid-2011), credit guarantees of 14 trillion won (1.3% of 2009 GDP) were provided to green industries by two public institutions. Green industries thus account for a significant share of the 62 trillion won in outstanding guarantees, which are primarily given to small and medium-sized enterprises (SMEs). The large share reflects the priority given to green industries in deciding which loans to guarantee. In addition, the ceiling on the amount guaranteed is higher for green loans at 7 billion won ($6.2 million), compared to 3 billion won for

non-green loans, and the fee for the guarantees is lower. Total bank loans to green industries amounted to 17.7 trillion won between 2009 and mid-2011.

In the new and renewable energy industry, the government provides long-term, low-interest loans for customers or manufacturers of NRE systems which have been completely commercialized. The objective of the program is to expand the deployment of NRE systems as well as to promote commercialization of large-scale facilities. Installation loans are provided when customers install NRE systems, while operation loans are provided to the manufacturer of NRE facilities or to operate and manage such facilities. Loans are provided for up to 90% of the total cost (up to 50% for large corporations). In addition, about 10% of total investment in installation of NRE systems can be deducted from the income tax or corporate income tax.

To reduce the risk of green finance, a well-functioning certification system to determine which firms are truly green was established by the Green Certification Committee, which determines which technologies, projects and firms qualify, based on evaluation by the Korea Institute of Advancement of Technology. By October 2011, 456 technologies and 12 projects had been certified. In addition, firms in which certified green technologies account for more than 30% of sales can be certified as green firms. The Small and Medium Business Administration also grants

Table 10. Green Financing in Korea

(Unit: billion won)

		2009	2010	First half of 2011	Total
Guarantees	KODIT	1662	1820	1475	4975
	KOTEC	2624	3612	2931	9167
	Sub-total	4286	5432	4406	14124
Bank loans		5292	8009	4381	17682
Venture capital (Number of firms)		367	527	337	1231

Source: Jones, R. S. and B. Yoo (2012). " Achieving the "Low Carbon, Green Growth" Vision in Korea", OECD Economics Department Working Papers, No. 964, OECD Publishing.

green venture certificates under its venture certification system. The number of such certificates increased from 1133 (7.4% of all venture businesses in 2008) to 1785 in 2010 (9.5%).

In China, the Banking Association began to publish "Social Responsibility Report of China's Banks" from 2009, which was a summary of the information submitted by commercial banks. It reveals the status of implementation of the green credit in China. Two indicators in the report, "the bank to withdraw for two high projects" and "environmental protection projects loans", directly reflect the implementation of green credit policy and measures. China's commercial banks adopted a "list-style" management approach, as well as differentiated pricing of risk, adjustment of economic capital coefficient, special allowance and other methods to control the credit to the "two high and one left" industry. This drastically reduced lending to thermal power generation, coke and other industries. In 2010, commercial bank loans to steel, cement, plate glass, coal, chemical, electric power, petrochemical and shipbuilding industries with excess capacity declined by 0.37 percent, compared to 2009. Meanwhile, the size of commercial banks' green loans in energy saving and low-carbon economy grew rapidly from 2008 to 2011. As the first domestic bank to carry out the green credit business, as of the end of March 2013, the Industrial Bank has provided accumulated financing of 243.2 billion Yuan in the energy-saving field. And the financing balance reached 126.9 billion Yuan.

Still, the overall evaluation in the "China Green Credit Development Report 2011" showed that the green credit of China's banking industry was at low level. And the banking industry was in a dilemma between economic efficiency and

Table 11. The Change of Loan for energy-saving and environment-friendly projects in China

(Unit: Billion Yuan)

	2004	2005	2006	2007	2008	2009	2010	2011
Loan balance of energy saving and environmental protection	90	130	200	340	370	860	1010	1265

Source: 许黎惠,徐晓然, 我国商业银行绿色信贷的开展, 财会月刊, 2013.

environmental protection and social responsibility. In China, loans to the projects of "two high and one left" still represent a high proportion, which is reflected especially in city commercial banks. The total loans to green credit projects or energy saving projects are increasing, but their proportion remain low. There is also the lack of transparency regarding environmental information disclosure of banks. And information exchange regulatory authority need to be strengthened. Most important, a well-functioning certification system was still lacking in China's green credit. Because the projects of new energy and energy efficiency technology are mainly in the development stage, market maturity is not high. Banks face a potential high risk in granting loans to these projects. So an authoritative certification system is important to guide the bank loans and reduce the potential risk.

2.5.2. Improve Air Quality with Market Mechanism

According to the OECD Better Life Index in 2011, levels in Korea of atmospheric PM10-tiny air pollutants small enough to enter and cause damage to the lungs-was 33 micrograms per cubic meter, which was considerably higher than the OECD average of 21 micrograms per cubic meter. Improving air quality is a priority in Korea, given that PM10 levels in the capital region (Seoul, Incheon and parts of Gyeonggi province) is one of the worst among OECD countries. The government's objective is to improve air quality in the capital region to the average OECD level by 2014. To that end, an emission cap-and-trade programme was introduced in 2008 covering NOx, SOx and Total Suspended Particles (TSP) in the capital region. The system was extended in 2010 to mid-size emitters, covering a total of around 300 factories in the capital region. It thus covers 84% of NOx, 78% of SOx and 57% of TSP emissions in the capital region.

In China, compared to developed countries, emissions trading carried out in the past were not exactly market transactions, which were mostly conducted with the coordination of government departments. According to statistics, from 2008, when the Ministry of Finance approved the pilot, to April 2012, there were more

than 12,000 transactions in the 10 pilot provinces, and the trading volume was over 1.8 billion Yuan. However, most of these transactions happened in the way of auctioning emission allowances between the government and enterprises. The real active secondary market is far from mature. And this administrative intervention hindered, to a large extent, the establishment of a market price mechanism.

Currently, the objects of pollutant emissions trading are sulfur dioxide and chemical oxygen demand. They are also the major pollutants for which total amount control policy is being implemented. After the energy conservation target responsibility system was established, local governments were faced with stringent pressure to reduce pollutant emissions. Therefore, the total amount available for trading in emission rights was not the sum of the emission rights owned by existing polluters, but the remaining part after the emissions reduction requirements by region have been fulfilled. This has resulted in a cutback in the tradable number of emission rights during each cycle of emissions reductions. Some enterprises have difficulties reaching the emissions reduction target. Even if they reach the target, they exhaust the quota which can be traded in the market and transaction cannot be carried out. In breaking down sulfur dioxide control targets in 2006, the Chinese government set aside 477,000 tons of emissions right as compensation for the allocation of emission rights and emissions trading pilot, but until now, the use of this amount of emission rights has been unaccounted for. This fully shows the fading market trading mechanism and the dominant role of administrative means during the "Eleventh Five-Year" period.

2.5.3. Flourishing Market for Carbon Emissions Trading

Since 2005, the government has been operating a voluntary carbon market called Korea Certified Emissions Reductions (KCERs), which is open to firms that have reduced CO2 emissions by more than 500 tonnes a year through improved energy efficiency and production processes and investment in renewable energy development. Companies receive KCERs for their voluntary GHG reduction projects,

which can be traded in the market or purchased for around 5000 won (about $4.50) per tonne. In practice, there are few buyers given the lack of domestic reduction obligations, so the government buys most KCERs to promote and compensate measures to reduce GHG emissions. As of the end of 2009, 287 projects had generated 5.6 million KCERs, out of which 4.7 million had been purchased by the government for 23 billion won ($20 million). The government also launched a carbon fund of 105 billion won with the participation of private capital in 2007 to invest in CDM projects and purchase CERs or allowances.

Then, in May 2012, the National Assembly approved legislation to create a cap-and-trade ETS in 2015 covering six types of GHGs. The first step is the creation of a "Target Management System" (TMS), which requires firms emitting more than 15 thousand tonnes annually to set targets with the government beginning in 2012. Firms emitting over 25 thousand tonnes, a threshold that included 497 firms in 2011 accounting for around 60% of total emissions, will join the ETS in 2015. Less than 5% of the permits may be auctioned in the first (2015-17) and second phases (2018-20). The system for allocating the remainder of the permits is yet to be decided. Firms with 15 to 25 thousand tonnes of emissions can enter the ETS or remain in the TMS after 2015. Firms that fail to meet their objectives in the TMS will be subject to fines. In total, Korea's carbon trading system would include 60 percent of the country's greenhouse gas emissions. Industries such as steel, manufacturing, shipbuilding, electric power and other industries will be included in the system.

There is no doubt that the enactment of a carbon trading system could accelerate the development of energy conversation technologies in industry. And this will allow Korea to gain an opportunity for long-term benefits to gain a big lead with respect to the environmental industry. The Korea Industrial Association stressed that although up to 95% of the emission target is allocated freely at the early stage of implementation and only 5% needs to buy, it will mean 4.7 trillion won (about $ 4.2 billion) of additional costs to the industry. Many Korean companies opposed these mandatory measures to limit carbon emissions. They believe that

this will weaken local companies' competitiveness in the global market and affect GDP growth in Korea. However, a study by the Korean government shows that the direct cost to achieve the emission reduction targets by 2020 is only about 0.5% of GDP. The government believes that a carbon trading mechanism is the most effective way to control greenhouse gas emissions in Korea.

Although China has the largest carbon resource in the world and is the largest carbon CERs supplier in the international carbon trading market, it has not formed a unified national carbon trading market. So it lacks the pricing power and is only a passive participant in the international carbon trading market, which led to massive carbon CERs sold cheaply to developed countries. And the latter packaged them into financial products of high-end carbon assets and changed hands to reap huge profits. In 2013, the carbon trading markets in Shenzhen, Shanghai, and Beijing were launched, followed by those of the other four pilot provinces and cities, which are also expected to start this year. This is considered to be an ice-breaking behavior on the part of China to form a national unity carbon trading market. The seven pilot provinces and cities will confirm pilot enterprises based on their own situation and how much carbon dioxide enterprises discharge. Some provinces confirmed pilot enterprises with an annual amount of more than 5,000 tons of carbon dioxide emissions. The rests can apply to join the carbon emission quotas distribution system by themselves. Beijing municipal government announced that the units in the administrative areas of Beijing with emissions from fixed facilities and more than 10,000 tons of direct and indirect carbon dioxide emissions can participate in emissions trading.

III. Conclusion

At present, China and Korea are cultivating their own strategic emerging industries. And the measures taken by the two governments such as subsidies,

tax breaks, emissions trading market building have some similarities. From the perspective of long-term cooperation, China and Korea should avoid homogeneous competition on development of strategic emerging industries. In this way, products and technologies of Korea's strategic emerging industries will able to adapt and meet the needs of a range of new green markets in China during the green transformation period. This has important implications for the expansion of cooperation and trade between China and Korea.

In the field of new energy industries, along with structural changes in energy demand and strong government support, China began to accelerate the development of clean energy industries and some industries have entered growth and maturation stages. China is close to or even exceeds the level of Korean technology and market share in the photovoltaic cell manufacturing, solar water heaters, wind power equipment manufacturing and other industries. It demonstrates significant potential advantages. In fact, compared to China's more favorable endowments for new energy of China, Korea's land and climate conditions are not conducive for the development and popularity of renewable energy. Inadequate level of production scale also leads to a lack of cost competitiveness of clean energy (except nuclear power) compared with traditional fossil fuels. And nuclear technology output to China by Korea will be hindered by the fact that development prospects for nuclear power is not clear. In my opinion, the products of solar energy, wind energy, hydropower in Korea will not be more attractive than similar products produced by comparative firms in China. Therefore, investment and R&D efforts of Korea should give greater focus to fields of new energy vehicles, green building products, smart appliances and other equipment, which would gain more comparative advantages for Korea in technical terms; in addition to increased focus on mature segments such as power generation from waste incineration. Meanwhile, it would be worthwhile for companies of Korea to investment in emerging green service industries in China such as energy performance contracting, contract for environmental services and operation services for smart cities, all of which have great prospects for development and market potential for the future.

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6

The Study on China and Korea's Position on the Global Value Chain after Financial Crisis

Li Dawei[1)]

1. Preface

Given the rapid pace of economic globalization, the volume of foreign trade of both China and Korea has been increasing quickly in the last ten years. By 2012, the foreign trade volume of China had reached $ 3886.98 billion, almost 7.59 times the volume in 2001. And the foreign trade volume of Korea had reached $1067.43billion, almost 3.66 times the volume in 2001. Foreign trade played a very important role in stimulating employment, increasing tax revenue and economic growth in both China and Korea.

One of the most important reasons for rapid growth in foreign trade is that both China and Korea has been participating in the specialization of the global value chain. After China joined the WTO in 2002, there was a significant decline in China's trade barriers. Because of differences in production factor endowments,

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the MNCS can put different links of the value chain in the different countries in the East Asia to maximize the profit. So China and Korea both participated in certain links in the global value chain through intra-product specialization and intra-industry specialization, and became important parts of the East Asian production network. Because of the comparative advantage of the labor-intensive production factor, China assumed most of the role as a processing and assembling link in the global value chain, especially in the IT industry. In essence, China has become the largest processing and manufacturing base in the world.

But after the financial crisis, there have been changes with respect to comparative advantage of China. The price of certain production factors, such as labor, has increased rapidly. So the position on the global value chain of China and Korea may change. Therefore, it is important to use theories of modern value chains and international specialization to analyze the respective positions of China and Korea in the global value chain.

This article also analyzes positions of China and Korea in the global value chain after the financial crisis. The article is divided into five parts: part 2 is a literature review, describing previous research and methodologies related to those used in this article; part 3 focuses on characteristics of the global value chain in certain important industries; part 4 is an empirical study of the position of China and Korea in the global chain of total manufacturing and certain important industries such as IT, automobiles, pharmaceuticals; part 5concludes.

II. Review of Previous Research

2.1. Research on the theory of the value chain

The value chain concept was first put forth by Michael E. Porter in 1985. He deconstructed production as a series of value creation "links"; thus the connection of these "links" is called a value chain. Porter concluded that most value chains

share similar characteristics and contain both production and supporting links. The former mainly includes production and marketing links, while the latter mainly includes related supporting links, such as construction, research and development (R&D), human resources, etc.

Gereffi (1999), from the perspective of product characteristics, divided value chains into producer-driven and buyer-driven chains. Kaplinsky and Morris (2000) further divided value chains into simple value chains and extended value chains. They pointed out that most value chains can be reduced to four interrelated links: R&D, production, sales, and consumption. The detailed value chain is much more complicated than the one mentioned above. It is normally related to several lines of business or industry, and thus forms a bigger value chain network. Gereffi (2005) put forward the world value chain concept, including the entire R&D design link of the upper stage, the spare parts manufacture and assembly found in the middle stage, and the sales, branding, and service found in the lower stage in the world production network. This provided a new perspective for analyzing every country's international specialization within the global chain.

2.2. Research on international specialization

The earliest conception of international specialization can be traced back to Adam Smith's Absolute Advantage Theory, David Ricardo's Relative Advantage Theory, and Heckscher and Ohlin's Resource Endowment Theory. Since the latter part of the previous century, intra-industry trade has gradually increased and became a part of mainstream trade theory. Verdoom (1960) first forwarded the phenomenon of increased trade within the same standard international trade classification (SITC) product group. Balassa (1963) also provided evidence in Europe of the same phenomenon. Gray (1979) and Krugman (1981) developed theoretical models of intra-industry trade. Grubel& Lloyd (1975) also put forward the concept of dividing intra-industry trade into horizontal and vertical trade, a convention that most scholars

have adopted.

In recent years, as multinational companies produce via various value chain links worldwide, vertical specialization is becoming the new type of intra-industry division. Vertical specialization refers to international specialization in different production stages in the same industry. This can be carried out not only by multinational companies but also by nonrelated companies whose markets are in different countries. The vertical specialization (VS) index proposed by Hummels, Ishii, and Yi (2001) provided a method of measuring vertical specialization. Since then, many scholars have conducted in-depth research and measurement of every country's vertical specification status. This theory shares the same theoretical base as the world value chain and will likely become one of the mainstream theories of international specialization.

Many researchers currently use the multi-country input-output models to calculate the different country's value added in the global value chain. Many recent literatures have been devoted to measuring different aspects of international production sharing including Feenstra and Jensen (2009), Jorgenson and Vu (2011), Daudin et al (2011), Jorgenson and Timmer (2011), Johnson and Noguera (2012), Antras (2013), and Timmer, et. al (2013) etc. Zhi Wang & William Powers (2009) extended the quantitative measures of vertical specialization proposed by Hummels, Ishii, and Yi (2001) into a framework that includes many countries and provided systematic quantitative evidence for the nature of East Asian value chains from 1990 to 2000. Jason Dedrick (2009, 2012) calculated the value capture and earnings of different countries in the iPod value chain. Based on the new framework of decomposition of a country's total gross exports, Zhi Wang, Shang-jin Wei &Kunfu Zhu (2013) were the first to decompose the foreign value added in America exports in the industry level.

2.3. Research on China's overall value chain and international specialization

Until now, many scholars have studied the value chain and international

specialization of China's overall industry or individual industries. Liu and Chen (2007) measured the domestic total value added (TVA) in Chinese exports in 41 sectors, using a noncompetitive input-output Table. A research team led by Ping (2005) calculated the VS index for trade between China and the United States. However, an input-output Table that includes 123 sectors is required to analyze the pharmaceutical industry, so there has not been research on the TVA and VS indices of the pharmaceutical industry until presently.

III. Study of the value chain structure in the different industries

3.1. The simple structure of the value chain

Kaplinsky and Morris (2000) studied value chain structure and concluded that value chains can be classified as simple or extended. They maintained that a simple value chain of one product can be described by the four-link model: R&D, production, sales, and consumption, such as Figure 1.The dashed line indicates that the marketing link and consumption link can transfer the feedback of consumers to the R&D link.

Now there are many intermediate products in the production process for every final products. It seems that every intermediate product extends value chains of different products, which become more complicated. The value chain of some final

Figure 1. Four links in a simple value chain

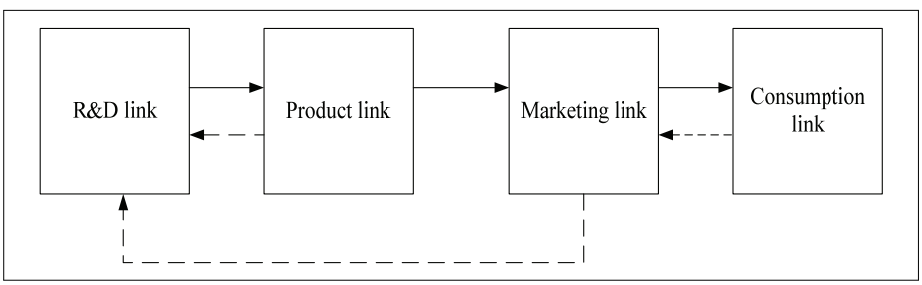
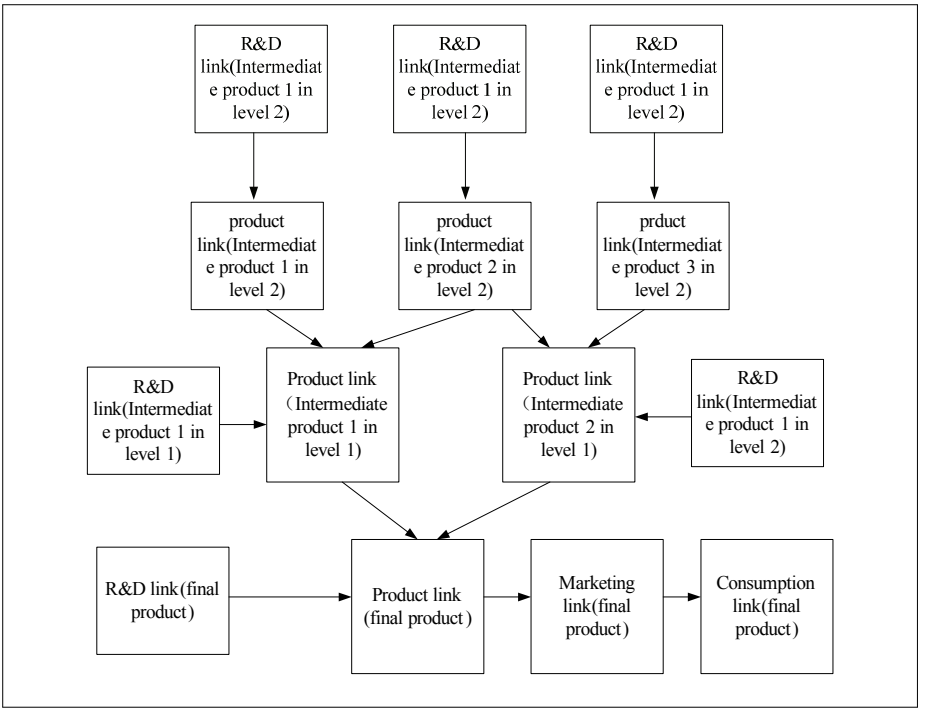


Table 1. Producer-driven and buyer-driven value chains

	Producer-driven Commodity Chains	Buyer-Driven Commodity Chains
Drivers of Global Commodity Chains	Industrial Capital	Commercial Capital
Core Competencies	R&D; Production	Marketing; Design
Barriers	Economies of Scale	Economies of Scope
Typical Industries	Automobiles, Aircraft	Apparel; Footwear; Toys
Ownership of Manufacturing Firms	Transnational Firms	LocalFirms, predominantlyin developing countries
Main Network Links	Investment-based	Trade-based

Figure 2. The structure of a two-level global value chain



products whose product process is simple will be simple, such as agriculture products or foods. But most industrial products have a complex production process and many intermediate products, so the value chain is difficult to analyze. Kaplinsky and Morris used the timber industry as an example to illustrate an extended value chain link chart.

This paper simplifies the value chain in two ways. First, in the real economy, the sales link of intermediate products operate mainly among manufacturers; so this part of the value chain analysis and production processes can be combined. Second, we only choose the two-level structure in the intermediate products. So the value chain of the final products can be designed as Figure 2. However, value chain of different products has the different characteristics. Gereffi (1999) provides a method to judge the characteristics of the product's value chain, as in Table 1.

3.2. The structure of the value chain in the IT industry

IT industry is one of the fastest growing industries in the world and plays a huge role in trade growth of China and Korea in the 21th century. The East Asia is the biggest IT manufacture base in the world, with both China and Korea as the main suppliers of IT products such as PC, smart mobile phone and network equipments. They both have many well-known brands in this field such as Samsung, Lenovo, Huawei,etc. It is obvious that the most important products in the IT industry are PCs and Smartphones, in both China and Korea. They are also the most common products.

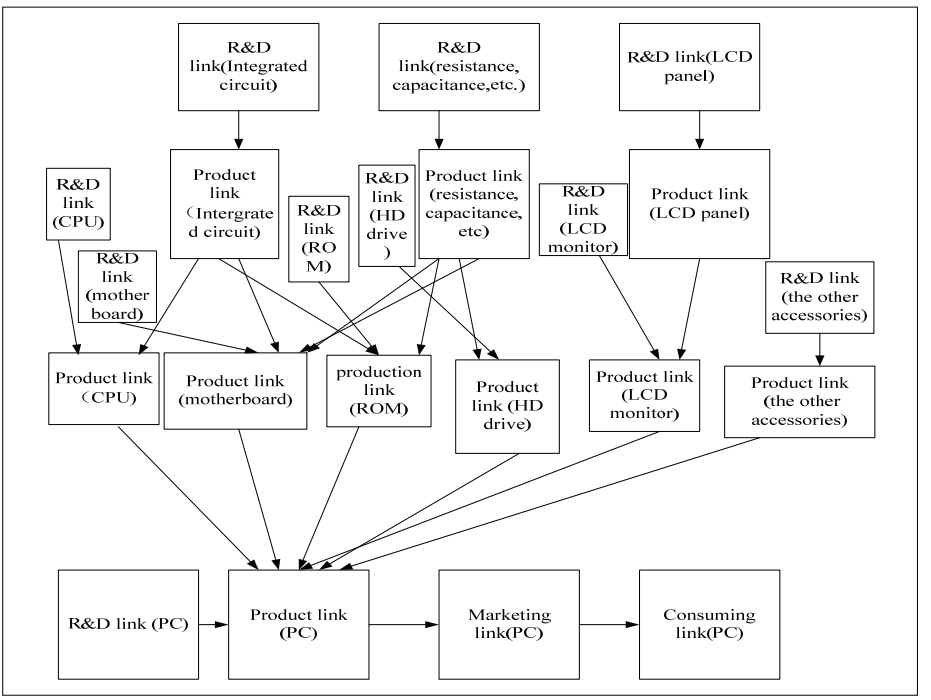
According to an investigation of several IT companies in China and Jason Dedrick's study (2012), the simple value chains of PCs (including Notepad) and smartphones are similar to that of other finished products and follows Kaplinsky's model (2000), as illustrated in Figure 1.

However, the extended value chain of PCs and smart mobile phones has some

noticeable particularities. First, the degree of modularization in IT product's value chain is relatively high. For example, every PC can be easily divided into several computer accessories such as CPU, hard drive, CD-ROM, motherboard, etc. And the production of a PC or a smartphone only represents an assembly link. Also, accessories of smartphone may not be judged as final products, but some accessories are similar to PC accessories.

Second, for some IT products such as PCs, accessories can be deemed both final and the intermediate products. Every accessory has its special value chain. But for the keyboard, mouse or monitor, the integrated circuit is less important. So the study on the value chain of the accessories is more important in the IT industry than in others.

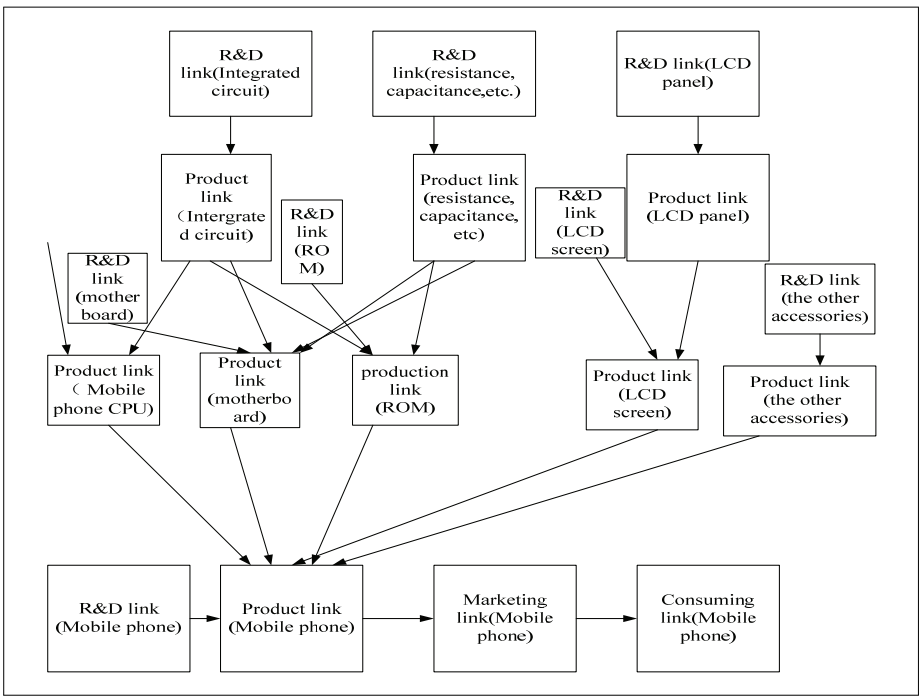
Figure 3. The simplified value chain of a PC (including Notepad)



Considering the feature of the IT industry, this paper will focus on three types of intermediate products in the production of accessories, which are integrated circuits, LCD panels and semiconductor components. The Integrated Circuit is the most important intermediate product in the production of motherboards, CPUs, memories, etc. An LCD panel is the most important intermediate product in the LCD monitor or phone screen. Semiconductor components which include resistors and capacitors are also used frequently in the production of most PC or mobile phone accessories.

Based on the above, this paper shows the extended value chain for PCs and smartphones in Figure 3 and Figure 4. The value chain may include three levels. First level is the R&D and product link of three important intermediate products

Figure 4. The simplified value chain of smart phone

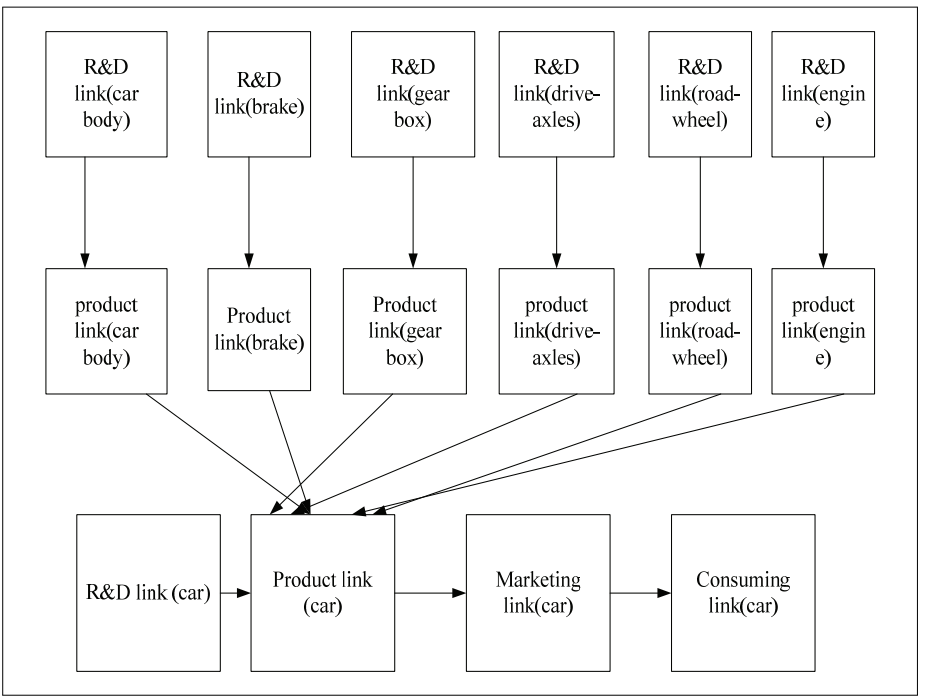


of the accessories. Second level is the R&D and product link of six accessories, including CPUs, motherboards, ROM, HD drives, LCD monitors or screens and other accessories. The third level is the R&D, product, marketing and consuming link of PC or smartphones.

3.3. The structure of the value chain in the auto industry

The value chain of the auto industry is a little different from that of the IT industry. The degree of modularization in a car's value chain is relatively high, but the auto parts can hardly be considered final products. And the assembly link

Figure 5. The simplified value chain of an automobile



of the auto industry is more comprehensive than the IT industry.

This paper focuses on several important auto parts including car bodies, brakes and servo-brakes, Gear boxes, drive-axles, road-wheels, frames and engines. The value chain of the auto industry can be shown in Figure 5.

3.4. The structure of the value chain in the medicine industry

The pharmaceutical industry's value chain is very different from the IT and auto industries. First, there are only two links in the production link of a medicine's value chain: raw medicine production and preparation production. The former is a chemical or biological link, while the latter is a physical link.

Second, the R&D link of the pharmaceutical industry is more complicated, and the degree of modularization is comparatively higher than the IT and auto industries. According to Pfizer, the R&D link of one proprietary medicine will include many links; for example, finding the ingredients, clinical trial development, multiple phases of clinical trials, etc. Even after many years of clinical trials, a new medicine will not be sold on the market if it has not undergone a sufficient number of trials.

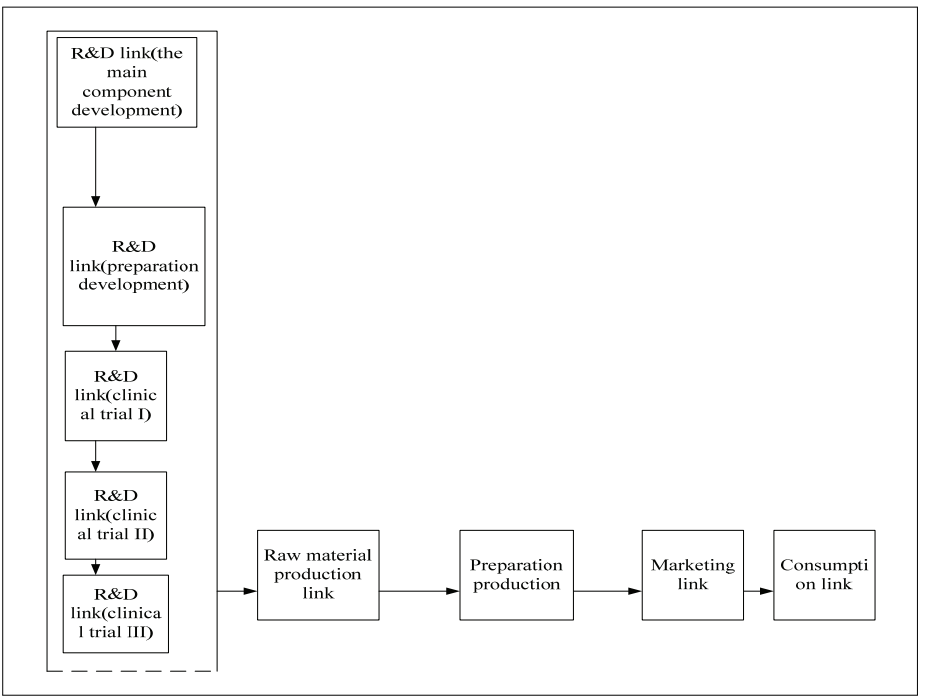
Third, there exist clear differences among the value chains of the two main types of medicines, proprietary and nonproprietary, which are divided by standards of intellectual protection. Though the above medicines are all final products, divisions within their production links show visible differences. In the automobile and IT industries, on the other hand, the production links of different types of final products share many similarities.

The extended value chains, respectively, of proprietary medicine and nonproprietary medicine are different. Figure 6 shows the extended value chain of proprietary medicine production. There is a long section of R&D links in proprietary medicine, which are indispensable for the follow-up link. Proprietary medicine production thus has high risk, high R&D input requirements, and high value added.

According to PHRMA, in 2006, the R&D input of every proprietary medicine was about $1.3 billion. Because only large firms can afford such a high level of investment in R&D, the R&D and production links of proprietary medicine tend to be monopolized by multinational companies.

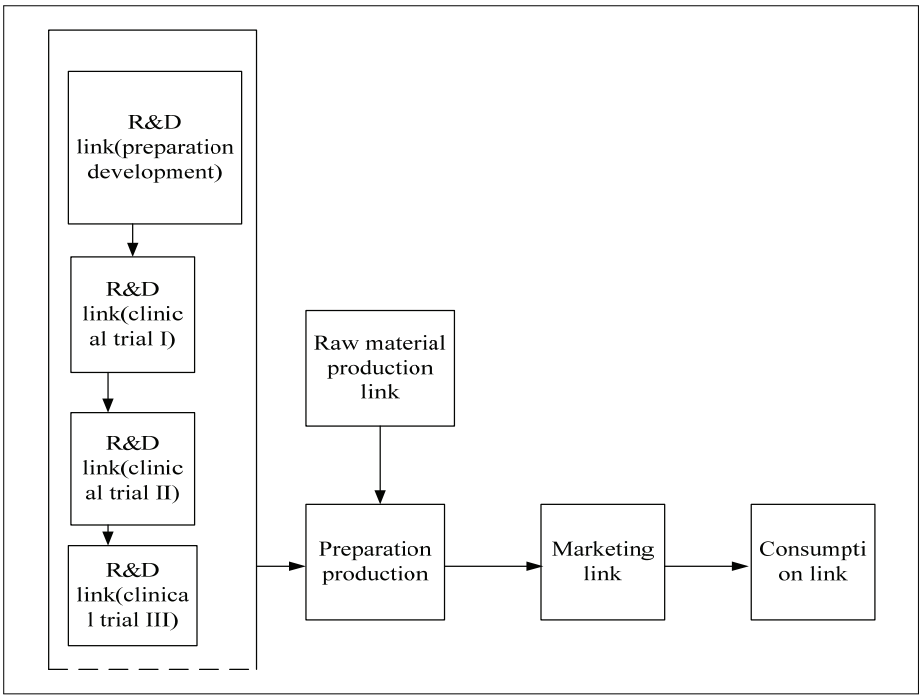
Figure 7 shows the extended value chain of nonproprietary medicine. A comparison of Figures 6 and 7 reveals the following differences. First, the total value-added ratio of nonproprietary medicine is clearly lower than that of proprietary medicine. This is because nonproprietary medicine has no link of finding components, whereas for proprietary medicine, this link is located on the upper left of the "smile curve," which is the maximum value-added link. Thus the value-added ratio of nonproprietary medicine is clearly lower than that of proprietary medicine.

Figure 6. The simplified value chain of proprietary medicine



Second, within nonproprietary medicine production is the link called "R&D before the clinical trial" which is also the main source of value-added in the chain. Figure 7 shows that raw medicine production for nonproprietary medicine is outside of the main value chain, and has no clear relation with the former R&D link, while the nonproprietary medicine pharmaceutical production has a direct connection with the R&D link. In fact, some nonproprietary medicine's pharmaceutical formulation is the same as that of the proprietary medicine, so there is no second sub-link of the R&D link in their value chain.

Figure 7. The simplified value chain of nonproprietary medicine

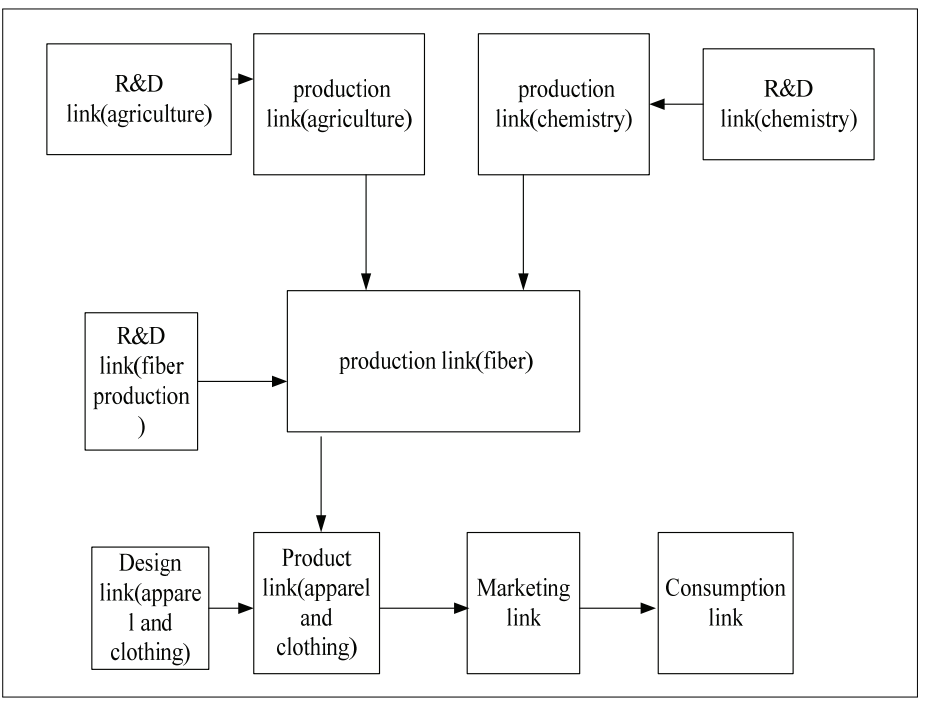


3.5. The structure of the value chain in the Textile and apparel industry

The value chain of textile and apparel industry is somewhat similar to the pharmaceutical industry. First, there are only two important production links: the link for fabric production and that for apparel production. But the 'Design' link is more important than R&D link in the value chain. The design link is relatively independent of the product link.

Second, there are also two types of textile and apparel products in the industry. One is plant fiber, the other is chemical fiber. For apparel made with plant fiber, the first production link is in agriculture while for chemical fibers, it is in the chemical industry. So the value chain is shown in Figure 8.

Figure 8. The simplified value chain of the textile and apparel industry



IV. The empirical research on positions of China and Korea in the global value chain

4.1. Methodology

There are many links in the value chain of every industry or product, including R&D links, product links and marketing links. And there are many intermediate products in the whole process of production. First, we need to determine positions of China and Korea on the production links, including intermediate product links and final product links.

As described in part III, we can divide the value chain into two or three levels. So at different levels, we can use some indexes to ascertain positions of China and Korea, and finally identify the correct position through contrast among different levels.

First index is trade competitiveness index (TC index). It is frequently used in research on foreign trade which is defined as follows:

$$TC_j = \frac{X_j - M_j}{X_j + M_j}$$

X_i : export of the I product; M_i : import of the I product.

Obviously, if the TC index of country k is below zero even near -1in one level of the value chain, it means country k has little position on this level.

Second index is the GL index which is defined as follows by Grubel& Lloyd (1975):

If there are N products in j industry, then

$$GL_j = \frac{\sum_{i=1}^{N}(X_i + M_i) - \sum_{i=1}^{N}(|X_i - M_i|)}{\sum_{i=1}^{N}(X_i + M_i)} \times 100$$

X_i: export of the I product; M_i : import of the I product.

GL_j is in the interval [0,100]. If GL_j is bigger, there is a higher degree of intra-industry trade.

So we can calculate the GL index of different levels to judge whether or not it exists in the intra-industry trade in the same level.

Every product link includes different kinds of product. So we can calculate the GL index to calculate the degree of intra-industry trade.

The second index is IIT index which is defined as follows by Fukao&Ishido (2004):

$$IIT_{kk'j} = \frac{Min(M_{kk'j}, M_{k'kj})}{Max(M_{kk'j}, M_{k'kj})} \le 0.1, \text{ unilateral trade;}$$

$$0.1 \le \frac{Min(M_{kk'j}, M_{k'kj})}{Max(M_{kk'j}, M_{k'kj})} \le 1 \text{ and } 0.8 \le \frac{P_{kk'j}}{P_{k'kj}} \le 1.25, \text{ horizontal intra-industry trade;}$$

If $0.1 \le \frac{Min(M_{kk'j}, M_{k'kj})}{Max(M_{kk'j}, M_{k'kj})} \le 1$ and $\frac{P_{kk'j}}{P_{k'kj}} \ge 1.25$ or $\frac{P_{kk'j}}{P_{k'kj}} \le 0.8$, vertical intra-industry trade.

$\frac{P_{kk'j}}{P_{k'kj}}$ *is the ratio of export price to import price from country*? o **k**' t

$M_{kk'j}$ is export from country k to k' in product j

then there is unilateral trade (including unilateral export and unilateral import) in product j between country k and k' ;

If $0.1 \le \frac{Min(M_{kk'j}, M_{k'kj})}{Max(M_{kk'j}, M_{k'kj})} \le 1$ and $0.8 \le \frac{P_{kk'j}}{P_{k'kj}} \le 1.25$, then there is the horizontal intra-industry trade (HIIT) in product j between country k and k', $\frac{P_{kk'j}}{P_{k'kj}}$ is the ratio of export price to import price from country k to k';

If $0.1 \le \frac{Min(M_{kk'j}, M_{k'kj})}{Max(M_{kk'j}, M_{k'kj})} \le 1$ and $\frac{P_{kk'j}}{P_{k'kj}} \ge 1.25$ or $\frac{P_{kk'j}}{P_{k'kj}} \le 0.8$, then there is vertical intra-industry trade(VIIT) in product j between country k and k', $\frac{P_{kk'j}}{P_{k'kj}}$ is the ratio of export price to import price from country k to k'.

Obviously, if country k is considered a unilateral exporter or intra-industry trader in one product link, we can say country k is in that position of this link, similar as the TC index. And the exact number of $\frac{Min(M_{kk'j}, M_{k'kj})}{Max(M_{kk'j}, M_{k'kj})}$ and $\frac{P_{kk'j}}{P_{k'kj}}$ can help us make the accurate position in the link. If IIT index of one level is between 0.1 and 1, we can say country k has intra-industry specialization at this level. The signal $\frac{P_{kk'j}}{P_{k'kj}}$ can be seen there is a HIIT or VIIT in the products.

On the other hand, if country k is considered as unilateral importer in one product link, we can say country k is not in that position of the link.

But these indexes can only be used to assess the position in the production link. To analyze the position in the R&D or marketing link, we use signals including world brand ranking, PCT patents condition, etc. We then forward a hypothesis that if country k was in position in more R&D links, it would have more world famous brands and PCT patents.

4.2. The Empirical analysis of China and Korea's position in the value chain of total manufacture

The manufacture is composed of many independent industries, so it is difficult to evaluate the position in the value chain of total manufacture. This paper uses a relatively simple method by the classification by broad economic categories (BEC). The United Nations (2002) provided the correspondence of the 19 BEC basic categories

with the basic classes of goods in SNA (capital goods, intermediate goods and consumption goods) as follows:

Because Category 7 in BEC includes, among other commodities, a range of military equipment, postal packages and special transactions and commodities not classified according to kind, and can be a mix of SNA classes of goods, this paper chooses not to discuss them.

So there are two levels in the simplified production link of global value chain based on BEC codes. One is intermediate products, the other are capital products and consumption products. Based on these categories, we calculated the trade volume of China and Korea's capital, intermediate and consumption goods in Tables 3, 4 and 5.

Table 2. The correspondence of BEC with SNA

SNA code	BEC code	Name in BEC classification
Capital goods	41	Capital goods (except transport equipment)
	521	Transport equipment, other than passenger motor cars, industrial
Intermediate goods	111	Food and beverages, primary, mainly for industry
	121	Food and beverages, processed, mainly for industry
	21	Industrial supplies not elsewhere specified, primary
	22	Industrial supplies not elsewhere specified, processed
	31	Fuels and lubricants, primary
	322	Fuels and lubricants, processed (other than motor spirit)
	42	Parts and accessories of capital goods (except transport equipment)
	53	Parts and accessories of transport equipment
Consumption goods	112	Food and beverages, primary, mainly for household consumption
	122	Food and beverages, processed, mainly for household consumption
	522	Transport equipment, other than passenger motor cars, non-industrial
	61	Consumer goods not elsewhere specified, durable
	62	Consumer goods not elsewhere specified, semi-durable
	63	Consumer goods not elsewhere specified, non-durable
	51	Passenger motor cars
	321	Motor spirit

Table 3. TC index and IIT index of China's foreign trade in BEC categories

		TC index			IIT index		
		2002	2007	2012	2002	2007	2012
Intermediate products	Food and beverages, primary, mainly for industry	-0.485	-0.713	-0.886	0.346	0.168	0.060
	Food and beverages, processed, mainly for industry	-0.757	-0.784	-0.806	0.139	0.121	0.108
	Industrial supplies not elsewhere specified, primary	-0.548	-0.873	-0.919	0.292	0.068	0.042
	Industrial supplies not elsewhere specified, processed	-0.212	0.076	0.095	0.651	0.859	0.826
	Fuels and lubricants, primary	-0.524	-0.861	-0.965	0.312	0.075	0.018
	Fuels and lubricants, processed (other than motor spirit)	-0.074	0.020	-0.621	0.862	0.961	0.234
	Parts and accessories of capital goods (except transport equipment)	-0.258	-0.198	-0.132	0.589	0.669	0.767
	Parts and accessories of transport equipment	-0.001	0.224	0.232	0.997	0.634	0.624
Capital products	Capital goods (except transport equipment)	0.019	0.317	0.395	0.963	0.518	0.434
	Transport equipment, other than passenger motor cars, industrial	0.080	0.395	0.510	0.853	0.433	0.324
Consumption products	Food and beverages, primary, mainly for household consumption	0.565	0.495	0.294	0.278	0.338	0.546
	Food and beverages, processed, mainly for household consumption	0.542	0.477	0.282	0.297	0.354	0.561
	Transport equipment, other than passenger motor cars, non-industrial	0.976	0.974	0.916	0.012	0.013	0.044
	Consumer goods not elsewhere specified, durable	0.909	0.854	0.787	0.048	0.079	0.119
	Consumer goods not elsewhere specified, semi-durable	0.916	0.891	0.889	0.044	0.058	0.059
	Consumer goods not elsewhere specified, non-durable	0.715	0.749	0.587	0.166	0.143	0.260
	Passenger motor cars	-0.975	-0.646	-0.828	0.013	0.215	0.094

Table 4. TC index and IIT index of Korea' s foreign trade

		TC index			IIT index		
		2002	2007	2012	2002	2007	2012
Intermediate products	Food and beverages, primary, mainly for industry	-0.994	-0.997	-0.900	0.003	0.001	0.053
	Food and beverages, processed, mainly for industry	-0.906	-0.922	-0.880	0.049	0.040	0.064
	Industrial supplies not elsewhere specified, primary	-0.869	-0.842	-0.889	0.070	0.086	0.059
	Industrial supplies not elsewhere specified, processed	0.043	0.001	0.138	0.918	0.998	0.758
	Fuels and lubricants, primary	-1.000	-0.999	-1.000	0.000	0.000	0.000
	Fuels and lubricants, processed (other than motor spirit)	-0.967	-0.979	-0.975	0.017	0.011	0.013
	Parts and accessories of capital goods (except transport equipment)	0.062	0.180	0.219	0.884	0.695	0.641
	Parts and accessories of transport equipment	0.100	0.402	0.543	0.818	0.426	0.296
Capital products	Capital goods (except transport equipment)	0.194	0.255	0.301	0.675	0.593	0.538
	Transport equipment, other than passenger motor cars, industrial	0.867	0.726	0.752	0.071	0.159	0.142
Consumption products	Food and beverages, primary, mainly for household consumption	-0.341	-0.617	-0.598	0.492	0.237	0.251
	Food and beverages, processed, mainly for household consumption	-0.393	-0.482	-0.346	0.435	0.349	0.486
	Transport equipment, other than passenger motor cars, non-industrial	-0.044	-0.448	-0.713	0.915	0.381	0.168
	Consumer goods not elsewhere specified, durable	0.579	0.289	0.196	0.266	0.551	0.673
	Consumer goods not elsewhere specified, semi-durable	0.140	-0.388	-0.442	0.754	0.441	0.387
	Consumer goods not elsewhere specified, non-durable	-0.029	-0.264	-0.187	0.944	0.583	0.685
	Passenger motor cars	0.916	0.869	0.807	0.044	0.070	0.107

Table 5. TC index and IIT index of China and Korea's foreign trade in three main categories

	2002,China		2002,Korea	
	TC index	IIT index	TC index	IIT index
intermediate products	-0.258	0.590	-0.146	0.745
capital products	0.023	0.955	0.317	0.518
consumption products	0.815	0.102	0.360	0.471
	2007,China		2007,Korea	
	TC index	IIT index	TC index	IIT index
intermediate products	-0.174	0.704	-0.155	0.732
capital products	0.323	0.512	0.351	0.481
consumption products	0.785	0.120	0.253	0.596
	2012,China		2012,Korea	
	TC index	IIT index	TC index	IIT index
intermediate products	-0.235	0.619	-0.144	0.749
capital products	0.405	0.423	0.397	0.432
consumption products	0.652	0.211	0.201	0.666

Table 6. The GL index of the two levels of China and Korea

Product Type	2002		2007		2012	
	China	Korea	China	Korea	China	Korea
intermediate products	74.23	76.65	73.87	68.98	66.27	56.27
capital products	97.71	68.28	67.69	64.93	59.49	60.31
consumption products	14.92	51.50	17.65	40.53	23.30	46.03

We can draw some conclusions from the calculations:

First, in the second level, China and Korea's position in the value chain are mostly in capital product and intermediate product links instead of the consumption product link. The TC index of capital products is increasing from 2002 to 2012 both in China and Korea. And while both China and Korea are also in the final

consumer product manufacturing link, but their positions are being weakened. The TC index of China in the consumption products link decreased from 0.815 in 2002 to 0.652 in 2012. The GL index of capital products has been decreasing both in China and Korea.This means the degree of intra-industry specialization in capital products decreased. In consumption products, the GL index rose for China and decreased for Korea. It means China's absolute advantage in the consumption products link decreased, as Korea is specializing in certain products such as transport equipment and durable consumption goods. And the IIT index of China in consumption products link is 0.102,which means there is unilateral exporting in China's consumption product links. But the IIT index increases to 0.211, meaning there is intra-industry trade presently. Korea's TC index also decreased from 0.36 to 0.201,which is lower than China.

At the first level, Korea and China areboth involved in the intermediate product link; the degree of involvement is lower than capital product and consumer product links. The TC index of Korea and China is both below zero. But we can discover that the degree is increasing slowly from -0.258,-0.146 to -0.235, -0.144. There is intra-industry specialization at both levels of the value chain. The LG index of Korea decreased more quickly than China which means Korea is specializing in certain intermediate products.

Second, China's position in different type of products link in the two levels varies greatly. In the intermediate product level, China's TC index in three types: BEC code in 22 (industrial supplies not elsewhere specified, processed), 42 (Parts and accessories of capital goods except transport equipment) and 53 (Parts and accessories of transport equipment) increased rapidly but the other intermediate products is stable. So we can say China is represented more in the three intermediate product links than the others in the first level. But in consumption products, the BEC code in 112 (food and beverages, primary, mainly for household consumption), 122 (Food and beverages, processed, mainly for household consumption, 61 (Consumer goods not elsewhere specified, durable), 62 (Consumer goods not elsewhere specified, semi-durable), 63 (Consumer goods not elsewhere specified, non-durable)

decreased rapidly but the BEC code in 522 (Transport equipment, other than passenger motor cars, non-industrial) decreased slowly.

Third, Korea's position in the value chain of different products is varies slightly from China. TC index decreased rapidly in most of the consumption products and increased rapidly in most intermediate and capital products. But in consumption products, Korea's TC index decreased faster than that of China. And in BEC code 53 (Parts and accessories of transport equipment) of intermediate products, Korea increased from 0.1 to 0.543, faster than China.

Then we use the TC and IIT index in bilateral trade between China and Korea in Tables 7 and 8.

The position of China and Korea in the value chain of bilateral trade is a little different from their positions in the global value chain. Both China and Korea is weak in the intermediate products link in the world, but in bilateral trade, Korea plays the role of the intermediate products link. And Both China is also strong in the capital products link in the world, but in bilateral trade, Korea plays the role more frequently than China.

But in recent years, the TC index in intermediate products link has been stable but the TC index in capital products and consumption products changed rapidly. China's comparative disadvantage decreased rapidly in capital products while China's comparative advantage in consumption products increased with equal rapidity.

In the intermediate products, Korea's advantage increased most rapidly in the BEC code 53 (Parts and accessories of transport equipment) and decreased in many other codes in BEC categories. In the consumption products, China's advantage decreased most rapidly in the BEC code 61 (Consumer goods not elsewhere specified, durable).

But the analysis above has two obvious lacunae. One is that BEC categories are too simple to explain the value chain. One code in BEC includes many types of products. Perhaps China's position is in one product in the codeand Korea's position in another product within in the same code. The other is that the study has no focus on R&D or marketing link in the value chain.

Table 7. TC index and IIT index of the bilateral trade between China and Korea

		2002		2007		2012	
		TC index	IIT index	TC index	IIT index	TC index	IIT index
intermediate products	Food and beverages, primary, mainly for industry	0.995	0.002	0.992	0.004	0.948	0.027
	Food and beverages, processed, mainly for industry	0.781	0.123	0.911	0.046	0.852	0.080
	Industrial supplies not elsewhere specified, primary	0.840	0.087	0.419	0.409	0.070	0.870
	Industrial supplies not elsewhere specified, processed	-0.493	0.340	-0.208	0.656	-0.280	0.562
	Fuels and lubricants, primary	1.000	0.000	0.841	0.086	0.999	0.000
	Fuels and lubricants, processed (other than motor spirit)	-0.379	0.450	0.264	0.582	-0.124	0.779
	Parts and accessories of capital goods (except transport equipment)	-0.538	0.300	-0.565	0.278	-0.558	0.284
	Parts and accessories of transport equipment	-0.152	0.736	-0.235	0.619	-0.337	0.496
capital products	Capital goods (except transport equipment)	-0.527	0.310	-0.478	0.353	-0.194	0.675
	Transport equipment, other than passenger motor cars, industrial	0.740	0.149	0.879	0.065	0.941	0.030
consumption products	Food and beverages, primary, mainly for household consumption	0.851	0.080	0.785	0.120	0.862	0.074
	Food and beverages, processed, mainly for household consumption	0.816	0.101	0.764	0.133	0.592	0.257
	Transport equipment, other than passenger motor cars, non-industrial	0.998	0.001	0.996	0.002	0.944	0.029
	Consumer goods not elsewhere specified, durable	0.776	0.126	0.554	0.287	-0.040	0.922
	Consumer goods not elsewhere specified, semi-durable	0.729	0.157	0.675	0.194	0.684	0.187
	Consumer goods not elsewhere specified, non-durable	0.551	0.290	0.632	0.225	0.315	0.521
	Passenger motor cars	-0.987	0.007	-0.999	0.001	-0.987	0.007

Table 8. TC index and IIT index of bilateral trade between China and Korea

	2002		2007		2012	
	TC index	IIT index	TC index	IIT index	TC index	IIT index
intermediate products	-0.403	0.426	-0.323	0.511	-0.405	0.424
capital products	-0.477	0.354	-0.451	0.378	-0.156	0.731
consumption products	0.694	0.180	0.568	0.275	0.350	0.482

The first problem may be solved in the analysis in four special industries. There will be the result which is calculated by HS 6-digit code to avoid errors.

Now we use the data of PCT patents and brands to explain China and Korea's position in the R&D or marketing link in the global value chain.

The Patent Cooperation Treaty (PCT) is an international patent law treaty, concluded in 1970. It provides a unified procedure for filing patent applications to protect inventions in each of its contracting states. A patent application filed under the PCT is called an international application, or PCT application. The EU and USA frequently use this to evaluate R&D status. From the data of World Intellectual Property organization, we are able to find the number of PCT patents in China, Korea, USA, Japan and Germany, shown in Figure 9 and Figure 10.

We can see China and Korea are both weak in the R&D link in the total global value chain now. China's PCT patents is below twenty thousand and Korea is a little above 10 thousand, but USA and Japan is near 50 thousand. But the proportion grew quickly from 1994 to 2012.Korea grew more smoothly but China has a small peak in recent years after the financial crisis. So we can say China and Korea are active in R&D links, but they are still a long way from becoming an R&D country.

Another signal to measure the position in R&D and marketing link is the Brand Rank in the world's 500 most influential brands.

Figure 9. Number of PCT patents in China, Korea, USA, Japan and Germany

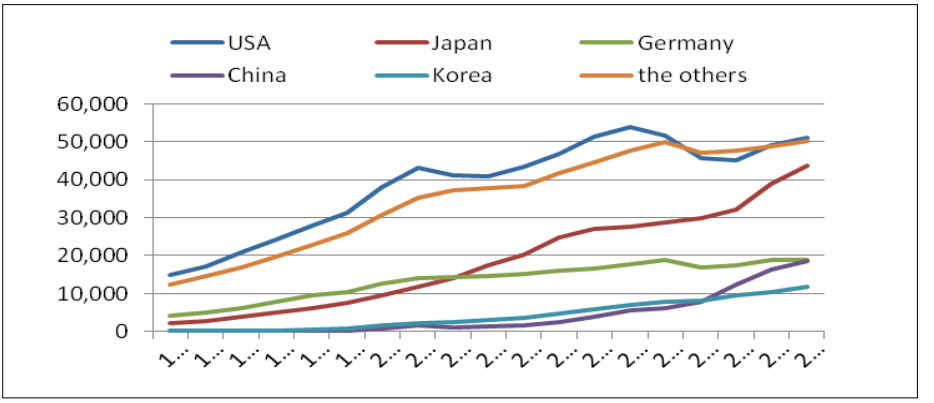
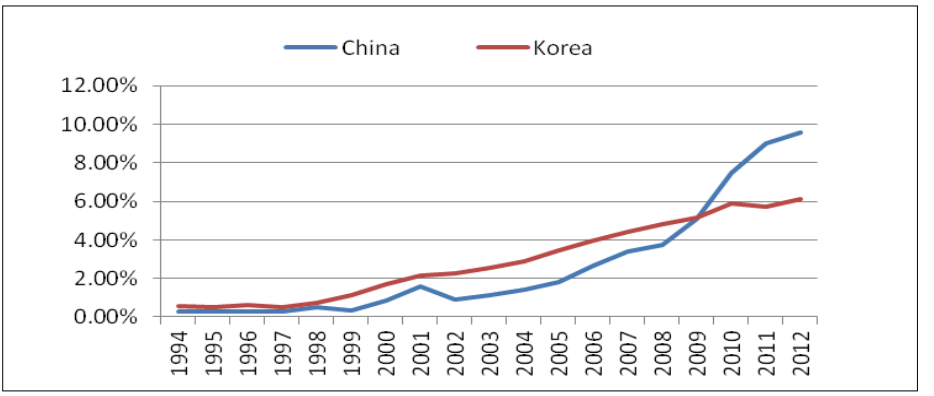


Figure 10. China and Korea's proportion in the PCT patents



In 2007, China has 12 brands in the ranking, but only four among final manufacturing products. The brand of service products, such as ICBC and CCTV, has little to do with the global manufacture value chain. Korea has 4 brands and three belongs to the final manufacture products. In 2013, China has 25 brands in the ranking, but only five belongs to final manufacture; Korea has 5 and with three in final manufacture. So both Korea and China is weak in the R&D and

Table 9. China and Korea's brand in the world's 500most influential brands (only in final manufacture products)

Year	China		Korea	
2007	Brand Name	Rank	Brand Name	Rank
	Haier	83	SAMSUNG	56
	Chang Hong	299	Hyundai Motors	188
	Lenovo	337	LG	201
2013	Brand Name	Rank	Brand Name	Rank
	Lenovo	103	Samsung	7
	Haier	157	Hyundai	142
	Huawei	246	LG	185
	Chang Hong	298		
	Tsingtao	368		

marketing links.

But the three brand of Korea: Samsung, Hyundai and LG's ranking increased significantly and Samsung is in the top ten. China has more brands than Korea, but their ranking is obviously lower than Korean brands. So we can say in some special fields, Korea demonstrated good performance in R&D and marketing link than most countries including China.

The comprehensive analysis on the R&D link and marketing link is not enough. China and Korea may have advantage in R&D and marketing link of some special fields. So we will analyze the position in the global value chain of four special industries as follows.

4.3. Empirical analysis of China and Korea's position in the value chain of IT industry

As discussed in the chapter 2, we choose the two typical products (PC and

Smart Phone) to analyze the value chain. We also use the method in the last sector to calculate the TC and IIT index of every intermediate product in the value chain

Table 10. The HS code of important products in the value chain of PC and Smart Phones

Product Name	HS CODE
Final products:	
PC(Notepad) and the other computers	847130
Smart Mobile Phone	851712
Accessories:	
Parts of Mobile Phone	851770
CPU `Motherboard and MEMORY	847330
HARD DISK AND CDROM	847170
Flash disk	852351
Keyboard and Mouse	847160
CRT Monitor	852841
LCD Monitor	852851
Intermediate products of accessories:	
IC:	8542
IC for processors and controllers	854231
IC for memories	854232
IC for Amplifiers	854233
Electrical capacitors:	8532
Fixed capacitors	853210
Tantalum capacitors	853221
Aluminum capacitors	853222
Ceramic dielectric, single layer	853223
Ceramic dielectric, multi layer	853224
Electrical resistors:	8533
Fixed carbon resistors	853310
the other fixed resistors	853321
Wire wound variable resistors	853331
LCD Panel	901380
Printed Circuit Board (PCB)	8534

Table 11. The TC index and IIT index of all products in China

Product name	TC index			IIT index		
	2002	2007	2012	2002	2007	2012
PC (Notepad)	0.783	0.982	0.988	0.121	0.009	0.006
Keyboard and Mouse	0.729	0.608	0.266	0.156	0.244	0.580
Hard Disk and CDROM	0.144	-0.124	-0.157	0.748	0.780	0.728
CPU, motherboard, memory and some other accessories	0.176	0.314	0.264	0.701	0.522	0.582
Smart Mobile phone		0.902	0.961		0.052	0.020
Parts of Mobile phone		0.212	0.099		0.651	0.820
Flash disk		0.295	0.318		0.544	0.518
CRT monitor		0.861	0.532		0.075	0.306
LCD monitor		0.876	0.931		0.066	0.036
Electrical capacitors:	-0.476	-0.520	-0.358	0.355	0.316	0.473
Fixed capacitors	-0.370	-0.382	-0.146	0.460	0.447	0.745
Tantalum capacitors	-0.621	-0.412	-0.276	0.234	0.417	0.567
Aluminum capacitors	-0.276	-0.450	-0.324	0.568	0.379	0.511
Ceramic dielectric, single layer	-0.718	-0.603	-0.625	0.164	0.248	0.231
Ceramic dielectric, multi layer	-0.453	-0.609	-0.437	0.377	0.243	0.392
Electrical resistors:	-0.427	-0.208	-0.222	0.401	0.656	0.636
Fixed carbon resistors	-0.527	-0.689	-0.581	0.310	0.184	0.265
the other fixed resistors	-0.526	-0.095	-0.305	0.311	0.826	0.533
Wire wound variable resistors	-0.654	-0.873	-0.659	0.209	0.068	0.206
Printed Circuit Board (PCB)	-0.158	-0.061	-0.026	0.727	0.885	0.949
IC:	-0.719	-0.687	-0.564	0.164	0.186	0.279
IC for processors and controllers		-0.736	-0.600		0.152	0.250
IC for memories		-0.523	-0.451		0.314	0.378
IC for Amplifiers		-0.661	-0.343		0.204	0.490
LCD PANEL	-0.653	-0.356	-0.161	0.210	0.475	0.722

to draw a conclusion.

In HS 6-digit code, Table10 gives the code of all the intermediate products (including raw materials and accessories) in Figure 3 and Figure 4. So there are three levels in the value chain: the intermediate products of accessories, the accessories of PC or smart mobile phones and the final products (PC and smart mobile phones).

We use the similar method to analyze China and Korea's specialization in the value chain. Table 11 gives the TC index, IIT index of all products in Table 10 in China.

From Table 11, we can find:

First, China's advantage on the link of PC assembly and smart phone has been strengthened in the last ten years. The TC index of PC (Notepad) increased from 0.783 in 2002 to 0.988 in 2012. And the TC index of smart mobile phone increased from 0.902 in 2007 to 0.967 in 2012. And the IIT index of PC and smart mobile phone is below 0.1, so there is almost unilateral export in China's foreign trade in the two products.

Second, China's position on the link of the accessories varies greatly. On the link of production of certain important accessories, such as CPU, motherboard, memory and LCD monitor, etc, the TC index is above zero and increasing, but the IIT index is above 0.1, so we only can say that China has little increasing advantage. And on the link of other important accessories such as HD drives, China's disadvantage decreased. But on the link of labor-intensive accessories such as keyboard and mouse, China's advantage decreased. So we can say that China is turning from the labor intensive accessories to the capital intensive and technology intensive accessories.

Third, China's disadvantage in the link of intermediate products of accessories decreased quickly. The TC index of electrical capacitors, electrical resistors, and LCD panels has been rising in the last ten years but was below zero in 2002, 2007 and 2012. And the IIT index is above 0.1, so we can state there is VIIT or HIIT in the intermediate products trade. The results in Table 12 show that the ratio of most intermediate products is increasing but is below 0.8 presently.

Therefore, Chinese foreign trade in intermediate products is VIIT, with China exporting low quality products and importing high quality products.

Tables 13 and 14 show the TC index and IIT index of all Korean products in Table 10. Korea's position in the IT industry is different from China. In 2002, Korea possessed great advantage in the assembly link of PCs (Notepads) because of the 0.61 TC index. But in 2007, the MNCs of Korea has relocated assembly links in China, Vietnam, Malaysia and the other countries, so the -0.851 TC index means that Korea has a big disadvantage on this link. But in 2012, the TC index becomes -0.075, or near zero, meaning Korea has entered this link again after the financial crisis. And in the link of assembly of smart mobile phones, Korea retained its sizable advantage in 2012.

Table 12. The ratio of export price to import price in intermediate products

Product name	IIT index			Ratio of export price to import price		
	2002	2007	2012	2002	2007	2012
Electrical capacitors:	0.355	0.316	0.473	0.438	0.355	0.415
Fixed capacitors	0.460	0.447	0.745	0.298	0.323	0.392
Tantalum capacitors	0.234	0.417	0.567	1.265	0.721	0.735
Aluminum capacitors	0.568	0.379	0.511	0.525	0.523	0.633
Ceramic dielectric, single layer	0.164	0.248	0.231	0.246	0.560	0.357
Ceramic dielectric, multi layer	0.377	0.243	0.392	0.489	0.421	0.620
Electrical resistors:	0.401	0.656	0.636	0.432	0.524	0.378
Fixed carbon resistors	0.310	0.184	0.265	0.303	0.174	0.169
the other fixed resistors	0.311	0.826	0.533	0.304	0.569	0.307
Wire wound variable resistors	0.209	0.068	0.206	0.447	0.197	0.239
IC for processors and controllers		0.152	0.250		0.519	0.466
IC for memories		0.314	0.378		0.906	0.746
IC for Amplifiers		0.204	0.490		0.675	1.562
LCD PANEL	0.210	0.475	0.722	0.176	0.477	0.793

Table 13. The TC index and IIT index of all products in Korea

Product Name	TC index			IIT index		
	2002	2007	2012	2002	2007	2012
PC (Notepad)	0.610	-0.851	-0.075	0.242	0.080	0.860
Keyboard and Mouse	0.605	-0.517	0.266	0.246	0.318	0.580
Hard Disk and CDROM	0.198	0.403	0.166	0.669	0.425	0.716
CPU, motherboard, memory and some other accessories	0.610	0.517	0.295	0.242	0.318	0.545
Smart Mobile phone		0.947	0.842		0.027	0.086
Parts of Mobile phone		0.636	0.495		0.222	0.338
Flash disk		0.031	0.176		0.939	0.701
CRT monitor		0.426	0.961		0.403	0.020
LCD monitor		0.744	0.135		0.147	0.762
Electrical capacitors :	-0.201	-0.130	0.026	0.666	0.770	0.949
Fixed capacitors	-0.014	0.331	0.079	0.972	0.503	0.853
Tantalum capacitors	-0.761	-0.941	-0.605	0.136	0.031	0.246
aluminum capacitors	0.068	0.178	0.366	0.873	0.699	0.464
Ceramic dielectric, single layer	-0.224	-0.530	-0.540	0.634	0.308	0.299
Ceramic dielectric, multi layer	-0.069	0.108	0.118	0.871	0.805	0.788
Electrical resistors :	-0.548	-0.320	-0.361	0.292	0.516	0.469
Fixed carbon resistors	-0.312	0.470	-0.423	0.524	0.360	0.406
the other fixed resistors	-0.556	-0.388	-0.282	0.285	0.441	0.560
Wire wound variable resistors	-0.987	-0.988	-0.672	0.007	0.006	0.196
Printed Circuit Board (PCB)	0.167	0.071	0.227	0.713	0.867	0.630
IC	-0.105	0.089	0.239	0.810	0.836	0.615
IC for processors and controllers		-0.142	0.191		0.752	0.679
IC for memories		0.567	0.531		0.277	0.307
IC for Amplifiers		-0.524	-0.645		0.312	0.215
LCD PANEL	-0.189	0.874	0.825	0.681	0.067	0.096

In the accessories, the TC index of most accessories decreased quickly. In the CPU, motherland, memory and some other accessories, the TC index comes down from0.61 to 0.295. In the parts of smart mobile phones, Korea comes down from 0.636 to 0.495. In the LCD monitors, comes down from 0.744 to 0.135.

In intermediate products of the accessories, Korea's advantage increased further. In 2002, Korea was at a disadvantage in electrical capacitors, electrical resistors, LCD panels and ICs. But in 2012, Korea's TC index is above zero in the electrical capacitors, LCD panels and ICs. Specifically in LCD panels, Korea has a great advantage with a 0.825 TC index. And the IIT index is also above 0.1, so we can state there is VIIT or HIIT in the intermediate products trade. The result in Table 13 shows that the ratio of most intermediate products is increasing. In 2012,

Table 14. The ratio of export price to import price in the intermediate products in Korea

Product name	IIT index			ratio of export price to import price		
	2002	2007	2012	2002	2007	2012
Electrical capacitors:	0.666	0.770	0.949	0.641	0.932	1.050
Fixed capacitors	0.972	0.503	0.853	0.225	0.302	0.166
Tantalum capacitors	0.136	0.031	0.246	0.573	0.382	0.964
Aluminum capacitors	0.873	0.699	0.464	0.964	1.066	
Ceramic dielectric, single layer	0.634	0.308	0.299	0.831	0.485	0.934
Ceramic dielectric, multi layer	0.871	0.805	0.788	1.170	1.438	1.395
Electrical resistors:	0.292	0.516	0.469	0.442	0.819	1.037
Fixed carbon resistors	0.524	0.360	0.406	0.803	0.425	1.419
the other fixed resistors	0.285	0.441	0.560	0.364	0.646	0.878
Wire wound variable resistors	0.007	0.006	0.196	1.855	9.326	0.997
IC for processors and controllers		0.752	0.679		0.583	0.844
IC for memories		0.277	0.307		0.959	0.909
IC for Amplifiers		0.312	0.215		0.216	0.582
LCD PANEL	0.681	0.067	0.096		0.338	1.930

Table 15. TC index and IIT index of the bilateral trade between China and Korea in the IT industry

Product name	TC index			IIT index		
	2002	2007	2012	2002	2007	2012
PC (Notepad)	-0.802	0.989	0.998	0.110	0.006	0.001
Keyboard and Mouse	-0.193	0.578	-0.165	0.676	0.268	0.717
Hard Disk and CDROM	-0.476	-0.749	-0.752	0.355	0.143	0.142
CPU, motherboard, memory and some other accessories	-0.266	-0.681	-0.526	0.579	0.190	0.311
Smart Mobile phone		-0.222	0.972		0.636	0.014
Parts of Mobile phone		-0.038	-0.047		0.927	0.910
Flash disk		-0.723	-0.740		0.161	0.150
CRT monitor		0.995	-1.000		0.003	1.000
LCD monitor		0.972	0.928		0.014	0.037
Electrical capacitors:	-0.347	-0.592	-0.365	0.485	0.256	0.465
Fixed capacitors	0.497	-0.393	0.096	0.336	0.435	0.826
Tantalum capacitors	-0.172	-0.617	-0.595	0.707	0.237	0.254
Aluminum capacitors	0.243	-0.158	-0.393	0.609	0.727	0.436
Ceramic dielectric, single layer	-0.619	-0.738	-0.755	0.235	0.151	0.139
Ceramic dielectric, multi layer	-0.440	-0.795	-0.397	0.389	0.114	0.432
Electrical resistors:	-0.459	-0.527	-0.120	0.371	0.310	0.785
Fixed carbon resistors	-0.321	-0.657	-0.764	0.514	0.207	0.134
the other fixed resistors	-0.401	-0.439	0.041	0.427	0.390	0.921
Wire wound variable resistors	-0.493	-0.474	-0.383	0.340	0.356	0.446
Printed Circuit Board (PCB)	-0.779	-0.482	-0.560	0.124	0.349	0.282
IC:	-0.752	-0.776	-0.846	0.141	0.126	0.083
IC for processors and controllers		-0.868	-0.951		0.071	0.025
IC for memories		-0.654	-0.704		0.209	0.174
IC for Amplifiers		-0.702	-0.698		0.175	0.178
LCD PANEL	-0.876	-0.888	-0.765	0.066	0.059	0.133

most of the ratio is above 0.8 and some is above 1.25. So Korea foreign trade in the intermediate products is mainly HIIT. In some VIIT products (LCD Panel and fixed carbon resistors), Korea exports high quality products and imports low quality products.

Table 15 gives the TC index in the bilateral trade between China and Korea. China and Korea's position in the bilateral trade is a little different from their position in total foreign trade.

In the assembling link, China has a great advantage. The TC index increased from -0.802 in 2002 to 0.998 in 2012 in PC (Notepad) and from -0.222 in 2007 to 0.972 in 2012 in Smart Mobile phones.

Table 16. The ratio of export price to import price of intermediate products in the bilateral trade between China and Korea

Product name	IIT index			ratio of export price to import price		
	2002	2007	2012	2002	2007	2012
Electrical capacitors:	0.485	0.256	0.465	0.380	0.260	0.472
Fixed capacitors	0.336	0.435	0.826	0.258	0.380	1.083
Tantalum capacitors	0.707	0.237	0.254	4.736	3.321	1.814
Aluminum capacitors	0.609	0.727	0.436	0.494	0.740	0.546
Ceramic dielectric, single layer	0.235	0.151	0.139	0.165	0.494	0.427
Ceramic dielectric, multi layer	0.389	0.114	0.432	0.253	0.283	0.558
Electrical resistors:	0.371	0.310	0.785	0.477	0.394	0.591
Fixed carbon resistors	0.514	0.207	0.134	0.458	0.308	0.300
the other fixed resistors	0.427	0.390	0.921	0.750	0.453	0.679
Wire wound variable resistors	0.340	0.356	0.446	3.447	0.562	1.396
IC for processors and controllers		0.071	0.025		0.388	0.131
IC for memories		0.209	0.174		5.346	0.420
IC for Amplifiers		0.175	0.178		0.447	0.967
LCD PANEL	0.066	0.059	0.133	0.089	0.185	1.100

But in the link of accessories production, China's disadvantage increased quickly in bilateral trade such as CPU, motherboard, Hard disk and Keyboard. And in the link of intermediate products, China's disadvantage remained static or increased. Table 16 shows that the ratio of most of the intermediate products is increasing but below 0.8 for now. So Chinese foreign trade in intermediate products is VIIT, and China exports the low quality products and imports the high quality products. But in few products, such as Tantalum capacitors, China exports high quality products and imports low quality products.

To evaluate the position in the three levels of bilateral trade in IT industry, Table 17 shows the GL index in the three levels. We can find that the GL index of final products decreased quickly from 2002 to 2012. Based on the TC index of the two final products, the intra-industry specialization has turned into inter-industry specialization and China has a great advantage in this level. And the GL index of accessories increased quickly in the past five years which means the degree of intra-industry specialization has increased. It tells us that China has competitiveness in the accessories product link with Korea, especially in low-quality products. But at the third level, the GL index contains stable which means Korea's comparative advantage has been stable in the last five years.

This paper evaluates the degree of one special production link in five types: very strong (TC index above 0.6 in 2012), strong (TC index below 0.6 and above 0.2), medium(TC index below 0.2 and above -0.2), weak (TC index below -0.2 and above -0.6), very weak (TC index below -0.6).And based on the change of TC index, this paper identifies three types of the trend signals: increasing (the change of TC index from 2007 to 2012 above 0.1), decreasing (the change of

Table 17. GL index in the three levels

Product Type	2002	2007	2012
Final products	90.09	44.33	2.34
Accessories	65.15	59.28	81.04
Intermediate products of accessories		19.23	19.72

Table 18. China and Korea's position in the production link of global value chain

Product name	China	Korea
level 3: the final products:		
PC (Notepad)	very strong, stable	medium, decreasing
Smart Mobile phone	strong, stable	very strong, decreasing
Level 2: the accessories:		
Keyboard and Mouse	strong, decreasing	strong, increasing
Hard Disk and CDROM	medium, decreasing	medium, decreasing
CPU, motherboard, memory and some other accessories	strong, stable	strong, decreasing
Parts of Mobile phone	medium, decreasing	strong, decreasing
Flash disk	strong, stable	medium, increasing
CRT monitor	strong, decreasing	very strong, increasing
LCD monitor	very strong , stable	medium, decreasing
Level1: the intermediate products of accessories:		
Electrical capacitors:	weak, increasing	medium, increasing
Fixed capacitors	medium, increasing	medium, decreasing
Tantalum capacitors	weak, increasing	very weak, increasing
Aluminum capacitors	weak, increasing	strong, increasing
Ceramic dielectric, single layer	very weak, increasing	weak, stable
Ceramic dielectric, multi layer	weak, increasing	medium, stable
Electrical resistors :	weak, increasing	weak, stable
Fixed carbon resistors	weak, increasing	weak, decreasing
the other fixed resistors	weak, increasing	weak, increasing
Wire wound variable resistors	weak, increasing	very weak, increasing
Printed Circuit Board (PCB)	medium, stable	strong, increasing
IC:	weak, increasing	strong, increasing
IC for processors and controllers	weak, increasing	strong, increasing
IC for memories	weak, stable	strong, stable
IC for Amplifiers	weak, increasing	very weak, decreasing
LCD PANEL	medium, increasing	very strong, increasing

TC index from 2007 to 2012 below -0.1) and stable (the change of TC index from 2007 to 2012 is above -0.1 and below 0.1. Based on the above, the position of China and Korea in the global value chain is in Table 18. And the position

Table 19. China and Korea's position in the production link of bilateral trade

Product Name	China	Korea
PC (Notepad)	Very strong, stable	Very weak, stable
Keyboard and Mouse	medium, decreasing	medium, increasing
Hard Disk and CDROM	very weak, stable	very strong, stable
CPU, motherboard, memory and some other accessories	weak, increasing	strong, decreasing
Smart Mobile phone	very strong, increasing	very weak, decreasing
Parts of Mobile phone	medium, stable	medium, stable
Flash disk	very weak, stable	very strong, stable
CRT monitor	very weak, decreasing	very strong, increasing
LCD monitor	very strong, stable	very weak, stable
Electrical capacitors:	weak, increasing	strong, decreasing
Fixed capacitors	medium, decreasing	medium, increasing
Tantalum capacitors	weak, decreasing	medium, increasing
Aluminum capacitors	weak, decreasing	medium, increasing
Ceramic dielectric, single layer	very weak, decreasing	very strong, increasing
Ceramic dielectric, multi layer	weak, stable	strong, stable
Electrical resistors:	medium, increasing	medium, decreasing
Fixed carbon resistors	very weak, decreasing	very strong, increasing
the other fixed resistors	medium, increasing	medium, decreasing
Wire wound variable resistors	weak, stable	strong ,stable
Printed Circuit Board (PCB)	weak, decreasing	strong, increasing
IC:	very weak, stable	very strong ,stable
IC for processors and controllers	very weak, stable	very strong,stable
IC for memories	very weak, stable	very strong, stable
IC for Amplifiers	very weak, stable	very strong, stable
LCD PANEL	very weak, increasing	very strong, stable

of China and Korea in the bilateral trade is in Table 19.

At last, we do some simple analysis on China and Korea's position on the R&D link of IT industry. Both China and Korea's PCT patents increased quickly after crisis. But China has almost no brands on the list of top 20 famous brands in the semiconductors which is the most important field in level 1. Korea has two famous brands in the same level (Samsung and SK). China has almost no famous brands in the LCD monitor, CPU and memory in level 2. Korea has famous brands in the memory and LCD monitor category, but very few famous brands in CPU, motherboard, and hard disks. China has some famous brands in level 3, such as Lenovo and Huawei. But the brand value is lower than Korea. So we can draw the conclusion that China and Korea are both weak in the R&D link of both three levels, but Korea is better than China.

4.4. Empirical analysis of China and Korea's position in the value chain of the auto industry

Similar as IT industry, we also use the method in the last section to calculate the TC and IIT index of every intermediate product in the value chain in Figure 5. In HS 6-digit code, Table 20 gives the code of all the intermediate products (including raw materials and accessories) in Figure 5.

We use the similar method to analyze China and Korea's specialization in the value chain. Table 21 gives the TC index, IIT index of intermediate and final products in the Chinese auto industry.

From Table 15, we can see China's disadvantage in the car production link has decreased. In certain specialized vehicles types, T C index turned from negative to positive. And China's disadvantage in some car parts has turned to advantage, too. For example, TC index of car bodies is near -1 in 2002 but above zero in 2012. In the most important part, engine, China's disadvantage has decreased from -0.989 in 2002 to -0.525 in 2012. From Table 16, the result in Table 22 shows

that the ratio of most intermediate products is below 0.8 now. So China's foreign trade in the intermediate products is VIIT, and China exports the low quality products and imports the high quality products in most products in the car industry.

Table 21. The TC and IIT index of important products in the value chain of the auto industry in China

Product name	TC index			IIT index		
	2002	2007	2012	2002	2007	2012
cylinder capacity not exceeding 50cc	0.998	1.000	1.000	-0.001	0.000	0.000
cylinder capacity exceeding 50cc, not exceeding 250cc	0.993	0.994	0.996	-0.003	0.003	0.002
cylinder capacity exceeding 250cc, not exceeding 1000cc	-0.817	-0.714	0.940	-0.101	0.167	0.031
cylinder capacity exceeding 1000cc, not exceeding 3000cc	-0.989	-0.274	-0.535	-0.005	0.569	0.303
diesel engine exceeding 180 HP	-0.990	-0.619	0.413	-0.005	0.235	0.415
Car (type 1)	0.260	0.981	-0.032	-0.587	0.010	0.939
Car (type 2)	-0.899	0.950	0.373	-0.053	0.026	0.457
Car (type 3)	-0.981	-0.574	-0.896	-0.010	0.271	0.055
Car (type 4)	-0.988	-0.996	-0.998	-0.006	0.002	0.001
Car (type 5)	1.000	0.400	-0.549	-1.000	0.428	0.291
Car (type 6)	-0.747	-0.881	-0.495	-0.145	0.063	0.338
Car (type 7)	0.636	0.441	-0.973	-0.223	0.388	0.014
auto bodies	-0.987	0.770	0.049	-0.007	0.130	0.907
brakes and servo-brakes		0.389	0.553		0.440	0.288
Gear boxes	-0.808	-0.852	-0.752	-0.106	0.080	0.141
drive-axles	-0.755	0.146	0.085	-0.139	0.745	0.844
road-wheels	0.873	0.929	0.893	-0.068	0.037	0.057
Frames	-0.374	0.143	0.238	-0.455	0.750	0.616

Table 22. The ratio of export to import price of China

Product name	IIT index			ratio of export to import price		
	2002	2007	2012	2002	2007	2012
cylinder capacity not exceeding 50cc	-0.001	0.000	0.000	0.634	0.615	0.522
cylinder capacity exceeding 50cc, not exceeding 250cc	-0.003	0.003	0.002	0.254	0.309	1.042
cylinder capacity exceeding 250cc, not exceeding 1000cc	-0.101	0.167	0.031	0.301	1.278	0.169
cylinder capacity exceeding 1000cc, not exceeding 3000cc	-0.005	0.569	0.303	1.052	0.604	0.474
diesel engine exceeding 180 HP	-0.005	0.235	0.415	0.106	0.350	0.211
autobodies	-0.007	0.130	0.907	1.062	0.108	0.856
brakes and servo-brakes		0.440	0.288		0.119	0.198
Gear boxes	-0.106	0.080	0.141	1.091	1.018	0.418
drive-axles	-0.139	0.745	0.844	0.925	0.282	0.292
road-wheels	-0.068	0.037	0.057	0.572	0.491	0.466
Frames	-0.455	0.750	0.616	0.400	0.238	0.344

Korea is different from China regarding the auto industry. In most car parts, Korea's advantage has strengthened rapidly. The TC index of cylinder capacity exceeding 1000cc, not exceeding 3000cc increased from -0.782 in 2002 to 0.462 in 2012. And in the car bodies, brakes and servo-brakes, etc, TC index is also increasing.

The result in Table 24 shows that the ratio of most of the intermediate products is near 0.8. Korea's foreign trade in most intermediate products is VIIT, and Korea exports low quality products and imports the high quality products in most products in the auto industry. But some products such as engines can be seen as HIIT.

Table 23. TC index, IIT index of intermediate and final products in the Korea auto industry

product name	TC index			IIT index		
	2002	2007	2012	2002	2007	2012
cylinder capacity not exceeding 50cc	-0.844	-1.000	-0.411	-0.085	1.000	0.417
cylinder capacity exceeding 50cc, not exceeding 250cc	-0.058	0.014	-0.151	-0.890	0.973	0.738
cylinder capacity exceeding 250cc, not exceeding 1000cc	0.988	0.962	0.984	-0.006	0.019	0.008
cylinder capacity exceeding 1000cc, not exceeding 3000cc	-0.782	-0.520	0.462	-0.122	0.316	0.368
diesel engine exceeding 180 HP	-0.425	-0.425	-0.509	-0.403	0.403	0.326
Car	0.999	0.997	0.989	-0.001	0.002	0.005
Car	0.998	0.997	0.990	-0.001	0.002	0.005
Car	0.930	0.904	0.915	-0.036	0.051	0.044
Car	0.665	0.514	0.435	-0.201	0.321	0.393
Car	0.999	0.997	0.986	-0.001	0.001	0.007
Car	0.984	0.963	0.608	-0.008	0.019	0.244
Car	0.977	0.800	-0.480	-0.011	0.111	0.351
auto bodies	0.987	0.914	0.948	-0.006	0.045	0.027
brakes and servo-brakes		0.250	0.524		0.600	0.313
Gear boxes	-0.924	-0.787	0.411	-0.039	0.119	0.418
drive-axles	0.484	0.310	0.581	-0.348	0.527	0.265
road-wheels	0.621	0.588	0.651	-0.234	0.259	0.211
Frames	0.669	0.830	0.870	-0.198	0.093	0.069

Table 24. The ratio of export to import price of Korea

Product name	IIT index			Ratio of export price to import price		
	2002	2007	2012	2002	2007	2012
cylinder capacity exceeding 1000cc, not exceeding 3000cc	-0.122	0.316	0.368	1.793	1.292	0.804
car bodies	-0.006	0.045	0.027			0.567
brakes and servo-brakes		0.600	0.313		0.444	0.806
Gear boxes	-0.039	0.119	0.418	1.092	0.717	0.795
drive-axles	-0.348	0.527	0.265	1.070	0.648	0.547
road-wheels	-0.234	0.259	0.211	1.840	1.576	1.170
Frames	-0.198	0.093	0.069	0.453	0.681	0.632

Table 25 gives the TC index in the bilateral trade between China and Korea. Obviously, China's disadvantage in nearly all of the intermediate products decreased quickly. But in the car production link, China has almost no ability to export automobiles to Korea to bridge the technical gap. But China can export some car parts, such as drive-axles and frames, to Korea. In these products, the bilateral trade is VIIT and China exports the low quality products and imports high quality products.

In fact, the bilateral trade in the car industry is relatively small. First, the car industry is different from the IT industry in the production mode. There are strict rules in assembling the parts into a whole car, so the fragmented parts are imported less than the sets of parts. Second, Korea has invested in China in an effort to enter the local market for many years, and most of the parts are produced in the factory in China instead of imports from Korea. Third, certain important parts of Korea cars, such as Hyundai, are also imported from USA, Japan or Germany so it has little effect in the bilateral trade between China and Korea.

Table 25. The TC index in the bilateral trade of the auto industry

Product Name	TC index		
	2002	2007	2012
Cylinder capacity exceeding 1000cc	-1.000	0.343	-0.484
Diesel engine exceeding 180 HP	-1.000	-1.000	-0.384
Car	-0.995	-0.999	-0.996
Car	-0.992	-1.000	-0.810
Car	-1.000	-1.000	-1.000
Car	-1.000	-1.000	-1.000
Auto bodies	-1.000	-0.886	-0.954
Servo brakes		-0.514	-0.168
Gear boxes	-1.000	-0.877	-0.847
Drive-axles	-1.000	-0.134	-0.292
Road-wheels	0.364	0.172	0.707
Frames	-0.430	-0.007	-0.160

Table 26. China and Korea' s position in the production link of global value chain of the auto industry

Product name	China	Korea
The final products:		
Car	very weak, increasing	very strong, stable
The intermediate products (car parts):		
Cylinder capacity exceeding 1000cc, not exceeding 3000cc	weak, decreasing	strong, increasing
Diesel engine exceeding 180 HP	strong, increasing	weak, stable
auto bodies	medium, decreasing	very strong, stable
Brakes and servo-brakes	strong, increasing	strong, increasing
Gear boxes	very weak, stable	strong, increasing
Drive-axles	medium, stable	strong, stable
Road-wheels	very strong, stable	very strong, stable
Frames	strong, stable	very strong, stable

We also can calculate the GL index to analyze China and Korea's participation in the two levels. The result shows the final product level has little intra-industry specialization but in unilateral trade. But the degree of the intra-industry specialization in the intermediate product level increased quickly.

Based on above, the position of China and Korea in the global value chain is in Table 26. And the position of China and Korea in the bilateral trade is in Table 27.

We also conducted a simple analysis on China and Korea's position on the R&D link of the auto industry. Both China and Korea has less PCT patents in the transport equipment than Germany and Japan. China and Korea both account for5% of the total, with Germany and Japan at about 25%.The brand value of Korea MNCs is higher than China. None of China's auto brands are in the top 500 of the World Brand rank, but Hyundai of Korea is included, making Korea's position in the R&D link stronger than China's.

Table 27. China and Korea's position in the bilateral trade in the auto industry

product name	China	Korea
The final products:		
Car	very weak, stable	very strong, stable
The intermediate products (car parts):		
Cylinder capacity exceeding 1000cc, not exceeding 3000cc	weak, decreasing	strong, increasing
Diesel engine exceeding 180 HP	weak, increasing	strong, decreasing
Car bodies	very weak, stable	very strong, stable
Brakes and servo-brakes	medium, increasing	medium, decreasing
Gear boxes	very weak, increasing	very strong, decreasing
Drive-axles	weak, decreasing	strong, increasing
Road-wheels	strong, increasing	weak, decreasing
Frames	medium, decreasing	medium, increasing

4.5. Empirical analysis of China and Korea's position in the value chain of the pharmaceutical industry

The pharmaceutical industry value chain production link is relatively simple, and is divided into raw medicine production and prepared medicine production. The product can be divided into two types: raw medicines and preparations. Most important products in the two types are shown in Table 28, allowing us to judge the position of the Chinese pharmaceutical industry in international specialization according to the Trade Competitive Index (TC Index) of China in Table 29.

TC index of the intermediate product in the pharmaceutical industry, raw medicine is positive and near 1. It shows that China has a great advantage in production of raw medicines. But TC index of the preparations, the final product of the pharmaceutical industry, is below -0.6 and decreasing. So China is at a great disadvantage in producing the preparations. We can also see that China's raw medicine tends to be unilaterally exported, while the leading industry - manufactured medicine products - tends to be unilaterally imported. So these trade flows are not characterized

Table 28. The HS code of important products in the value chain of thepharmaceutical industry

Production Name	HS code
Raw medicines:	
Alfentanril, anlieridine, etc.	293333
Allobarbital, amobarbital, etc.	293353
Alprazolam, camazepam, etc	293391
Aminorex, brotizolam, etc.	293491
Sulphonamides	2935
Vitamins and Provitamins	2936
Antibiotics	2941
Preparations:	
Preparations in measured doses	3004

by intra-industry trade.

China's status in raw medicine in the global pharmaceutical value chain is not a good sign for the development of the Chinese pharmaceutical industry. As described above, in the nonproprietary medicine field, raw medicine production has a weak connection with the core link of the value chain - the R&D link - while prepared medicine production has a closer connection. Thus, raw medicine production is the lowest end link in the nonproprietary medicine value chain, while R&D and production of prepared medicines are at the relatively high end. So we can conclude that China's international specialization within the nonproprietary medicine chain is at the lowest end of the "smile curve," while India is located at the relatively high end.

Korea's position is different from China. TC index is negative and decreasing in almost all raw medicine and preparation. Regarding some raw medicines such as Alfentanri, TC index is -1 which means Korea's export is zero. So the degree of Korea's participation in the global value chain in pharmaceutical industry is low. Korea only participates in some parts of preparation production. So in the bilateral trade between China and Korea, China has great advantage in almost all the products.

Table 30. TC index of important products in the pharmaceutical industry of China

Product name	TC index		
	2002	2007	2012
Alfentanril, anlieridine, etc.	-0.811	0.940	0.992
Allobarbital, amobarbital, etc.	0.675	1.000	0.999
Alprazolam, camazepam, etc.	0.747	0.299	0.992
Aminorex, brotizolam, etc.	1.000	-1.000	1.000
Sulphonamides	1.000	0.637	0.638
Vitamins and Provitamins	1.000	0.834	0.746
Antibiotics	1.000	0.749	0.753
Preparations in measured doses	1.000	-0.603	-0.617

Table 31. TC index of important products in the pharmaceutical industry of Korea

Product name	TC index		
	2002	2007	2012
Alfentanril, anlieridine, etc.	-1.000	-0.955	-1.000
Allobarbital, amobarbital, etc.	-1.000	-0.946	-1.000
Alprazolam, camazepam, etc.	-1.000	-1.000	-1.000
Aminorex, brotizolam, etc.	-1.000	-1.000	-1.000
Sulphonamides	-0.682	-0.703	-0.493
Vitamins and Provitamins	-0.838	-0.411	-0.478
Antibiotics	-0.295	-0.137	0.052
Preparations in measured doses	-0.588	-0.702	-0.649

Table 32. TC index of important products in the bilateral trade

Product name	TC index		
	2002	2007	2012
Alfentanril, anlieridine, etc.			
Allobarbital, amobarbital, etc.	1.000	1.000	1.000
Alprazolam, camazepam, etc	0.773	0.547	
Aminorex, brotizolam, etc	-0.989		1.000
Sulphonamides	0.962	0.933	0.884
Vitamins and Provitamins	0.996	0.821	0.749
Antibiotics	-0.127	0.719	0.611
preparations in measured doses	-0.257	0.433	0.477

Based on this, Table 33 and Table 34 gives the position of China and Korea in the global value chain of the pharmaceutical industry.

Table 33. The position of China and Korea in the global value chain

Product Name	China	Korea
The raw medicines(nonproprietary medicine):		
Alfentanril, anlieridine, etc.	very strong, stable	very weak, stable
Allobarbital, amobarbital, etc.	very strong, stable	very weak, stable
Alprazolam, camazepam, etc.	very strong, stable	very weak, stable
Aminorex, brotizolam, etc.	very strong, stable	very weak, stable
Sulphonamides	very strong, decreasing	weak, increasing
Vitamins and Provitamins	very strong, decreasing	weak, stable
Antibiotics	very strong, decreasing	medium, increasing
preparations(including nonproprietary medicine and preparation medicine):		
preparations in measured doses	very weak, stable	very weak, stable

Table 34. The position of China and Korea in the bilateral trade

Product Name	China	Korea
raw materials	very strong, stable	Very weak(nearly not participated in), stable
preparations in measured doses	strong, stable	weak, stable

Both China and Korea is weak in the R&D of medicines. China and Korea together account for about 6% of the total PCT patents. The proportion of USA is 50%.There is almost no proprietary medicine in China and Korea.

4.6. Empirical analysis of China and Korea's position in the value chain of the apparel and textile industry

The value chain of the apparel and textile industry value chain production link is relatively simple, and is divided into fibers production and apparel production. So the product can be divided into two types: fibres and apparels. Most important products in the two types are shown in Table 35.

Table 35. Important products in the apparel and textile industry

Production Name	HS code
Intermediate products:	
Silk and silk fibres	50
wool and the other animal hair	51
Cotton and cotton fibres	52
Other vegetable textile fibres	53
Man-made filaments	54
Man-made staple fibres	55
Final products:	
apparel, knitted or crocheted	61
apparel, not knitted or crocheted	62

Table 36. TC index of China and Korea in the important products in the textile industry

Product Name	China			Korea		
	2002	2007	2012	2002	2007	2012
silk and silk fibres	0.777	0.853	0.894	-0.062	-0.194	-0.072
wool and the other animal hair	-0.263	-0.119	-0.162	-0.581	-0.61	-0.572
cotton and cotton fibres	0.191	0.096	-0.115	-0.249	-0.281	-0.366
other vegetable textile fibres	0.2	0.103	0.278	-0.413	-0.357	-0.76
Man-made filaments	-0.157	0.35	0.582	0.725	0.563	0.567
Man-made staple fibres	-0.085	0.388	0.517	0.21	0.263	0.303
apparel, knitted or crocheted	0.937	0.975	0.97	0.402	-0.116	-0.362
apparel, not knitted or crocheted	0.928	0.958	0.917	0.124	-0.589	-0.654

As we all know, we calculated the TC index of the important products in Table 36. In plant fibres from HS 50 to Hs 53, the natural endowment is the main factor with respect to the position in the value chain. China's advantage in silk decides the high TC index in silk fibres. As China does not have much

land for cotton and wools, TC index of HS 51 and HS 52 is low. And in manmade fibres, China and Korea both have high TC indexes. And in apparel production, China's advantage is stable.

Table 37 gives the TC index of the bilateral trade. Only in manmade fibres production is there intra-industry trade in bilateral trade. In other products, especially

Table 37. TC index of the bilateral trade in the apparel industry

Product name	2002	2007	2012
silk	0.665	0.814	0.837
wool and the other animal hair	0.109	0.592	0.610
Cotton	0.262	0.324	0.262
other vegetable textile fibers	0.800	0.834	0.941
Man-made filaments	-0.747	-0.323	-0.139
Man-made staple fibres	-0.191	-0.007	0.074
apparel, knitted or crocheted	0.960	0.944	0.919
apparel, not knitted or crocheted	0.921	0.918	0.877

Table 38. The position of China and Korea in the global value chain of apparel and textile industries

Product Name	China	Korea
the intermediate products:		
silk and silk fibres	very strong, stable	medium, stable
wool and the other animal hair	medium, stable	weak, stable
cotton and cotton fibres	medium, decreasing	weak, stable
other vegetable textile fibres	strong, increasing	very weak, decreasing
Man-made filaments	strong, increasing	strong, stable
Man-made staple fibres	strong, increasing	strong, stable
the final products:		
apparel, knitted or crocheted	very strong, stable	weak, decreasing
apparel, not knitted or crocheted	very strong, stable	very weak, stable

apparels, there is almost unilateral export from China to Korea. The reason is that plant fibres production has much relation to the natural source endowment and the apparel production has much relation to the labor cost.

Based on this, Table 38 and Table 39 gives the position of China and Korea in the global value chain of the pharmaceutical industry.

Table 39. The position of China and Korea in bilateral trade

Product Name	China	Korea
the intermediate products:		
silk and silk fibres	very strong, stable	very weak, stable
wool and the other animal hair	very strong ,stable	very weak, stable
cotton and cotton fibres	strong, stable	weak, stable
other vegetable textile fibres	very strong, stable	very weak, stable
Man-made filaments	medium, increasing	medium, decreasing
Man-made staple fibres	medium, stable	medium, stable
the final products:		
apparel, knitted or crocheted	very strong, stable	very strong, stable
apparel, not knitted or crocheted	very strong, stable	very strong, stable

In the design link, well-established companies in China and Korea tried to improve the brand value after the crisis. The design of Korea apparel is better than China. China has no famous brand in the world, though China is the biggest exporter of apparels. Korea is like China but Korea's apparel brand is more influential than China in East Asia.

V. Conclusion

First, in the global value chain, both China and Korea has been climbing

from the final product link to the intermediate product link in the last ten years. And in the final product link, both China and Korea are focused on the value chain of capital product link instead of the consumption link. Korea climbed the smile curve faster than China.

In the bilateral trade, Korea's position on the intermediate product link is stable, but Korea position on the capital product link has been weakened. But, the position in the value chain varies greatly in different industries.

Second, in the IT industry, China's position in the final product link is very strong and stable. China's position in most accessories product link such as CPUs and LCD monitors is also strong and getting stronger. China's position in high-technology intermediate products, such as capacitors and ICs, is weak but is becoming stronger.

Korea's position is different from China. Korea's position in the final product link is weak and becoming weaker. Korea's position in most accessories product link is medium and is weakening. But Korea's position in the high-technology intermediate products is strong and is becoming stronger. The gap between China and Korea's position in the smile curve may be smaller in 2012 than in 2002.

In the bilateral trade, Korea is positioned in the high-technology intermediate product link and China is positioned in final product links. In the accessories links, there is vertical intra-industry specialization between China and Korea.

Third, in the car industry, China's position in final product link is weak but is being strengthened. In the intermediate product link, China also participated in intra-industry specialization and has greater focus on accessories in 2012 than in 2002. And Korea's position in both the final product link and intermediate product link is strong and stable. But in the bilateral trade, China's disadvantage in some low-technology products decreased gradually.

Fourth, in the pharmaceutical industry, China's position in the preparation product link is weak and is not being strengthened. China's position in raw medicine product link is strong and stable. Korea has only little participation in the value chain, in the preparation product link.

Fifth, in the apparel and textile industry, China's position in all products except man-made fibres is strong and stable. And Korea only participates in horizontal intra-industry specialization in the man-made fibres in the bilateral trade between China and Korea.

At last, both China and Korea is weaker in the R&D and marketing link of the global value chain than USA, Japan and Europe. But Korea is stronger than China in IT industry, the auto industry and the textile industry. And in some fields, Korea is strong in the R&D and marketing link, such as the R&D link related to the final product link in the IT and auto industries.

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