The Path of Trade and Economic Development in East Asian Countries

by

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List of abbreviations

BACI	Base pour l'Analyse du Commerce International
CEPII	Centre d'Etudes Prospectives et d'Informations Internationales
CJK	China, Japan, and Korea
EOI	Export-oriented industrialization
EPB	Economic Planning Board
FDI	Foreign Direct Investment
FGP	Flying Geese Paradigm
GDP	Gross Domestic Production
GHQ	General Headquarters
GMM	Generalized method of moments
GNI	Gross National Income
HDI	Human Development Index
HHI	Herfindahl-Hirschman index
HS	Harmonized System
ICT	Information & Communication Technology
IIT	Intra-Industry Trade
IMF	International Monetary Fund
ISI	Import substitution industrialization
MITI	Ministry of International Trade and Industry
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary least squares
RCA	Revealed Comparative Advantage
RTA	Regional Trade Agreement
SOE	State-owned enterprise
WCO	World Customs Organization
WTO	World Trade Organization

Chapter 1: Introduction

1.1 Path of Economic Development in in East Asian Countries

Economic development in East Asian region, often called the East Asian miracle has been extensively studied due to its dramatic achievement. The World Bank's 1993 publication "The East Asian miracle" examines the public policies of Asian economies and points out that policies including maintenance of export-driven regimes, relatively low taxes, and minimal welfare states were the important cause of the economic development. The report excludes mainland China since it was before the initiation of intensive development of China. More recently, another publication of The World Bank in 2007, "An East Asian Renaissance" highlights the rise of China in comparison with Japan and Korea. These three countries, concentrated in this thesis, are frequently considered as a group due to their similarities.

Economic development is used to describe qualitative changes of an economy while economic growth indicates quantitative changes. There is no consensus on how to measure the first concept although HDI (Human Development Index) is frequently used. In this thesis, the term "economic development" is used in the title since the thesis examines qualitative changes of trade

Although there are differences in the period and strategy, the economic growth of China, Japan, and Korea (CJK) has been progressed in a similar way. The growth of the three countries shares characteristic features which can be understood as stylized facts. First, there were substantial interventions of the government. The governments implemented import substitution industrialization (ISI) and export-oriented industrialization (EOI) to foster infant industries and reform the industrial structure. In some cases, processing trade is encouraged by giving tax benefits to increase exports. As a result, exports played a vital role in the economic growth. Specifically, the growth rate of export was much higher than GDP, and the trade surplus increased sharply. Before addressing specific research objectives, the following briefly describes the path of economic growth of CJK in order of development timing.

1.1.1 Economic Growth of Japan

Japan is the first among the three to experience intensive economic growth. The concentrated growth from the 1950s to the 1970s is often regarded as a miracle since it has begun in the wounds of World War II. At that time, Japan's real GDP growth rate was around 10%. In the 1970s, the growth rate dropped to 4% due to oil shocks in 1973 and 1978-79, and the rate of growth slowed to around 1% since 1990s.

There are several factors of Japan's rapid economic growth, but the successful economic reform driven by the government is the most important factor. The government-led economic reform policy first started in 1946. At that time, Japan suffered severe supply shortage of industrial goods. To resolve the problem, Japanese government-under the control of GHQ (General Headquarters) announced *the Priority Production System* which focused on the production of basic industrial sectors such as coal mining, steel, electricity, and railway. Under the policy, most of the output of the one industry was put into the other industry. Through this concrete input-output linkage, coal and steel industry rapidly recovered until 1949.

The Dodge Line, name after the inventor-GHQ's economic advisor Joseph Dodge, in 1949 is a turning point of economic policy of GHQ. Basically, it was a belt-tightening policy package that strengthened Japan's economic fundamentals. Specifically, it recommends balancing the national budget, efficient tax collection, dissolving the Reconstruction Finance Bank, decreasing the scope of government intervention, and fixing the exchange rate. Those recommendations were quite sudden and hard to accept for Japan. After the implementation of Dodge Line, Japan experienced a severe recession. However, the outbreak of the Korean War in the early 1950s substantially aided Japan's economic recovery by boosting export related with special procurement. Since Japan is geographically close to Korea, it was easy to export weapons and other materials to the Korean peninsula.

From 1949, the Ministry of International Trade and Industry (MITI) had served the vital role in industrial reformation of Japan. MITI served as a director of industrial policy. But it was an arbiter and regulator rather than authoritative agency of policy implementation according to a central pre-defined plan.

In 1960, *Income Doubling Plan* led by Prime Minister Ikeda, a former minister of MITI, is the highlight of economic miracle of Japan. Doubling income itself is the goal of the plan. It includes following specific objects: modernization of agricultural sector and SMEs, and expansion of exports.

Among others, vast export growth solved the trade deficit problem and supported the rapid growth of GDP. After World War II, Japan suffered trade deficit until the midst of 1960s. To overcome trade deficit, the Japanese government had been implemented policies facilitating processing export-which is the fastest way to enhance trade balance. As a result, Japan successfully substituted almost imports with domestic production in cooperation with policies. At 1964, the time joining IMF, Japan finally abandoned a restriction of import and reduced the scope of other devices including tax exemption for processing exports. This result reflexes changes in the industrial structure which is a consequence of economic reformation of Japan.

1.1.2 Economic Growth of Korea

Korea underwent similar extensive growth process from the 1960s to 1990s. Until the late 1950s, Korea was undergoing less restoration of the Korean War. The nominal GNI in 1961 was less than $ 100 and the US aid accounted about half of the national budget. However, from 1970 to 1995, Korea's real GDP growth rate became around 10% except periods of oil shocks. After the IMF shock, the rate of growth slowed to around 5% since 2000s.

In Korea's economic development, the role of the government was very crucial. In 1962, well-known national Five-Year Plans were implemented by Economic Planning Board (EPB). Since EPB held wide range of authorities, it was able to serve the core functions of the economic planning headquarters. The fact that there was a government body dedicated to development is characteristic of the history of economic development in Korea.

Before 1961, Korea also focused on ISI policy but export was not that emphasized. Entrepreneurs had bribed rather than improving productivity, which led to reduced efficiency. In the early 1960s, Korea had focused on exporting labor-intensive products by leveraging its skilled workforce. The imports were properly regulated with a focus on increasing exports, and various financial incentives including tax benefits were taken to increase exports. As a result of these efforts, Korea achieved high export-oriented growth within a relatively short period. However, in the 1970s, the external trade policies changed as Korea faced trade barriers from major trading partner countries. The government decided to upgrade its export products to increase exports. In order to increase exports, and to foster the heavy industry, ISI policy reemployed. During that period, various policy measures such as special interest rates, subsidies, and import restrictions were provided to exporters. For example, the finance interest rate for trade was 6.1 percent in 1966-1972, which was 17.1 percentage points lower than the general rate. Westphal (1978) evaluates Korea's outward-looking policies in this period resulted rapid industrialization with a certain level of efficiency.

However, there were also negative effects on the government-led economic growth. The effect including high inflation rate was unfolded during oil shocks. Thus, since the 1980s, the Korean government has launched market-led growth strategies instead government-led strategies to achieve economic stabilization. Also, trade policy was transformed into more open way. The government opened up the economy through the liberalization of imports. Also, in the late 1980s, the Korean government began to liberalize foreign exchange and capital markets, although in a gradual manner.

Trade balance of Korea remained deficit until 1997 from the modern era, only except 1986 to 1989. In the exceptional period, weak dollar, low oil price, and low international interest rates helped to maintain trade surplus. However, since 1998, when the IMF financial crisis broke out, it turned into a surplus and reaching the present. Korea started processing trade in the 1960s, but the turnover of the trade balance is very late. In addition, unlike Japan, Korea still actively operates special economic zones (SEZ) as a bonded processing area and exports from the area is accounting for around 30% of total exports until 2010s.

1.1.3 Economic Growth of China

China experienced rapid economic growth from the 1980s to the 2010s. In the period, the annual GDP growth rate remained at 7-10%. China, a socialist country, has been pursuing an explicit economic development plan since the 1950s. Similar to Korea in the period of intensive growth, Five-Year Plans have been established since 1953 to pursue a government-led economic development. From 2016, the 13th Five-Year Plan is in place until now. While MITI in Japan and EPB in Korea played the vital role for economic development, in case of China, all economic ministries functioned according to the objectives set by the Chinese Communist Party.

However, economic development was not visible before the economic reformation. *The Chinese economic reform* generally refers to the economic reform program called *Socialism with Chinese characteristics* initiated in 1978 by reformists-most notably by Deng Xiaoping. Most importantly, the reformation introduced market principles into the economy. Specifically, the reformation included privatization of state-owned enterprises, introduction of foreign capital, and trade liberalization. Paradoxically, the role of *open door policy* was just complementary, Zhu (2006) notes. Li and An (2004) summarized eight major industrial policy measures such as financing, pricing, and channeling FDI. Those policy measures are related with ISI or EOI. Different from Korea, China is a very easy market to implement ISI since it has a sufficiently large domestic market. As a result of the reformation, China joined the WTO in 2001 and became the world's largest trading country since 2008.

Although there are various policies for the miraculous growth of China, FDI inflows and increased exports are direct factors of the growth. In 2006, China's trade accounted for more than 65% of GDP. In 1978, the same share was only 9.6%. Given that China is a large country and has experienced rapid economic development, this high degree of openness is very surprising. China's trade has increased mainly with exports. As a result, the trade surplus in China has gradually increased since 1990, and since 2005, the trade surplus has reached more than $ 100 billion annually.

China's trade is closely linked to FDI. According to China Customs Statistical Yearbook, about 80% of processing exports-which accounts for 30% of total exports, are made by foreign enterprises (foreign-invested enterprise or joint-venture enterprise) in China. Notice that the meaning of processing trade in the thesis is a narrow definition only indicates two modes of trade. One is processing trade with supplied material from foreign country. The other one is processing trade with imported material. The latter is huge by now though the first one had been the majority in the early 1990s.

There are two conflicting characteristics of processing trade. First, China is still dependent on processing trade. However, the major products of processing trade are high-tech products from ICT industry. Different from the case of Japan and Korea, China is exporting capital (technology) intensive goods via processing trade.

Setting apart from mode of trade, China is now believed to the most threating export competitor for developed countries including Japan and Korea. Contrary to the two, there has been a debate about the productivity and maturity of export of China. Hausman, Hwang, and Rodrik (2007) constructed two indices to measure the level of sophistication of products and countries. It concludes that China shows a significantly high level of sophistication of export compared to the countries which has similar per capita GDP of China. Underlying idea of the measure is that a country with higher per capita GDP will trade more complex products. This plausible idea gives many implications except the case of China. Schott (2008) gives similar results presenting China's export overlapping with OECD countries.

1.1.4 Does Flying Geese Paradigm Valid?

The high growth of CJK has many similarities. The "Flying Geese" model (or Flying Geese Paradigm) of Akamatsu (1935, 1937, 1961, 1962) is a well-known method of explaining the rapid growth of East Asia. According to Kojima (2000), which summarizes the FG model, the model focuses not only on explaining the regional transmission phenomenon of economic development but also on explaining the process of economic development. FG model explains that imports, domestic production, and exports increase sequentially as follows.

Initially, the undeveloped countries do not demand or produce industrial goods. When a country opens its import market, it begins to import industrial goods (e.g., steel, machinery). When the demand for industrial goods increases, the domestic production of industrial goods starts. The important point here is that the center of domestic industrial structure changes from traditional (primary) goods to industrial goods. As the production increases, the competitiveness also increases due to economies of scale, which finally leads to exports.

Akamatsu verified this process with prewar time data. The FG model has various variants. The model is also used to explain the contagion of industrialization among countries, especially in East Asia. Actually, the growth pattern of CJK looks like the theory predicts. However, when it comes to the role export, it seems like there is a substantial difference. In case of Japan, the share of export in their national economy was already over 10 per cent in the 1970s and now around 16 per cent. China's exports were under 10 per cent until the 1980s, but it had been surging in the 1990s and the 2000s. In 2006, the share of export in China's

GDP recorded 37% which is the historical highest. As of 2016, it fell to 19% due to the 12th and 13th five-year plans. In Korea, exports account for the largest share of the gross domestic product. As of 2016, exports account for more than 40% of the gross domestic product.

A more interesting phenomenon is that the share of domestic value added is very different by country. Value added of Japanese exports is mostly derived from Japan. Although it varies by industry, domestic contribution of value added accounts for 80% to 90% of total export value. However, in case of Korea, it is as low as 50% to 70%. The value of China is located between Japan and Korea. The role of the government was also different. MITI mainly played a role of arbiter and regulator. EPB was able to exercise broader rights, and at times it had a direct policy on the company. In China, SOE still dominates the overall economy.

To summarize, the pattern of economic growth, a macro-level observation, of the three countries is similar. But, in micro-level, development strategies are different: for example, the role of government and role and pattern of export.

FG Paradigm describes the path of industrialization and economic growth that leads to import-production-export, but it does not provide a description of these regional differences. In this regard, it is meaningful to study the evolution path of exports in explaining economic development. Especially, the path of evolution, the competitiveness, and the maturity of Chinese export relative to Japan and Korea are very important issues in East Asia. Thus, tracking the export evolution pathway of the three will give various implications.

Thus, the main objective of this thesis is to analyze the development path of export to understand economic development path. To achieve the objective, this thesis studies the direction of structural changes, develops a more accurate measure, and gives some implication from China’s processing trade which generates a huge bias of export performance of China.

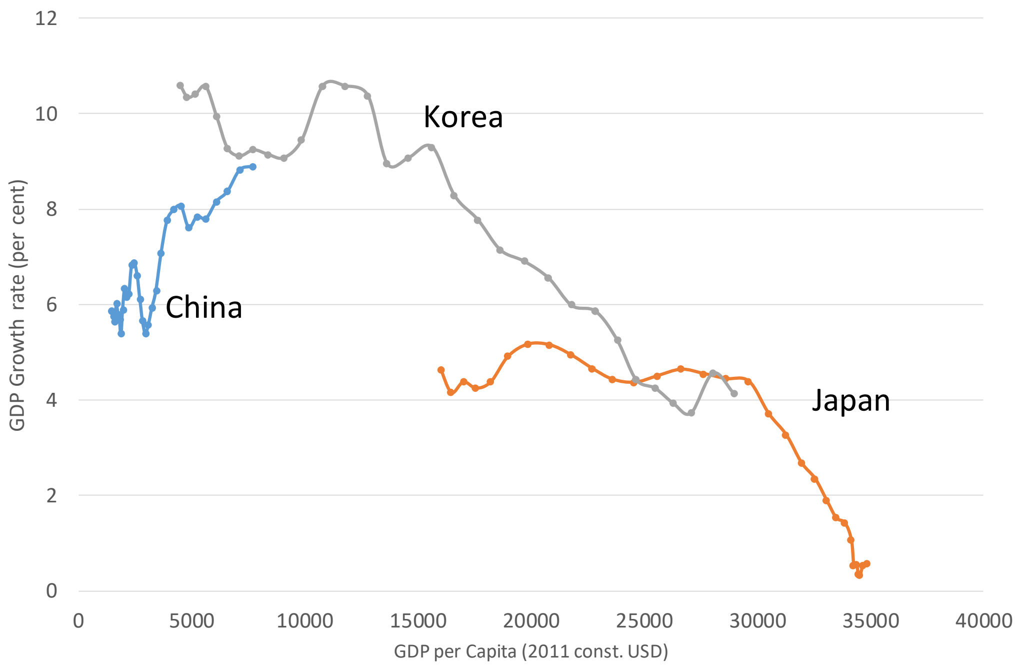

Figure 1-1: GDP per capita and growth of CJK

Source: Worldbank

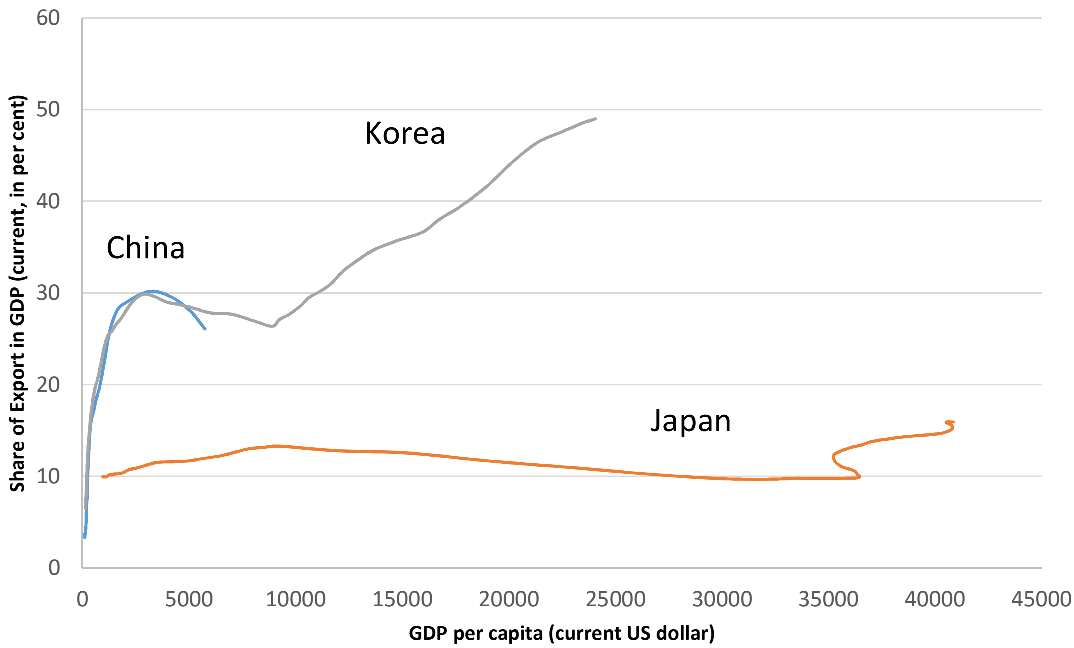

Figure 1-2: GDP per capita and Export share in GDP

Source: Worldbank

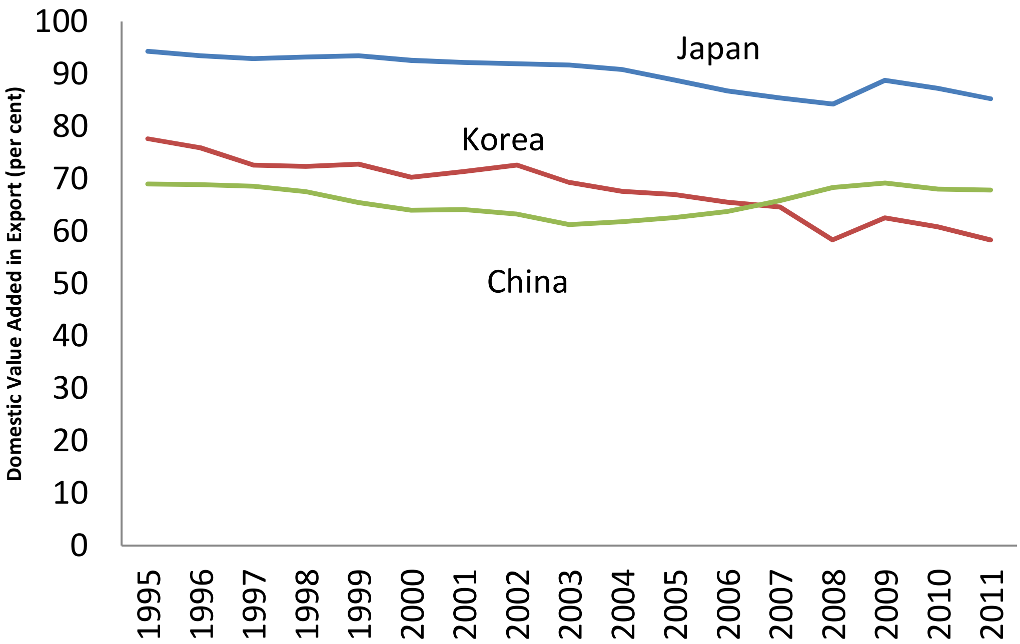

Figure 1-3: Domestic Value Added in Export of CJK

Source: WIOD

1.2 Path of Export Development in East Asian Countries

As for the expected pattern of export, the classical theories of international economics predict that countries will specialize due to difference in comparative advantage (Ricardo, 1817) or factor endowment (Heckscher, 1919). But, by now, contents of international trade look similar and goes forth more similar which contradicts the classical theory. One striking fact is that China, a labor abundant country, is specialized on electronic devices industry which requires huge capital investment. New trade theory after Dixit and Norman(1980), which is a standard at now, has introduced product differentiation, scale of economies, and firm heterogeneity (Melitz, 2003). It gives an appropriate explanation to intra-industry trade.

Although both the classical theories and new mainstream theories of international trade advocate the efficiency of free trade, Prebisch-Singer hypothesis (Prebisch, 1949, Singer, 1950) postulates that terms of trade could be deteriorated by trade. Bhagwati (1958) proved the possibility of immizerizing growth theoretically. There is a strand of literature which consistently emphasizes importance of structural properties of trade on national economies.

But, it is evident that a developing country cannot catch up developed economies without changing its production structure. Mimicking developed countries is a traditional strategy for developing countries. Cases of East Asian countries' industrialization attest the efficiency of policies such as import substitution industrialization which implemented by CJK at different periods. Therefore, what countries trade, in other words: pattern of export, has received much interest of academics as it reflects the change in supply side such as level of technology and production structure also demand side.

Two most distinctive facts in the export development of East Asian countries are substantial growth and structural synchronization. First, the background of synchronization is considered to be the emergence of intra-regional trade, especially intra-industry trade. The FG theory also states that a late comer replicates sophisticate products through intra-regional trade with a developed country, starts domestic production, and export finally.

Exports of the three countries have developed somewhat differently due to different export expansion strategies. It is necessary to diagnose the direction of export expansion in order to examine the export development paths. A country can extend their domain by exporting a new product or pioneering a new market. They are called *extensive margins*. Inversely, *intensive margins* indicate growth of existing export ties. Tracking how CJK has expanded its exports has policy implications. The synchronization phenomenon can be measured by the similarity index developed by Grubel-Lloyd (1975). Indicators measure which countries emulate different countries' export structures and how much is in-trade. For example, we can measure how much export structure China has in the global market. China's processing trade has had a dramatic impact on China's export growth in recent two decades. Still, about 30-40 per cent of China's exports are processing trade.

However, existing studies have some limitations. First, there is a lack of research on the export development path of the three countries from the perspective of extensive margins and intensive margins. Many studies compare two countries to make a bilateral comparison. Existing measurement methods of synchronization have a bigger drawback. Existing indices do not consider quality appropriately. More specifically, indices report that two countries have similar structure only if two countries share similar export structure in terms of value or quantity regardless of quality. Finally, there are conflicting conclusions about the Chinese processing trade between two perspectives. On the one hand, it emphasizes that processing trade is performed only by firms with low productivity, and on the other hand emphasizes the positive productivity enhancement of processing trade.

Thus, this thesis attempts to fill the gaps of existing studies, starting with the problem consciousness, and the specific objectives and research questions are introduced in the next section.

1.3 Research Objectives, Questions, and Methodologies

1.3.1 Research Objectives and Questions

The purpose of the thesis is to analyze the export development path of the three countries. For the purpose, the thesis has three specific objectives as follows:

1. **Decompose the extent of export growth of East Asian countries**
2. **Develop a bilateral similarity index improving and generalizing existing concepts**
3. **Analysis the effect of China's processing trade on China's export development**

In a relation with the first objective, there are two specific research questions which will be dealt in chapter 2.

1) **Does the export development of China, Japan, and Korea depend on extensive margins: extension of new products or new markets?**
2) **What are the survival rates of new export ties of the three countries?**

The second objective also has two questions and will be addressed in chapter 3.

1) **Can existing bilateral similarity indices be generalized? Can generalization yield any different results from the present?**
2) **Has export similarity of Korea, China and Japan increased? Is it also when considering quality?**

The last objective is examination of the role of processing trade and following research questions will be answered in chapter 4.

1) **Theoretically, does processing trade policy help to improve productivity?**
2) **Empirically, what China has learned from processing trade?**

1.3.2 Research Methodologies

The first objective of the thesis is to decompose the export structure in dynamics. Methodologically, the Theil index is mainly used to measure diversity level of export products (or destinations) of East Asian countries. The index is used to diagnose the main factor of export growth: extensive or intensive margins. However, as existing literature shows the possibility of the measurement error, two alternative methods (utilization ratio and direct calculation of contribution of new exports) are applied. Extensive margins and intensive margins are concepts that can change over baseline time definitions. If a reference period set long, most export expansions will be considered as intensive margins, but most cases will be identified as extensive margins with a short reference period.

This decomposition of export is a sort of positive side approach and does not provide enough information about the discontinued exports. However, the information about duration of established export ties is also important. This can be seen as a negative side approach, and this thesis attempts to do the approach through survival analysis. It also can be understood as a decomposition of intensive margins. Specifically, for the survival analysis, Kaplan-Meier estimate is applied.

The theoretical approach was made to achieve the second objective. The bilateral similarity index measures how similar the two countries export (or import). In order to overcome limitations of previous studies, a literature survey is conducted first. Then, a generalized bilateral index is suggested. In order to demonstrate the usefulness of the index, simulation results are presented through the sampling of virtual data as well as actual trade data. The new index was also used to diagnose the export similarity of CJK.

In order to achieve the final objective, both theoretic and empirical analyses were used. Cost-discovery model of Hausman (2007) is the foundation of theoretical development of this part. This thesis relaxed previous assumptions that entrepreneurs only can make two choices according to his productivity. Specifically, the original model assumes that an entrepreneur with low-productivity will imitate other's project to obtain fixed results, while more productive entrepreneurs will stick with their original project and will get results according to the productivity. The thesis added the third choice, processing trade, into the model.

Empirically, processing trade statistics of China is used to identify the correlation between processing trade export experience and ordinary trade exports. Econometric methodologies such as OLS and GMM are adopted along with descriptive analyses.

1.4 Dissertation Structure

The thesis has five chapters. **Chapter 1** describes the history of economic development of East Asian countries as a background of the research. Then, it discusses objectives, specific questions, and methodologies of overall thesis.

Chapter 2 analyzes intensive and extensive margins of export in East Asian countries. This chapter first shows CJK's export diversity in terms of product and region (partner country). Generally, countries can diversify their export portfolio to a market with similar demand structure. This chapter tests how the three countries have diversified in different markets. It includes the results limited to the machinery industry, which is known to be difficult to catch-up.

After specifying the pattern of diversification, the diversity is decomposed into extensive and intensive margins. Since the decomposition method tends to underestimate extensive margins and does not offer information inside intensive margins, two complementary analyses added. First, utilization ratio of CJK is calculated. The ratio measures how much the country has realized exports in a given condition - feasible products and tradable partners. Second, survival analysis of established trade ties was conducted to explore intensive margins inside.

Chapter 3 mainly provides a generalized similarity measure of a bilateral trade which unifies quantity and quality aspects in a single framework. From the 1960s, various indexes about bilateral trade similarity are constructed based on Minkowski distance. Since the literatures describe as they coined the concepts independently, similarity concepts are identical to the Minkowski distance with a fixed parameter only in formula. However, depending on the perspective about similarity, a measurement result may mislead the interpretation. To tackle this problem, the chapter first generalizes existing measures with a variable Minkowski distance parameter.

Previous concepts do not contain the information about quality heterogeneity of products. To consider the heterogeneity, the newly invented concept has a twofold evaluation process. First it gauges relative quality homogeneity of each exporting product of two countries. Then the final similarity is calculated by adding the quality homogeneity to the quantity similarity.

For checking effectiveness of the invented concept, a simulation with trade data in automobile is employed. Also, export similarity of CJK is re-evaluated with new concept.

Chapter 4 is giving an analysis of processing trade which accounts around one third of Chinese export. China's exceptional export performance cannot be exactly understood without regarding processing trade. Thus, the chapter studies role of processing trade in China's trade. Before the investigation, stylized facts about processing trade are addressed. A modification of cost discovery model that developed by Hausman et al. (2007) is a main theoretic contribution. In the modified setting, selected entrepreneurs can achieve higher level of productivity on average by using processing trade. After presenting the model, relationship between processing trade experience and ordinary export is examined to verify the model empirically.

The last chapter concludes the thesis with the summary of main findings. Limitations and future research possibilities are also provided.

Chapter 2: Evolution Path of Exports in East Asia: Intensive and Extensive Margins of Export

2.1 Introduction

Countries in East Asia have been experienced rapid economic growth. Since countries share a similar pattern of economic growth in aggregate level, Akamatsu coined *Flying Geese theory* name after their resembling trace of economic growth (for survey, see Kojima, 2000). Export driven economic growth, which is a prominent characteristic of the growth of China, Japan, and Korea, has been studied extensively. However, the three countries have different evolution path of export due to different given endowment and period of intensive growth. Aggregate exports of the three countries have increased in a similar way, but the components of exports are different.

There have been many studies about the path of export growth. After Imbs and Wacziarg (2003) revealed the existence of a non-linear pattern of sectoral concentration and income level, the pattern of export specialization has been interest. Cadot et al. (2011), Koren and Tenreryro (2007), and Cabellero and Cowan (2006) confirmed U-shaped pattern between export specialization and income level. The pattern predicts that countries will diversify its contents of exports as the economy develops but will specialize after reaching a certain level of economic development.

Since export concentration is calculated only with data of a fixed period of time, information on changes in export structure is generally omitted. For example, consider a country's export concentration is reduced. Without appropriate additional information, it cannot be determined whether the export of new items has increased or the concentration of certain items has decreased. Studies about extensive and intensive margins of export complement this limitation. Countries can extend their domain of export by shipping a new product or pioneering a new market. Those kinds of expansion are called "extensive margin". Inversely, "intensive margin" indicates growth of existing export ties. Two margins compare two different time periods and thus allow us to capture a structural change between time periods.

A large body of literature compares relative importance of extensive and intensive margins of export. Hummels and Klenow (2005) finds extensive margin as the main engine of export growth by using cross-sectional analysis. Theoretically, Helpman et al. (2008) concluded intensive margin as the decisive factor of export growth. Primitive level of extensive margin can be captured by comparing diversification indices. After Michaely (1958) studied trade diversification, there have been many examples measuring export diversification. Methodologically, the Herfindal index, the Gini index, and the Theil index are extensively used due to its simplicity of calculation. The Theil index which derived from Shannon's entropy index has a good decomposable property that can be applied to measure the extent of extensive margin from total diversification. However, extensive margins and intensive margins as a complement of extensive margin can be changed over baseline time definitions. If a reference period set long, most export expansions will be considered as intensive margins, but most cases will be identified as extensive margins with a short reference period.

By definition, intensive margin is the complementary concept of extensive margin. However, extensive margin is a concept that only measures positive extensions while intensive margin can be divided into *survival* and *deepening* as in (Farole et al., 2010). Deepening is a sort of extension and in the same line with extensive margin. Survival is much different concept than the others. Since many of new export relationships are disappeared in the following year, survival that measuring a non-negative part of growth is also important. Notice that only survived exporting ties can contribute to the export growth by its own growth. Thus, survival analysis of export relationships gives an insight on understanding intensive margin of export.

The objective of this chapter is to decompose the extent of export growth of CJK. The chapter first shows its export diversity in terms of product and region (partner country). Export diversification will be analyzed by income level of importing countries since countries can diversify their export portfolio to a market with similar demand structure. The Theil index is employed as the measure of diversification. China is expected to diversify exports to low-income countries, while Korea and Japan to high-income countries. It also includes the results limited to the machinery industry, which is known to be difficult to catch-up.

After specifying the pattern of diversification, the diversity is decomposed into extensive and intensive margins. Since the decomposition method tends to underestimate extensive margins and does not offer information inside intensive margins, two complementary analyses, following Besedes and Prusa (2011), added. First, utilization ratio of CJK is calculated. The ratio measures how much the country has realized exports in a given condition - feasible products and tradable partners. Second, survival analysis of established trade ties was conducted to explore intensive margins inside.

There are two research questions.

1. **Does the export development of China, Japan, and Korea depend on extensive margins: extension of new products or new markets?**
2. **What are the survival rates of new export ties of the three countries?**

This chapter relates to the literature of export development. Cadot et al. (2011) suggests using diversity measure for analysis of extensive and intensive margins and gives an example empirically. For a specific country, Min et al. (2011) analyzed extensive and intensive margins of Korean export by using the Theil diversity index. Different from Cadot et al. (2011), Min et al. (2011) analyzes diversity of products and diversity of partner countries. For the case of China, Amiti and Freund (2010) gives a similar analysis providing rich related backgrounds facts. Besedes and Prusa (2011) suggest a decomposition method of intensive margin which also adopted in here.

Existing studies have focused on all countries-omitting detailed analysis of individual countries, or focusing a specific country-omitting international comparison. Also, to the best of my knowledge, it did not directly handle the classification correlation problem. Since the HS classification nomenclature, which is the foundation of trade statistics, changes every 4-6 years, previous studies used a broad dataset with the loss of information, or a time-lagged dataset published at BACI.

This chapter gives in depth analysis of export structures of China, Japan, and Korea in terms of extensive and intensive margins. Also, to conduct more precise and detailed survival analysis, an original dataset converted from the UN public datasets is used. The conversion methodology is in the vein of Schott (2012).

The remaining part is as follows. In section 2.2, the Theil index and its characteristics are introduced first. And an analysis of the Theil index over products to interested countries is given. It also gives an analysis over regions. In section 2.3, the Theil index is decomposed into extensive and intensive margins. Since previous literatures points out a small contribution of extensive margin, to secure the robustness of analysis, alternative methods for calculating extensive margins are also applied. Survival analysis of export spells is conducted to see the intensive margin more precisely. Finally, in section 2.4, it concludes with some implications.

2.2 Export Diversity of East Asian Countries

2.2.1 Data

In order to analyze export diversity, a trade statistics dataset from UN COMTRADE was used. Countries engaged to WCO share common HS commodity classification mostly[1]. Each country has original national tariff lines divided from HS. A comparison across countries using national tariff lines is inappropriate since disaggregation level of analysis may affect the result. To deal with this problem, all analyses in whole thesis conducted at HS sub-heading level, which means so-called 6-digits level.

Our timespan of analysis starts at 1992 and ends at 2016. WCO revises HS system each 4 or 5 years. UN COMTRADE database supports new trade data converted to old nomenclatures by the guidelines set by UN statistics division. Also, CEPII provides a time-consistent BACI dataset by its own methodology. However, converted data has omissions due to the methodological limitation. Thus, in this section, combined dataset consists of five different nomenclatures is employed. Each nomenclature contains 5,020 to 5,224 products excluding the super code "999999". Every zero valued observation and non-regular codes were excluded in analysis. In 1992, the beginning of our analysis, China, Japan, and Korea exported more than 4,000 products at HS subheading level. The numbers suffice to guarantee the meaningfulness of consequent diversity analysis. Empirical analysis indicates the HS classification consistency issue is not that substantial in this section. Thus, a converted data will be applied in the next section.

2.2.2 Methodological Framework: The Theil index

Traditional measure of diversification in industrial organization literature is the HHI which named after its inventors Herfindal (1950) and Hirschman (1945). The Gini coefficient

[1] Some developing countries often use expired nomenclature.

by Gini (1912) is popular in inequality literatures. These two have a virtue of simplicity. Theil (1972) suggests more sophisticated one derived from Shannon's entropy index which has desirable properties that will be described latter.

Consider all tradable varieties of a country are indexed by $N = \{1,2,3,\dots,n\}$. The Theil index T can be defined as follows.

$$T = \frac{1}{n}\sum_{i=1}^{n}\frac{x_i}{\bar{x}}ln\left(\frac{x_i}{\bar{x}}\right)\ where\ \bar{x} = \frac{1}{n}\sum_{i=1}^{n}x_i \tag{2-1}$$

Notice that the index can be defined over trade destinations instead varieties. By definition, the index takes non-negative real value. If a country exports all varieties equally, then the index is 0. To see the meaning of the index, the derivation process from Shannon's entropy index is required. Shannon (1948) defined information entropy S for given n bits of information as follows.

$$S = \sum_{i=1}^{n}\left(p_i log\frac{1}{p_i}\right) \tag{2-2}$$

In the formula, p_i means the probability of finding member i from a random sample of population. The original base of log is 2 since Shannon devised the index to measure information expressed by bits. The definition of entropy is different by its base and three types of base are mainly used. In here, e is taken as the base for reducing formula. Entropy can be understood as a measure of disorder. Entropy will be zero if the given system is deterministic. In that case, entropy index is zero as $p_i = 1$ for some i and zero otherwise. When p_i is replaced by $\frac{x_i}{\sum_{i=1}^{n}x_i}$, export share of product i, the index becomes:

$$S^{observed} = \sum_{i=1}^{n}\left(\frac{x_i}{n\bar{x}}log\frac{n\bar{x}}{x_i}\right) \tag{2-3}$$

This is the observed entropy. The maximum entropy of the given system (in here, product classification), S^{max}, is equal to $log(n)$. The maximum entropy in terms of export diversification means extreme diversification: all items are being exported with equal weight.

The observed entropy represents the current degree of diversification. The more diversified, the larger the index. Thus, the difference between the maximum entropy and the observed entropy, $S^{max} - S^{observed}$, indicates the degree of specialization (negative diversification). The reason for the difference is that the level of diversification indicated by the same observed entropy varies on characteristic of classification (n).

The difference can be converted more simple form which called the Theil index.

$$T = S^{max} - S^{observed} = ln(n) - \sum_{i=1}^{n}\left(\frac{x_i}{n\bar{x}} ln\frac{n\bar{x}}{x_i}\right)$$

$$= \sum_{i=1}^{n}\left(\frac{x_i}{n\bar{x}} ln(n)\right) + \sum_{i=1}^{n}\left(\frac{x_i}{n\bar{x}} ln\frac{x_i}{n\bar{x}}\right)$$

$$= \sum_{i=1}^{n}\left(\frac{x_i}{n\bar{x}} ln(n)\right) + \sum_{i=1}^{n}\left(\frac{x_i}{n\bar{x}} ln\frac{x_i}{\bar{x}}\right) - \sum_{i=1}^{n}\left(\frac{x_i}{n\bar{x}} ln(n)\right)$$

$$= \frac{1}{n}\sum_{i=1}^{n}\left(\frac{x_i}{\bar{x}} ln\frac{x_i}{\bar{x}}\right) \qquad (2\text{-}4)$$

Again, notice that the Theil index indicates negative entropy. A high value of the index means highly concentrated situation and a low value indicates decentralization. Importantly, I assume that given classification partitions the product set appropriately.

The Theil index can be decomposed by within and between groups additively. Assume that $M = \{g_0, \dots, g_m\}$ be a partition over N. For simplicity, n_j and x_j to be the cardinality and average of g_j, respectively. Without loss of generality, the Theil index in (2-4) can be expressed as follows.

$$T = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{x_i}{\bar{x}} ln\frac{x_i}{\bar{x}}\right) = \sum_{j\in M}\sum_{i\in g_j}\left(\frac{x_i}{n\bar{x}} ln\frac{x_i}{\bar{x}}\right)$$

$$= \sum_{j\in M}\sum_{i\in g_j}\left(\frac{x_i}{n\bar{x}} ln\frac{x_i}{\bar{x}}\right) + \sum_{j\in M}\left(\frac{n_j\bar{x}_j}{n\bar{x}} ln\bar{x}_j\right) - \sum_{j\in M}\left(\frac{n_j\bar{x}_j}{n\bar{x}} ln\bar{x}_j\right)$$

$$= \sum_{j\in M}\sum_{i\in g_j}\left(\frac{x_i}{n\bar{x}} lnx_i\right) - \sum_{j\in M}\sum_{i\in g_j}\left(\frac{x_i}{n\bar{x}} ln\bar{x}\right) + \sum_{j\in M}\left(\frac{n_j\bar{x}_j}{n\bar{x}} ln\bar{x}_j\right)$$

$$- \sum_{j\in M}\left(\frac{n_j\bar{x}_j}{n\bar{x}} ln\bar{x}_j\right) \qquad (2\text{-}5)$$

Notice $\sum_{j\in M}\left(\frac{n_j\bar{x}_j}{n\bar{x}} ln\bar{x}_j\right)$ is inserted for the sake of algebraic manipulation. Replacing the notations by adopting $s_i = \frac{x_i}{n\bar{x}}$ and $s_j = \frac{n_j\bar{x}_j}{n\bar{x}}$ simplifies (2-5) as following.

$$T = \sum_{j\in M}\sum_{i\in g_j} s_i ln x_i - \sum_{j\in M}\sum_{i\in g_j} s_i ln\bar{x} + \sum_{j\in M} s_j ln\bar{x}_j - \sum_{j\in M} s_j ln\bar{x}_j$$

$$= \sum_{j\in M} s_j ln x_i - \sum_{j\in M} s_j ln\bar{x} + \sum_{j\in M} s_j ln\bar{x}_j - \sum_{j\in M} s_j ln\bar{x}_j \qquad (2\text{-}6)$$

Combining the first and the fourth, the second and the third gives

$$T = \underbrace{\sum_{j\in M} s_j ln\frac{\bar{x}_j}{\bar{x}}}_{T_B} + \underbrace{\sum_{j\in M} s_j ln\frac{x_i}{\bar{x}_j}}_{T_W} \qquad (2\text{-}7)$$

More specifically, let assume two groups, g_0, g_1, only exist: the set of active lines and the others. The first set includes all active export products. Note that the Theil index over the first set is different from the Theil index over the whole set that including some zeros. Now the Theil index can be decomposed into T_B and T_W as in (2-7): the Theil index between groups and within group. The first one can be defined as follows.

$$T^B = \frac{n_{g_0}\bar{x}_{g_0}}{n\bar{x}}\underbrace{ln\left(\frac{\bar{x}_{g_0}}{\bar{x}}\right)}_{d_0} + \frac{n_{g_1}\bar{x}_{g_1}}{n\bar{x}}\underbrace{ln\left(\frac{\bar{x}_{g_1}}{\bar{x}}\right)}_{d_1} \qquad (2\text{-}8)$$

Each d_j measures the distance between the total average and the group average. Along with the probability mass of each group, the sum of negative entropy of groups represents negative entropy between groups.

$$T^W = \frac{n_{g_0}\bar{x}_{g_0}}{n\bar{x}} ln\frac{x_i}{\bar{x}_{g_0}} + \frac{n_{g_1}\bar{x}_{g_1}}{n\bar{x}} ln\frac{x_i}{\bar{x}_{g_1}}$$

$$= \frac{n_{g_0}\bar{x}_{g_0}}{n\bar{x}}\left[\frac{1}{n_{g_0}}\sum_{i\in g_0}\frac{x_i}{\bar{x}_{g_0}} ln\frac{x_i}{\bar{x}_{g_0}}\right] + \frac{n_{g_1}\bar{x}_{g_1}}{n\bar{x}}\left[\frac{1}{n_{g_1}}\sum_{i\in g_1}\frac{x_i}{\bar{x}_{g_1}} ln\frac{x_i}{\bar{x}_{g_1}}\right]. \qquad (2\text{-}9)$$

One can easily verify that the first term of T^W is zero by definition (See Cadot et al., 2011 for the details). Changes in T^W denotes intensive margin since it captures the internal change of export structure. Inversely, T^B represents extensive margin.

Taking arbitrary logarithmic base may mislead interpretation of decomposition. A good summary of it can be found in Abayomi and Darity (2010). Despite of its intrinsic problems, the index extensively used in the diversification literature and this chapter applies the index to measure diversity of export and decomposition of export growth.

2.2.3 Product Diversification of East Asian Countries

In this section, CJK's export diversification patterns are analyzed by using the Theil index. Diversification of export varieties differs depending on given endowments and development strategy. It is important for developing countries since it generally reduces risk, but not for countries with top-end competitiveness for they would specialize on their monopolistic products. Thus, countries are expected to traverse various levels of diversification depending on economic development.

In cross-section, China's export diversity was the highest among the three countries. Korea recorded the lowest and Japan was in the middle. This is notable because the levels of export diversification have not changed much in spite of the huge changes in export of CJK. In 1992, Japan's exports were four times larger than China's. But in 2016, China exported three times as much as Japan. It can be seen here that export volume is not necessarily related to diversification.

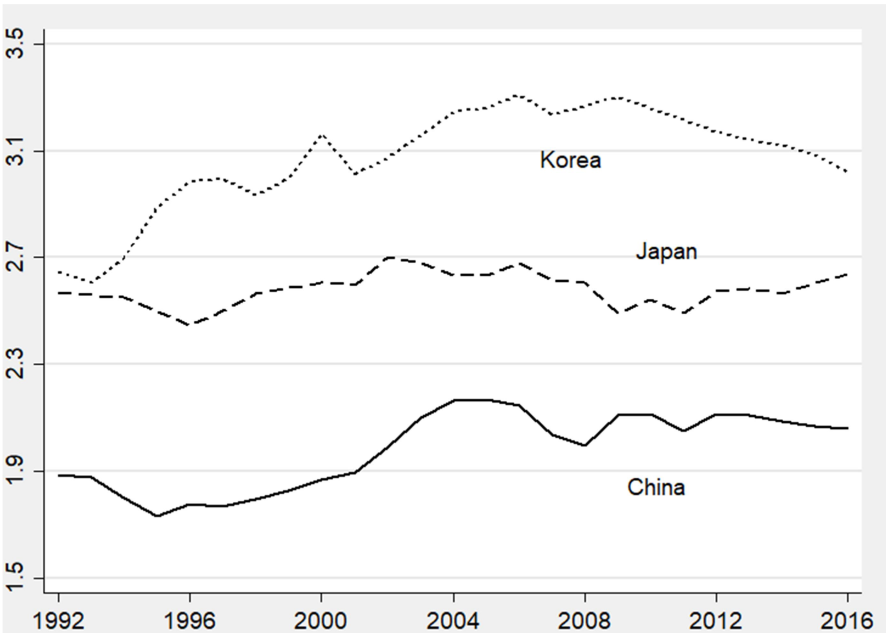

Figure 2-1: Exporting Product Diversity of China, Japan, and Korea

Source: Author's calculation from UN COMTRADE

About the trend of diversification, many empirical studies including Cadot et al. (2011) estimate the turning point of diversification would be lay on between $20,000 and $30,000 GDP per capita. Specifically, the pattern predicts that countries will diversify its contents of exports as the economy develops but will specialize after reaching a certain level of economic development. Korea may be located before or after the turning point according to the standard. At least, China's GDP is apparently lower than the interval until now. Thus, a diversification pattern is expected so far.

However, Figure 2-1 attests that China already started gradual specialization of export. Since Japan is right hand side of the turning point, upward pattern is expected as other developed economies. But the movement is quite subtle and hard to catch the pattern while other developed countries concentrate its exports as depicted in Figure 2-2. In case of Korea, it shows an inversed U-shape opposing the argument of Imbs and Wacziarg (2003). To be specific, the concentrating pattern has turned into diversification in 2006.

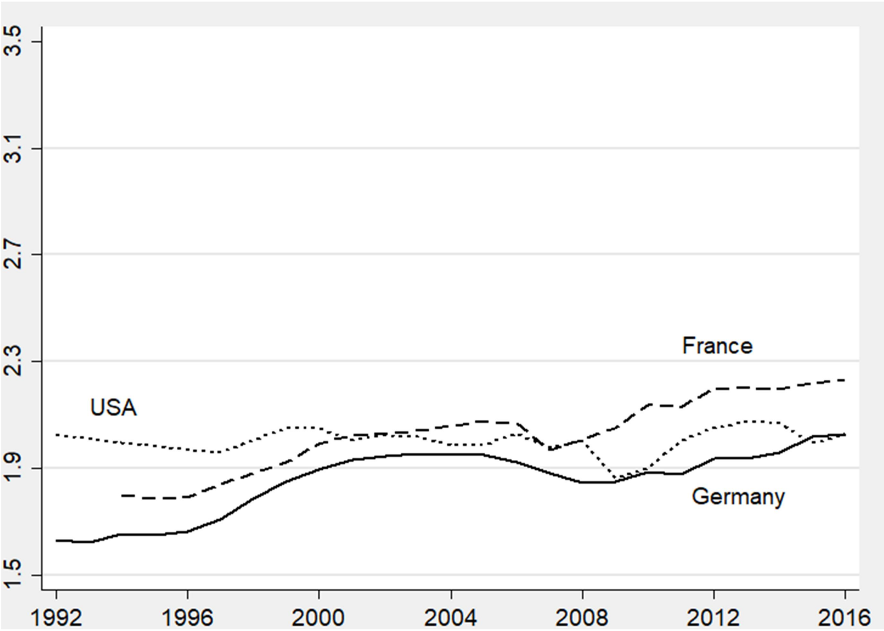

Figure 2-2: Exporting Product Diversity of France, Germany, and the U.S.A.

Source: Author's calculation from UN COMTRADE

To tackle this seemingly complex pattern, the Theil index is calculated by markets according to a classification from Worldbank. Four categories of income groups are given: high income, upper-middle income, lower-middle income, and low income countries. Japan and Korea belong to high income group while upper-middle income group includes China.

The Theil index of China by income group depicted in Figure 2-3 can shed lights on the complex pattern of diversification. China has diversified their export in every market except in high income countries. What driven this unexpected specialization? Since high income countries demands high quality goods, still China cannot be an omnipotent exporter to those countries. Also, exports by processing trade with high income countries may influence since it deals with limited number of variety. Note that processing trade is usually technology-dependent.

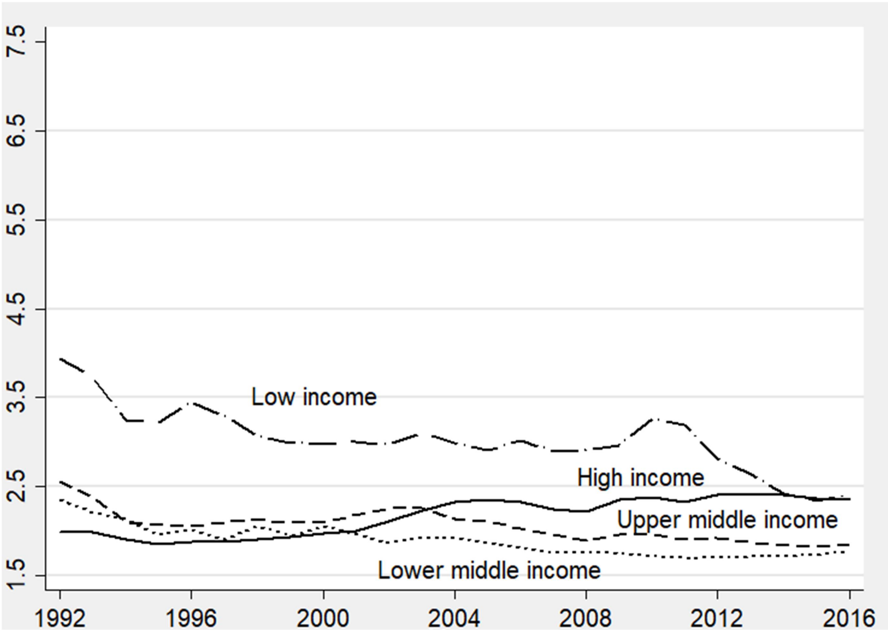

Figure 2-3: China's Exporting Product Diversity by Income Level of market

Source: Author's calculation from UN COMTRADE

Japan is the opposite case of China. Figure 2-4 shows a subtle specializing pattern in every market except in high income group. It can be understood as following way. As the income level of Japan increased, the export structure stick with items demanded by high-income countries. This would generate mismatch problem in emerging import markets and might reduce the diversity of export of Japan in those markets.

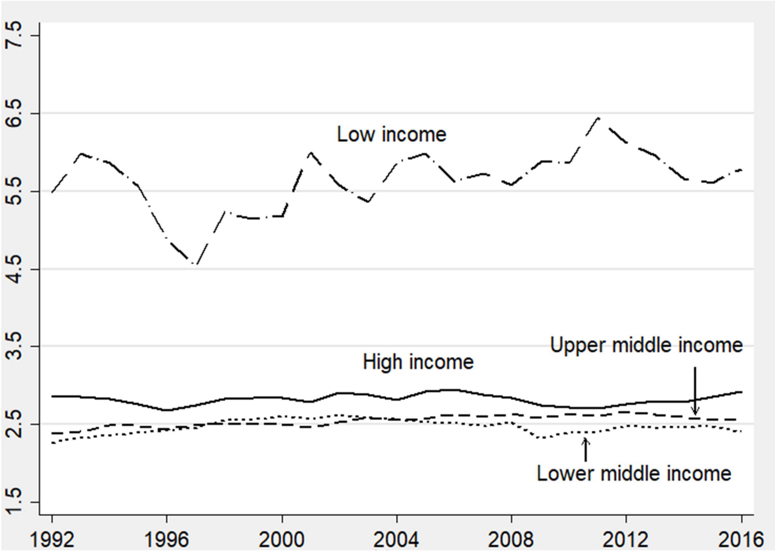

Figure 2-4: Japan's Exporting Product Diversity by Income Level of market

Source: Author's calculation from UN COMTRADE

Korea shows a humpty patterns as in Figure 2-5. Exports to high income countries have diversified since the mid-2000s. Since the income level of Korea is not certainly located in the specialization or the diversification area suggested by related researches, both movements can be understood.

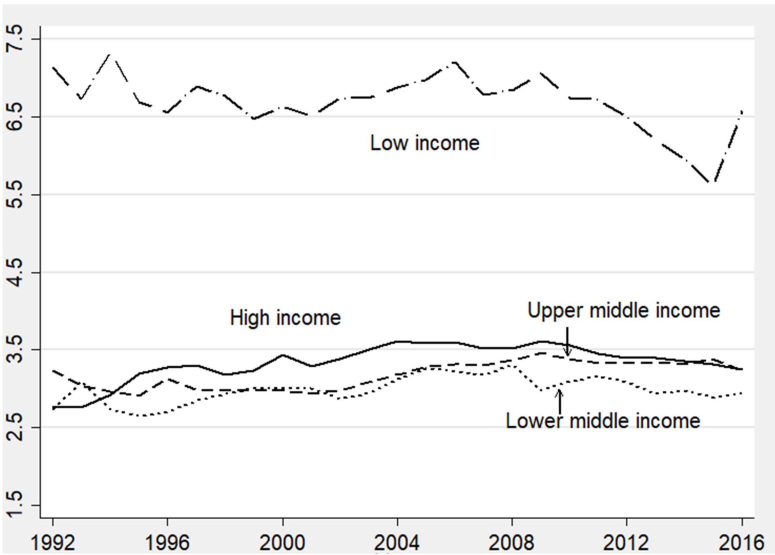

Figure 2-5: Korea's Exporting Product Diversity by Income Level of market

Source: Author's calculation from UN COMTRADE

It is possible to compare the same series by markets. Representative two figures are depicted below since China has more diversified than Japan and Korea in all four markets. Also, at all markets, Japan has a more diversified export structure than Korea.

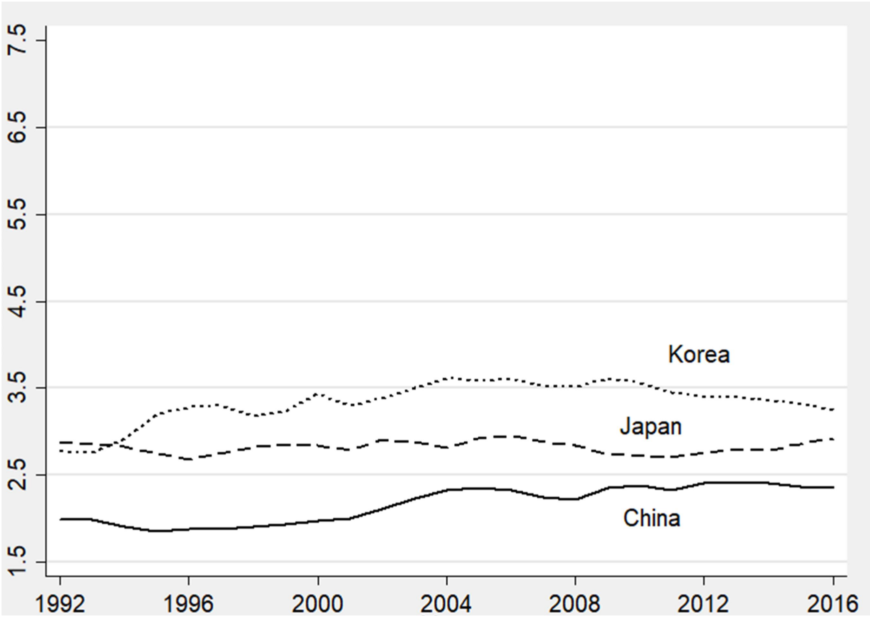

Figure 2-6: Exporting Product Diversity of CJK in High Income Countries

Source: Author's calculation from UN COMTRADE

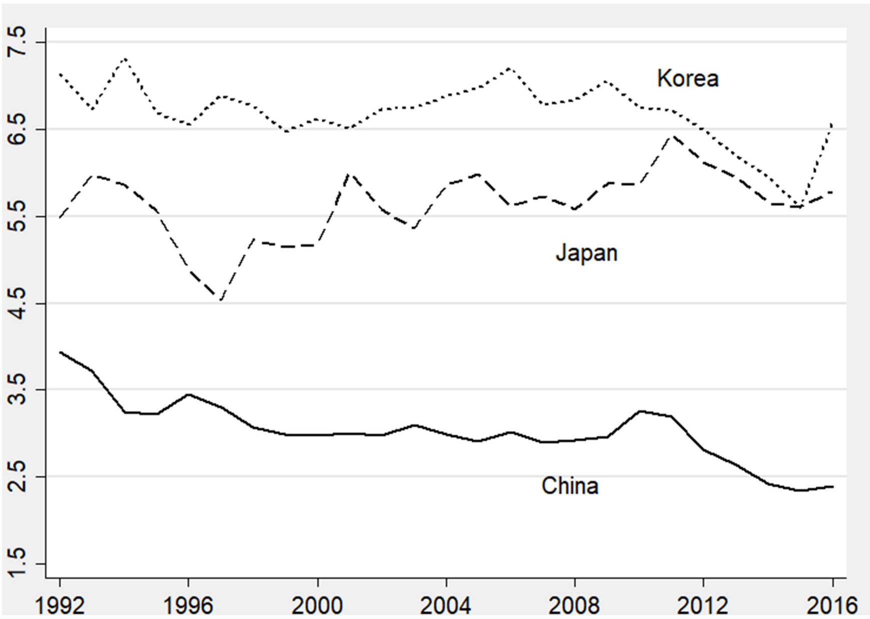

Figure 2-7: Exporting Product Diversity of CJK in Low Income Countries

Source: Author's calculation from UN COMTRADE

However, as depicted in Figure 2-6, the gap of diversifications among three countries is small in high income market while it is huge in low income market. Especially, in low income market, only China has diversified their export despite of their economic growth. This observation reflexes export coverage of Japan and Korea in low income countries are relatively narrower than China all times.

2.2.4 Regional Diversification of East Asian countries

What would be the result of applying the Theil index to the exporting country? In this section, the Theil index is applied to evaluate regional diversity of export. Countries replace products for the calculation as in Min et al. (2011) did to measure regional diversity of Korean exports. CJK are geographically close, and Japan and Korea are similar in that there is no border country where free trade is possible. Thus, if transport costs are huge, the diversification of the three will be similar.

However, the regional diversity of the three shows different levels and patterns. First, recent diversification of China is notable. Prior to the 2000s, China had the least diversified export portfolio among the three, but it has the most diversified one since 2008.

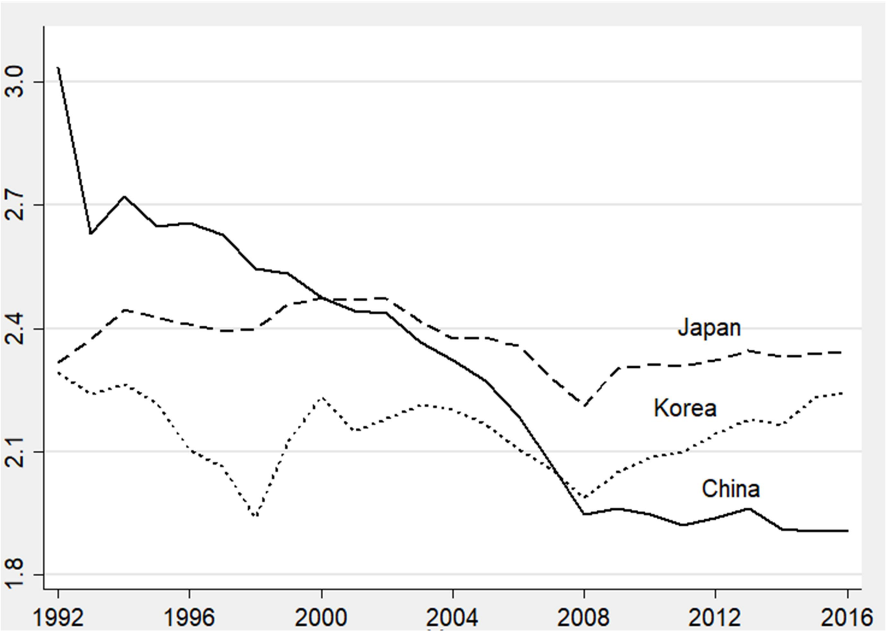

Figure 2-8: Export Destination Diversity of China, Japan, and Korea

Source: Author's calculation from UN COMTRADE

While the HS code has more than 5,000 codes, the number of countries is only 234.

Thus, remember that the analysis and scale in the previous section are different. To gauge the magnitude shown in Figure 2-8, a case of other developed economies (France, Germany, and USA) have shown in the next.

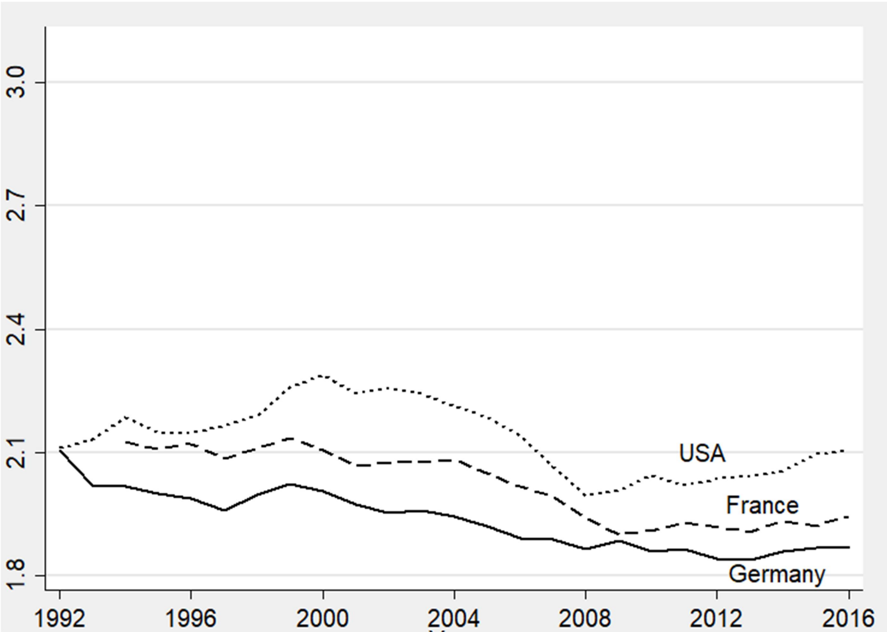

Figure 2-9: Export Destination Diversity of France, Germany, and the U.S.A.

Source: Author's calculation from UN COMTRADE

As shown in Figure 2-9, the other developed countries showed a similar level of diversification attesting the significance of China's recent regional diversification.

China's export product diversification has stagnated-even converted into specialization, but regional diversification is ongoing. What does this mean? It is difficult to diversify export products because the exports to high income countries still heavily rely on processing trade. Although the role of processing trade will be discussed in Chapter 4, at least, it is expected that export experiences with advanced economies can be a favorable factor for regional diversification. Thus, regional diversification of China in high tech sector reflects the catch-up of China. Confining the range of analysis to the machinery sector, which takes around half of total export of CJK, gives a more detailed insight about it. For analysis, SITC 7 is considered as machinery sector. Correlation tables between HS and SITC revision 3 were used to generate dataset.

Figure 2-10 shows that the diversity gap among CJK in machinery sector became very small recently. It partially supports the rapid catch-up of China in terms of export market extension. However, this information on diversification does not include the direction of catch-up or qualitative aspects.

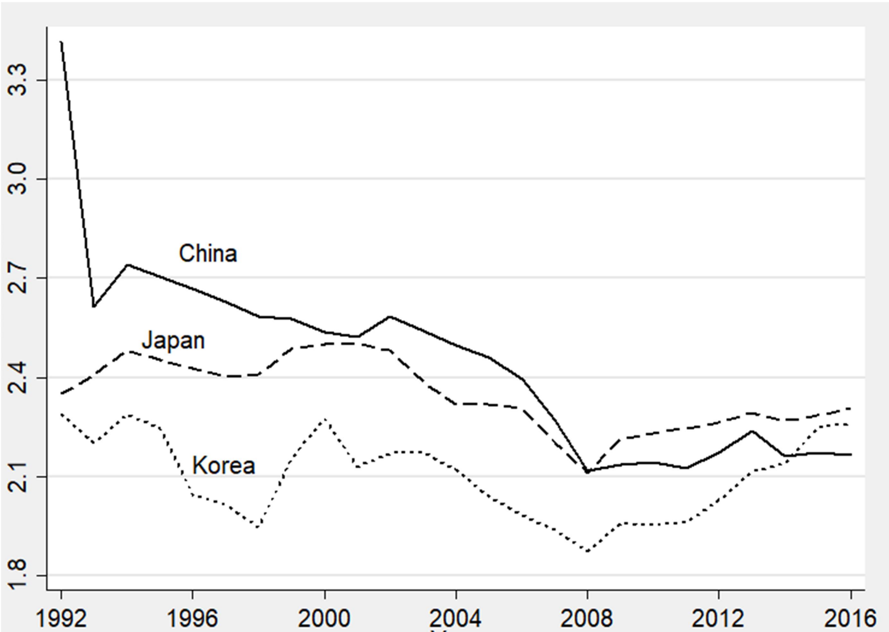

Figure 2-10: Export Destination Diversity of China, Japan, and Korea in Machinery

Source: Author's calculation from UN COMTRADE

To make a comparison, Figure 2-11 shows the diversification trend of the reference countries. As one can expect, Germany, the leading country in the industry, shows a highly diversified export market structure. Notice that automobile sector is a subset of the machinery. In case of the U.S., a few number of high-tech products such as aerospace products accounts the high proportion of the machinery industry. Naturally, the U.S. exports those products less to developing countries where demand has not been generated. This explains its relatively concentrated export portfolio.

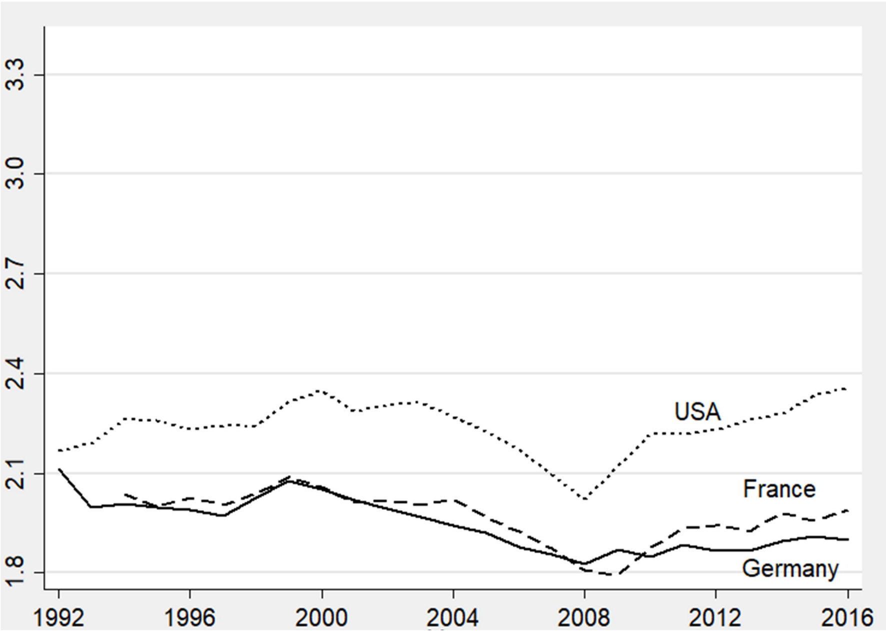

Figure 2-11: Export Destination Diversity of France, Germany, and the U.S.A. in Machinery

Source: Author's calculation from UN COMTRADE

2.3 Extensive and Intensive Margins of Export

2.3.1 Conversion Methodology

In following sub-section 2.3.2, a combined export dataset is used same as in section 2.2. However, for the sub-section 2.3.3, I used another converted dataset for more accurate analysis. As mentioned in beforehand, UN COMTRADE provides converted dataset for a longer time series analysis. However, the conversion is conducted based on the worldwide level ignoring specific structure of each country. Thus I constructed converted dataset and following is a sketch of the methodology.

Let assume there exist M, a set of nomenclatures. In case of HS, each revision can be denoted as a integer so that $M = \{0,1,2,3,4,5\}$ and $\#(M) = 6$. But, I set $M = \{0,1,2,3,4\}$ since there is no available annual trade data complying the 5th revision. Each nomenclature is valid for a distinct continuous period which starts from the January 1st and ends in the December 31st. A year h^m is the first year the nomenclature m is used. Similarly, a year t^m is the last year for the nomenclature m. Let x_{ij}^{t} be the volume of product i exported by country j at time t. Notice that $x_{ij}^{h^m}$ and $x_{ij}^{t^{m-1}}$ shares same notation for product. However

i may indicate different product since nomenclature is different.

Now, by using trade data in year h^m and t^{m-1} combining full correlation information from m to $m-1$, one can get a detailed conversion. There are four cases of correlation. 1) 1:1, 2) n:1, 3) 1:n, 4) n:n. As every conversion is conducted from a new one to the old one, the case 1) and 2) are trivial cases. In case of 3), product i under the nomenclature m has multiple counterparts $C_i^{h^m} = \{i^1, i^2, \dots, i^K\}$. Naturally, a new product i should be divided by relative trade volume of i^k. The last case is more complex but the same logic can be applied. Firstly, group new codes that are connected in the bipartite correlation graph. This grouping also includes product codes in a nomenclature that are not related directly to a same product in the other nomenclature. The grouping automatically works for the old codes. After a grouping, remove n:1 and 1:n relationships. Then remaining codes has n:n relationships. Now a new product i is correlated with a number of products. In this case, also relative trade volume of the old code is used. Because when I convert a trade dataset with a new code and weights of the new code automatically applied. Therefore, the conversion should be started from the last available nomenclature to the backward direction.

2.3.2 Decomposition of Export Diversity

To see the contribution of extensive margin and intensive margin, the previous results are decomposed into intensive and extensive margins. The decomposition method used for this subsection can be found in 2.2.2.

This subsection decomposes product diversification of CJK into intensive and extensive margins. Extensive margins omitted since reporting overall diversification and intensive margin suffices thanks to the additive property of the index. It reports averages of the index over specified periods. Periods were set considering HS revisions so that a cell is under the same HS version.

Table 2-1 shows substantial contribution of intensive margin to the overall variety diversity. In all countries that analyzed, intensive margin accounted more than 90% of total diversification in all periods. In high income market, contributions of intensive margins are slightly lower than in the overall until 2001. For example, in the first period (1992-1995), contribution of intensive margin Japan's overall diversity in all markets (96.9%=2.46/2.54) is higher than the case of high income markets (96.5%=2.73/2.83). Although the number is not that huge, this phenomenon was consistently observed until the second period only except for China in the first period. What the observation implies? It suggests that a bit more chance of extensive margin exists in high income countries. But, from the third period, the inverse phenomenon observed for Korea, Japan, and China successively. As a result, in the fifth period, contribution of intensive margin is slightly higher in the confined result than the overall one. This phenomenon can be understood by maturity of export to the high income countries. As the export structure matures, there is less chance to export a new product and almost expansion of export depends on deepening.

Table 2-1: Decomposition of Export Diversities of CJK over Products

	Diversification category	Product base, all markets				
		1992-1995	1996-2001	2002-2006	2007-2011	2012-2016
China	Overall	1.83	1.82	2.11	2.06	2.09
	Intensive margin	1.78	1.79	2.08	2.01	2.02
Japan	Overall	2.54	2.55	2.67	2.55	2.59
	Intensive margin	2.46	2.47	2.59	2.46	2.47
Korea	Overall	2.71	3.01	3.21	3.26	3.11
	Intensive margin	2.55	2.88	3.08	3.15	3.00
	Diversification category	Product base, high income countries only				
		1992-1995	1996-2001	2002-2006	2007-2011	2012-2016
China	Overall	1.93	1.93	2.27	2.31	2.39
	Intensive margin	1.88	1.89	2.23	2.25	2.32
Japan	Overall	2.83	2.79	2.90	2.78	2.83
	Intensive margin	2.73	2.70	2.81	2.69	2.70
Korea	Overall	2.91	3.29	3.54	3.53	3.35
	Intensive margin	2.73	3.14	3.41	3.42	3.24

Source: Author’s calculation from UN COMTRADE

The same decomposition method is applied to the Theil index calculated over regions. Table 2-2 reports average of the overall the Theil index and the decomposed one by countries and periods. It shows more substantial contribution of intensive margin to the overall diversity. In this case, intensive margin accounted more than 95% of total diversification. Generally, it is difficult to diversify the exporting country rather than to diversify export products.

When it comes to compare the overall case and the confined case for machinery, some different pattern appears. In the early period, intensive margin of China and Korea accounted lower in the confined cases than the overall cases. In other words, extensive margins contributed to export diversification in machinery industry more than overall average. However, those gaps had been consistently declined. This observation is coherent with the former one since high-income countries account for the majority of machinery demand.

Table 2-2: Decomposition of Export Diversities of CJK over Regions

	Diversification category	Partner country base, all products				
		1992-1995	1996-2001	2002-2006	2007-2011	2012-2016
China	Overall	3.38	3.28	3.21	3.03	3.02
	Intensive margin	3.26	3.16	3.08	2.93	2.91
Japan	Overall	3.19	3.22	3.25	3.19	3.22
	Intensive margin	3.13	3.16	3.15	3.09	3.11
Korea	Overall	3.12	3.06	3.14	3.07	3.15
	Intensive margin	3.00	2.98	3.06	3.01	3.08
	Diversification category	Partner country base, machinery (SITC 7) only				
		1992-1995	1996-2001	2002-2006	2007-2011	2012-2016
China	Overall	3.43	3.30	3.30	3.12	3.14
	Intensive margin	3.25	3.14	3.16	3.02	3.03
Japan	Overall	3.21	3.23	3.23	3.15	3.19
	Intensive margin	3.14	3.16	3.12	3.04	3.08
Korea	Overall	3.13	3.05	3.10	3.01	3.13
	Intensive margin	2.95	2.94	3.00	2.94	3.05

Source: Author’s calculation from UN COMTRADE

2.3.3 Contribution of New Exports

Decomposition of the Theil index shows very low contribution of extensive margins. However, the Theil index is calculated on product or destination country basis thus size of extensive margin varies by underlying classification. Any arise of a new product-market pair can extend the margin. Actually, extensive margin is defined by product-market basis. In that case, the captured extensive margin is larger than the former cases.

Besedes and Prusa (2011) defines extensive margin as "utilization ratio" of a country's export. Assume there is n products and m countries, utilization ratio of country j is defined as follows:

$$U_j = \sum_{j=1}^{m} \sum_{i=1}^{n} \frac{D_{ijk}}{D_{ijw} D_{iwk}} \tag{2-10}$$

$D_{ijk} = 1$ if product i exported by country j to country k and zero otherwise. To secure the calculation, define $D_{ijk} = 0$ when $j = k$. Subscript w denotes the world. Note that time is not considered explicitly for the simplicity. But the formula should be applied to the cross sectional data. The numerator counts the possible spells since it counts only if exporting country j has a "revealed" supply (export) of product i and importing country k "revealed" demand (import) for product i. One can consider the numerator as "potential" product-country pairs a country can realize. The denominator counts the number of "realized" product-country pairs that exported by country j.

Naturally, a change of utilization ratio indicates a change in extensive margin. Also, utilization ratio can measure the remaining possibility of extension of export.

Table 2-3 shows utilization ratio of CJK. As one can expect, both number of potential and realized spells are smallest in Korea and largest in China. But the gap in numbers of potential spells is very slight over time while the gap in numbers of realized spells is dispersed. For example, the number of China's realized spell in the most recent period (258,147) is twice larger than those of Japan (89,757) or Korea (103,210). But the number of potential spell (485,621) is similar to those of Japan (462,997) or Korea (471,261) generating China's exceptionally high utilization ratio (53%) relative to Japan (19%) and Korea (22%). China's utilization ratio consistently increased from 22% to 53%. The case of Korea also increased from 16% to 22%. But Japan's utilization ratio decreased from 27% to 19%.

Furthermore, Japan's number of realized spells decreased in recent two periods reflexing specialization. Since the analysis in the previous chapter shows a sole trend in regional diversification of China and Korea, increase in utilization ratio is mainly driven by diversification of exporting markets.

Table 2-3: Utilization Ratio of China, Japan, and Korea

		1992-1995	1996-2001	2002-2006	2007-2011	2012-2016
China	Realized product-country pairs	64,045	109,768	192,145	240,058	258,147
	Potential product-country pairs	291,980	429,912	503,937	501,301	485,621
	Utilization ratio	0.22	0.25	0.38	0.48	0.53
Japan	Realized product-country pairs	74,624	86,827	93,090	90,482	89,757
	Potential product-country pairs	283,511	414,134	487,450	484,463	462,997
	Utilization ratio	0.27	0.22	0.19	0.19	0.19
Korea	Realized product-country pairs	42,936	61,681	79,355	89,730	103,210
	Potential product-country pairs	269,267	398,219	469,662	479,236	471,261
	Utilization ratio	0.16	0.16	0.17	0.19	0.22

Source: Author's calculation from UN COMTRADE

Utilization ratio only works with the numbers and do not consider weights of export volumes. Thus, to capture the extensive margin more precisely, I redefine the extensive margin as a weight of newly appeared export spells following the fashion of Besedes and Prusa (2011).

$$M^t = 1 - \frac{\sum_{i \in S^{\hat{t}}} x_i}{\sum_{i \in S^t} x_i} \qquad (2\text{-}11)$$

i is a product-destination pair, x_i is export of i, S^t is the set of all product-destination pairs that a country exported non-zero value at time t. To preserve most information given by reporting countries, beginning years of HS nomenclature revision were considered as a reference year $\hat{t}$ for the following years. Those type of setting guarantees to capture a wide notion of extensive margin of extensive margin as today's export structure is highly related with the yesterday.

Extensive margins were consistently low over the periods. Under 5 percent of exports were contributed by new exports which not existed in the reference year. This result is quite striking since the used classification is much more detailed than that Besedes and Prusa (2011) used.

Setting aside from the relative size of extensive margin, a certain decreasing trend of extensive margins observed. In case of China, contribution of new export spells was 3.34% in the first period but shrunk to 0.43% in the last period. Similar patterns observed for Japan and Korea. After 2012, China and Japan's new spell, combination of product and destination, have accounted around 1 percent. But, extensive margins were systemically higher when it comes to the high income countries. Interestingly, Korea shows most high ratio of extensive margin in almost periods. This can be understood that the size of economy is smallest among others and less trade ties existed in the early period as shown before. Thus much of the export growth can be accounted as extensive margin. It is worthy to note that contribution of new exports in high income countries is systematically higher than to the world market. Especially, for the recent two periods (2008-2011, 2013-2016), extensive margins of Japan and Korea in high income countries are twice higher than in the world market. Japan and Korea can export goods meeting the demand of new product in high income countries. Higher extensive margin in high income countries also implies more flexibility on change in demands.

Table 2-4: Extensive margin: share of new export compared to the reference year

	All products and all countries					All products, high income countries only				
	1993-1995	1997-2001	2003-2006	2008-2011	2013-2016	1993-1995	1997-2001	2003-2006	2008-2011	2013-2016
China	3.34	2.90	1.11	0.49	0.43	3.74	3.05	1.13	0.45	0.43
Japan	2.80	3.21	2.22	1.19	0.47	3.10	5.23	0.76	3.42	0.99
Korea	3.67	4.60	1.72	2.08	1.70	3.91	6.35	2.99	4.26	4.04

Source: Author's calculation from UN COMTRADE

2.3.4 Inside Intensive Margin: Survival analysis of export

Why a new spell accounts only a few friction of export growth? The answer can be found from the frailty of export. Consider a country started to export a product to a new market. Even though its fixed cost sunk before the first export, the exporter can found revealed competitiveness only after enter the market. In a pioneering trade model by Melitz (2003) assumes only competitive firms start exporting. However, uncertainty of product-destination specific variable cost can crowd out some firms from the market. This argument is supported by Segura-Cayuela and Vilarrubia (2008) with a modified Melitz model. Also, it explains why intensive margin accounts most export growth. Thus, in this section, I analyze the survival of export spells, defined over product-destination pairs, by using Kaplan-Meier estimates.

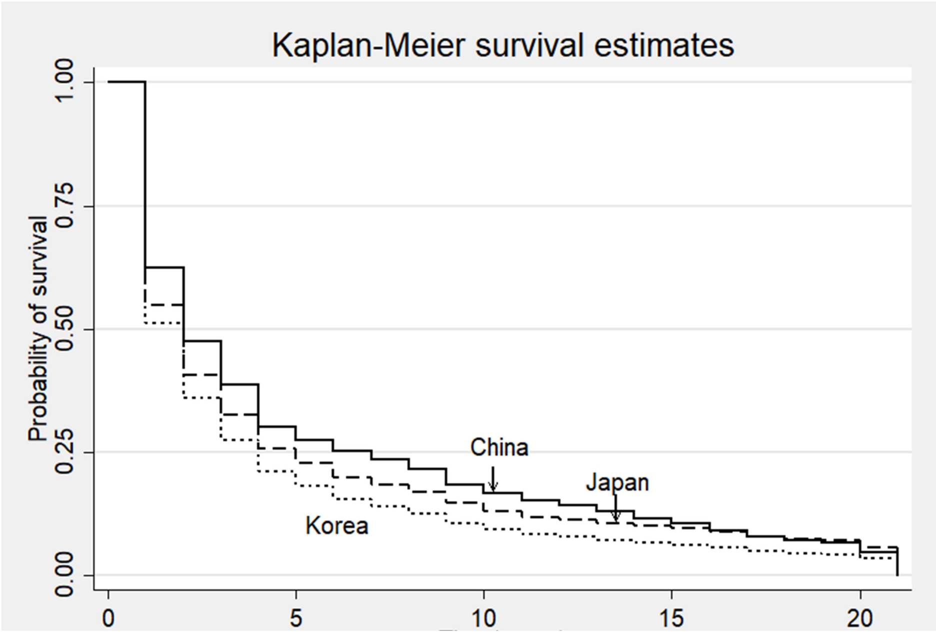

Figure 2-12: Survival Estimates of exports of China, Japan, and Korea

Source: Author's calculation

Similar to previous studies such as Besedes and Prusa (2011), Figure 2-12 shows that CJK's survival rate of the first year was lower than 70%. There are discrepancies among countries. China's survival rate is highest in general, especially for the first few years. Korea's survival rate in the first year was 51%, lowest among others as Yoon (2017) states. Yoon (2017) points out the low long-run competitiveness of Korea by using a survival analysis with different dataset. Japan was midst in almost times.

Figure 2-13 demonstrates high long-term survival rate of the reference countries. They have relatively fat tails then CJK. France has the most high survival rate among them. Since the 1990s, the biggest export items of France are aircrafts and pharmaceuticals. The first one is a capital good and the other is a consumer good that has sticky demand elasticity in general. This explains the highest export survival rate of France.

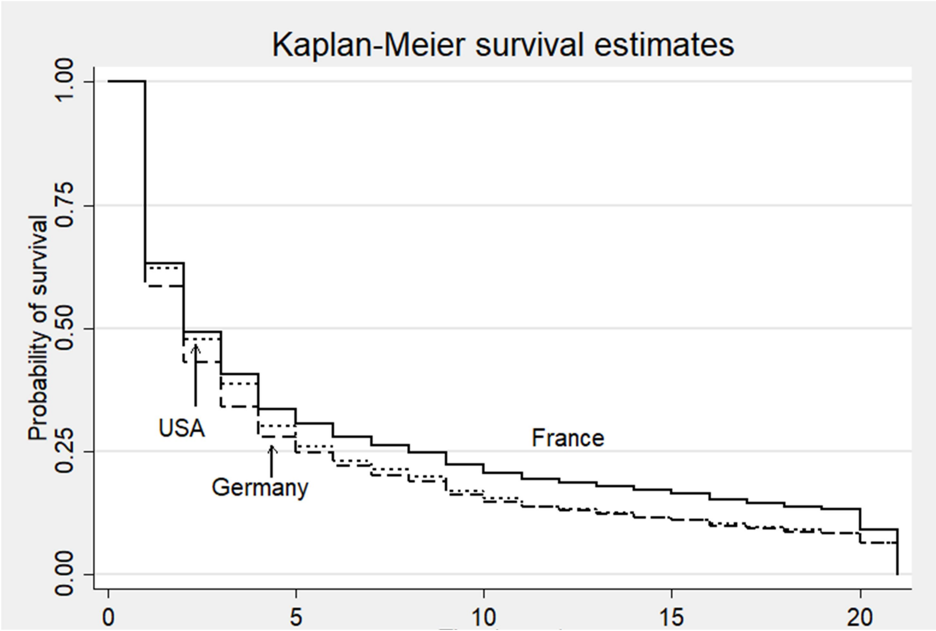

Figure 2-13: Survival Estimates of exports of France, Germany, and the U.S.A.

Source: Author's calculation

Relatively high level of survival rate of the reference countries can be understood easily. However, the high survival rate of China has not been explained yet. Why China's frailty of export is most low? An answer can be found in the decomposition of survival estimates.

Table 2-5 shows the survival estimates of CJK in two ways: as a whole and confining to high income countries. Since the three export most of their exports to high income countries, information on other markets are omitted.

Table 2-5: Survival estimates (hazard rates of exports of China, Japan, and Korea)

Country	Market	Hazard Rates (years)							
		1	2	3	5	7	10	15	20
China	Overall	0.62	0.48	0.39	0.27	0.23	0.17	0.10	0.05
	High income countries	0.63	0.49	0.42	0.35	0.31	0.26	0.18	0.10
Japan	Overall	0.55	0.41	0.32	0.23	0.18	0.13	0.10	0.06
	High income countries	0.55	0.41	0.34	0.26	0.22	0.18	0.14	0.09
Korea	Overall	0.51	0.36	0.28	0.18	0.14	0.09	0.06	0.03
	High income countries	0.51	0.36	0.29	0.21	0.17	0.13	0.08	0.05

Source: Author's calculation

The average export survival rate of the three countries towards higher income countries was higher than the overall average. According to Table 2-5, when China initiates to export by developing a new product or a new market (or both), the probability of lasting 20 years is of 5% on average. However, if the importing partner is a high-income country, the probability is 10%. Country-wise figures show this trend more clearly.

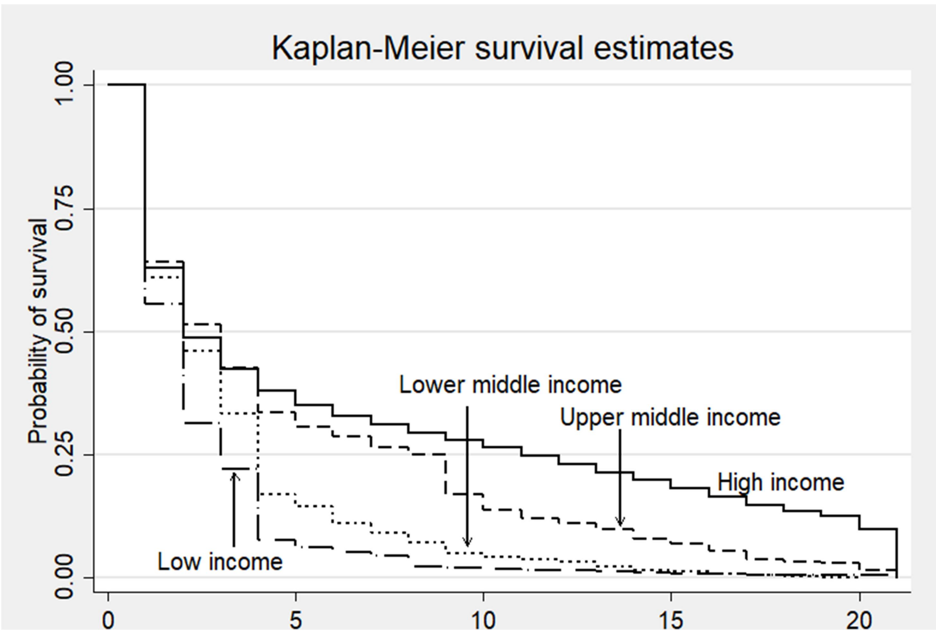

Figure 2-14: Survival Estimates of exports of China by Income Level of Market

Source: Author's calculation

In Figure 2-14, China shows diversified survival rate by income level of markets.

Especially, to high income countries, they show very low fatality during fifth year to the twentieth year. However, when it comes to middle or low income countries, survival rate becomes substantially low in the same period. It means, if China initiates an export relationship with a high income country, the expected survival rate is higher than the others. It may be related with processing export of China.

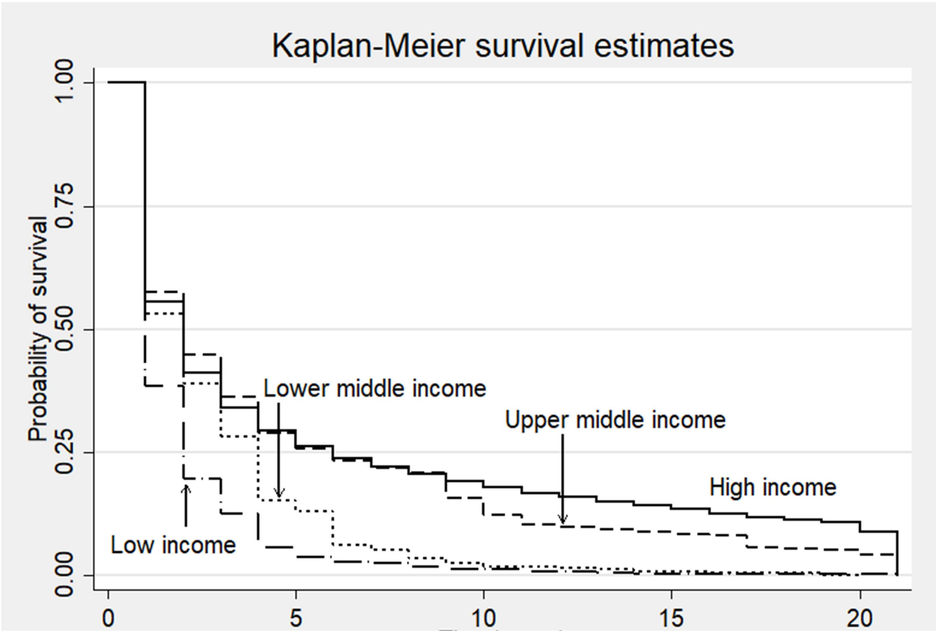

Figure 2-15: Survival Estimates of exports of Japan by Income Level of Market

Source: Author’s calculation

In Figure 2-16, Japan shows a bit less survival rate than China in all markets stating high long-run competitiveness. The gap between the survival rate for high income countries and the survival rate for upper middle income countries is smaller than in China. Also, the initial survival rate in low income countries is significantly lower than in China. However, the survival rate in Japan is not so low compared to Korea. Japan has a significantly higher survival rate than Korea in the upper middle and high income countries. Figure 2-17 shows relatively low survival rate of Korea. Since Japan became a high-income country before Korea, it seems to have long-term export relations with countries with high incomes. However, China's export survival rate, especially the exports to high-income countries, is very high compared to other countries.

An interesting fact is that the frailty of export is systemically low in high income countries. All countries showed a very low survival rate in low income countries. Thus, one can say the frailty of exports is decided by the frailty of exports to high income countries. Also, a poor diversity in low income countries comes from high frailty of exports.

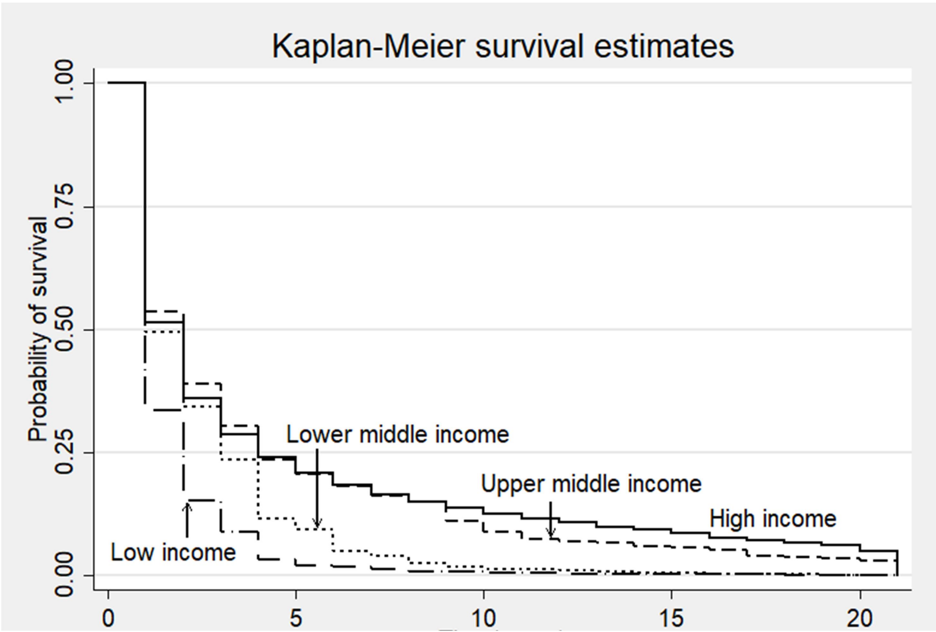

Figure 2-16: Survival Estimates of exports of Korea by Income Level of Market

Source: Author's calculation

2.4 Concluding remarks

It is believed that a country can more easily diversify export portfolio of products in the importing countries that have similar income level of the exporter. It is also known that when the income level goes beyond a certain level, a country concentrates on exporting certain products.

To track the development path of export, this chapter first calculated the Theil index of export varieties and regions of CJK. Then the results are decomposed into the extensive and intensive margins. The export development of the three countries is mostly due to the expansion of the intensive margin. Exports growth of more than 90% is due to increased exports to existing product-country pairs. The utilization ratio was calculated in order to analyze the extensive margins considering the feasibility of the exporting and importing countries. Survival analysis is added to find out the long-term characteristic of intensive margins.

As the result, the export diversification path to high income countries decides the entire direction of export diversification of CJK. Also, intensive margins take account almost export growth. However, historically, the three countries have undergone different pattern of diversification in different situations.

China has a huge land, population, and size economy. Since China is not yet a high-income country, it is expected to diversify its export items, but the result is the opposite. Instead they diversified export markets. The first sentence of this section explains why China has restrictions on export diversification. Chinese domestic market is not as mature as the high income countries that consists the majority of China's trading partner. Around half of the goods shipped to high-income countries are exported by processing trade. Processing trade is basically demand driven and there are natural restrictions on product diversification.

To summarize, China's export development can be specified as follows. China has a stable export experience to high income countries. It is supported by the exceptionally high export survival rate to high income countries. Meanwhile, China successfully diversified its exports by expanding the region. The contribution of intensive margins to export development is greater since the share of exports to developed countries is the majority. However, extensive margins due to regional diversification contributed to China's export development. Given the size of the economy, China may have a fully diversified export structure. However, China is contrary to the export diversification. Those seemingly unrelated observations imply that China has not yet reached the stage of producing various sophisticated items.

Japan has a bit less diversified export varieties than that of China and the reference countries such as Germany. Its export pattern can be characterized by small fluctuation. Japan also has not diversified its export partners. This seems to be due to the fact that the industrial structure of Japan already changed and has limitations to increase export volume to developing countries. Those observations suggest the dominant role of intensive margins. In fact, since 2002, the utilization ratio of Japan has remained almost unchanged. In other words, Japan maintained export ties rather than initiate new ties. Relatively high export survival rates also support this observation.

To summarize, Japan appears to be maintaining a very stable export structure. Despite many marginal firms offshored, the domestic production chain did not change significantly. A low GVC participation supports this. However, this structure may be vulnerable to local risks thus provisions and monitoring of the government are required.

Due to the small size of the economy, Korea has a bit concentrated export structure over products. Intensive margins, exports of existing products, led most export development. Since the mid-2000s, a modest export products diversification has been underway although still less diversified than Japan or the reference countries. When it comes to the export regions, Korea seems to be diversifying its partners. The growing utilization ratio also supports this observation. However, new export ties of Korea have shown relatively high frailty.

Export is especially important to Korea-a small open economy. To achieve sustainable economic growth, Korea first needs to diversify partner countries by strengthening the competitiveness of major items. Also, a diversification of export varieties is needed. The results of the analysis show that Korea’s trial of regional diversification. But low survival rates indicate that Korea remains in the early stages of export diversification.

Chapter 3: Generalized Measure of Bilateral Similarity

3.1 Introduction

Comparing a country's trade structure with another one gives various implications since a country's export structure is influenced by other countries, especially competitors. First, the bilateral export similarity between two countries shows the overlapping extent of exports. The more the two countries compete, the higher the similarity. In the economic development literature, the similarity is considered to be important, because high similarities between a newcomer and an incumbent may indicate a rapid catch-up of the newcomer.

What makes the trade structures of the two countries similar? Intra-industry trade between two countries would make two bilateral flows to be similar. Rival countries often share similar export structure naturally. FGP, which introduced in the first chapter, predicts that developing countries will have different export structure from the developed since they will import industrial goods and export raw materials. However, high mobility of capital and technology allows developing countries to imitate export structures of developed countries quickly.

Similarity has been at the heart of seminal works comparing trade structures. Balassa (1966), Grubel and Lloyd (1975) suggest similarity indices for IIT while Finger and Kreinin (1979) do for exports of two economies. RCA, a famous concept developed by Balassa, also measures a similarity in a wide sense. However, intrinsic limitations of existing concepts come from two assumptions about quality homogeneity and linearity. The first problem can be observed when two countries share similar export structures in terms of value, but have different unit values. In this case, any bilateral similarity measure will show a high proximity of two countries[2]. To solve this problem, additional quality dimension for each product is introduced to existing concepts. By adopting quality heterogeneity, one can get more exact measure of similarity and this concept can be applied to any data coming with quantity and price information.

The second problem is a bit more complex and more theoretic. If a country can reallocate its export structure costless, any vector consists of gaps can be treated identically as

[2] One might relief that problem by applying the measure both to values and quantities. However in that case, two similarities are entangled inside and almost impossible to find out where the difference comes from.

the dimension and the sum of elements are identical. For example, a country may have many small gaps compared with a reference country. Another country has only one large gap. If someone considers marginal adjustment in multiple sectors as easier than one big adjustment, then the country with small gaps should be similar to the reference country than the other one. Actually, entropy-related indexes evaluate in this way. This problem can be solved by using a theoretic framework and empirics. However, for a practical reason, policy makers generally require a simple index as an indicator. To tackle this problem, this chapter generalizes existing similarity measures with Minkowski parameter that can adjust the relative impact of differences.

CJK are ideal candidates for studying similarities since they have grown exports by mimicking predecessors. In the past, Japan imitated the Western developed countries, Korea imitated Japan, and China imitated Japan and Korea. Recently, China explicitly declared that Germany, not Japan nor Korea, as a future rival and as a partner. However, the extent to which CJK has an export structure similar to a country has not been studied yet.

The main objective of this chapter is developing a bilateral similarity index which improves and generalizes existing concepts. This objective will be accomplished in theoretic perspectives. The other objective of the chapter is measuring change in export pattern of CJK. Thus the new index will be applied to compare the export structure of CJK bilaterally. Specifically, it analyzes how CJK are similar in export structures, especially when considering quality heterogeneity of exporting products.

There are two research questions.

1. **Can existing bilateral similarity indices be generalized? Can generalization yield any different results from the present?**
2. **Has export similarity of Korea, China and Japan increased? Is it also when considering quality?**

This chapter relates with measurement literature of IIT in the same line of Linder (1961) emphasizing quality aspects of a product. It also has a relation with development studies since it concerns heterogeneity among products like Rodrik et al. (2007). Most of all, it is in the vein of the policy studies about trade structure.

In the following section, first a survey on similarity indexes on international trade will be addressed in 3.2.1. The next section, 3.2.2, solves the second problem of the existing indexes mentioned above theoretically by introducing the Minkowski parameter explicitly. Then, a generalized similarity measure of two different trade flows concerning quality heterogeneity is introduced in 3.2.3. Empirical applications of the new index on CJK's export may be found in 3.3. Finally, in section 3.4, it concludes with some implications.

3.2 Measures of Bilateral Similarity

3.2.1 Existing Concepts of Bilateral Similarity

Development of bilateral similarity measures forms a strand in IIT literature (Lee and Lee, 1991). Balassa (1966) gives a very early index. The index averages absolute difference of export and import over the sum of export and import of each product ignoring relative trade volume. The index of Grubel and Lloyd (1975) normalizes each difference with the total trade to consider relative significance of products. Along come critiques including in this journal (Gleser et al., 1974), early studies of empirical measurement of IIT fostered complementary researches (for survey, see CEPII, 1997 or Ando, 2006) due to the lack of considerations to quality difference.

Balassa (1966) defines a similarity index for a product j and industry i as follows:

$$S_j^{Balassa} = \frac{|x_j - m_j|}{x_j + m_j} \tag{3-1}$$

$$S_i^{Balassa} = \frac{1}{n}\sum_{j \in i} \frac{|x_j - m_j|}{x_j + m_j} \tag{3-2}$$

where x_j and m_j denotes export and import of product j.

This index sums each ratio of absolute difference ($|x_j - m_{j|}$) to sum ($x_j + m_j$) and divides by n making a simple average of it.

Grubel and Lloyd (1975) reverse the polarity of Balassa's index and change the denominator. Specifically,

$$S_j^{Grubel-Lloyd} = 1 - \frac{|x_j - m_j|}{x_j + m_j} \tag{3-3}$$

$$S_i^{Grubel-Lloyd} = \frac{\sum_{j\in i}\left|x_j - m_j\right|}{\sum_{j\in i}\left(x_j + m_j\right)}. \tag{3-4}$$

Notice now the denominator is a sum of exports and imports of given industry. This evaluates each difference with a common standard. Notice that Balassa adopts the total trade of a product as the denominator which is a horizontal (or vertical) sum when we array data as a matrix. As for Grubel and Lloyd, the sum of every element in the matrix enters. Finger and Kreinin (1979) independently suggests Export Similarity Index (hereafter ESI) for measuring effectiveness of General System of Preferences. Their index of similarity applies a vertical (or horizontal) sum as the denominator. In IIT literature, Michaely (1962), Aquino (1978), and Glejser et al. (1982) share identical methodology with ESI (Kol and Mennes, 1986). Since Finger and Kreinin (1979) cited in most applications, this chapter name after them. In formula, it expressed as following:

$$S_i^{Finger-Kreinin} = \sum_{j\in i} \min\{\frac{x_j}{\sum_{j\in i} x_j}, \frac{m_j}{\sum_{j\in i} m_j}\} \tag{3-5}$$

Thanks to the intrinsic property between absolute value and minimum, ESI can be generalized with absolute operator as following:

$$\begin{aligned} S_i^{Finger-Kreinin} &= \sum_{j\in i} \min\{\frac{x_j}{\sum_{j\in i} x_j}, \frac{m_j}{\sum_{j\in i} m_j}\} \\ &= \sum_{j\in i} \frac{1}{2}\left(\frac{x_j}{\sum_{j\in i} x_j} + \frac{m_j}{\sum_{j\in i} m_j}\right) + \sum_{j\in i} \frac{1}{2}\left|\frac{x_j}{\sum_{j\in i} x_j} - \frac{m_j}{\sum_{j\in i} m_j}\right| \\ &= 1 - \frac{1}{2}\sum_{j\in i}\left|\frac{x_j}{\sum_{j\in i} x_j} - \frac{m_j}{\sum_{j\in i} m_j}\right|. \end{aligned} \tag{3-6}$$

3.2.2 Generalized Index of Similarity with Minkowski Distance Parameter

Now, by choosing appropriate parameter α and β, equations (3-2), (3-4), (3-6) can be expressed by a generalized formula (3-7).

$$S_i = \alpha + \beta\left[\sum_{j\in i}\left|f(x_j) - f(m_j)\right|^p\right]^{\frac{1}{p}} \tag{3-7}$$

The index becomes a similarity measure only if β is negative. Otherwise, the index represents dissimilarity. Two elements inside the summation operator, which assessing distance of two trade flows, can be generalized by $f(\cdot)$. Note that any trade flow to compare can enter to x_j and m_j since x_j or m_j itself does not represent a polarity of trade flow. For example, if ESI is chosen, x_j will denote export of product j from designated country 1 and m_j also represents the same export from country 2. Also, in this case, following $f(\cdot)$ will work for the formula (3-7).

$$f^{ESI}(x_{cj}) = \frac{x_{cj}}{\sum_{j \in i} x_{cj}} \tag{3-8}$$

We can extend our scope to L_p distance measures which also known as Minkowski's distance (see Kruskal, 1964). In formula (3-7), p is a parameter for shifting the space for measurement. For example, when we set $p = 2$, now the space is Euclidean space where Pythagorean theorem works. To the best my knowledge, all similarity indexes have used in international trade literature set $p = 1$ so that their space to be L_1, with the distance so-called "Manhattan distance".

What we can get by adopting various Minkowski distance parameters? Simply it provides an alternative non-linear valuation process. Let two developing countries that share a similar production structure want to rebalance their production structure from the traditional sector to the modern sector. They can concentrate or decentralize efforts for reallocation. As a reallocation of productions is rarely possible without a cost, a similarity index with $p = 1$ may entail a bias.

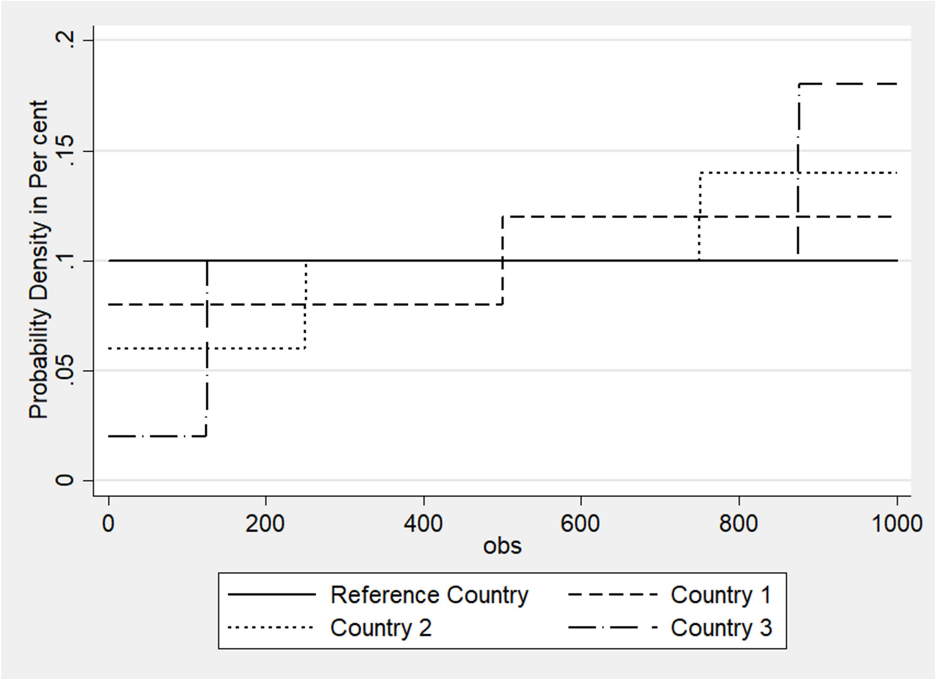

Figure 3-1: An Example for Explaining the Meaning of Minkowski Parameter

Source: Author’s calculation

Figure 3-1 helps to briefly sketch the meaning of Minkowski parameter in simil arity measures. Consider there are four countries with comparable size of economy. Th ey can export 1000 kinds of different product. A country has completely equalized ex port structure over products is set as the reference. There are three countries having d ifferent specialization patterns. Country 1 has a similar export structure with the refere nce. There is a systematic difference for all products. Country 2 also has a similar str ucture of the reference. However, the difference is concentrated on less numbers of pr oducts. Country 3 has different structure from the reference only for the less number of products.

The original ESI evaluate similarities between country and the reference equally. It equally treats a sum of small gaps as a one huge gap. But, one can weight sum of small differences more importantly, or inversely.

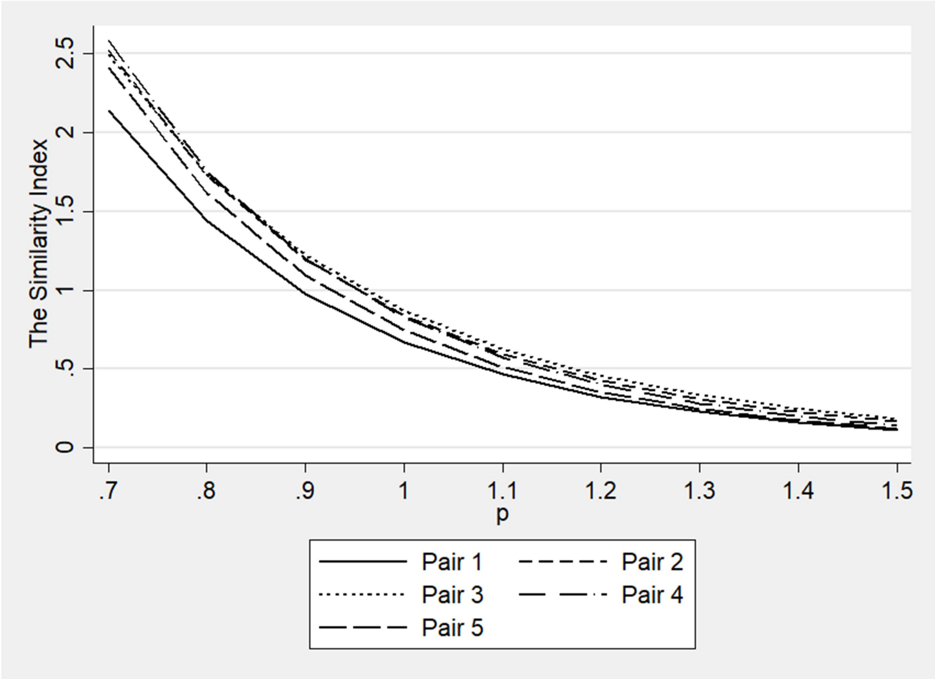

Figure 3-2: Simulated ESI of Arbitrary Country Pairs Assuming Log-Normal Distribution

Source: Author's calculation

Different from the first figure, Figure 3-2 is drawn from a simulation. For virtual 50 products and 10 countries, I randomly assigned a value from log-normal distribution which convinced to a good fitting with real trade data. For 5 pairs of countries, the extended concept of ESI is calculated with various Minkowski parameters. It turned out the parameter rarely change the order of pairs[3].

However, when it comes to actual dataset, due to the existence of fat tail, the parameter easily shifted the order of similarities of country pairs. To see a potential role of the parameter, export dataset of year 2006 is chosen. For the control, HS codes only related with automobile starts with 8703 are kept. To 10 arbitrary countries, 500 sample data randomly assigned without replacement.

As depicted in Figure 3-3, most pairs show a low similarity. The order of similarity changed over various Minkowski parameters The observation implies that combining with appropriate external knowledge, generalized similarity concept can enhance the risk of

[3] I conjecture that if one set a country as the reference, changing the parameter will not affect the order of similarity in most cases.

mislead interpretation.

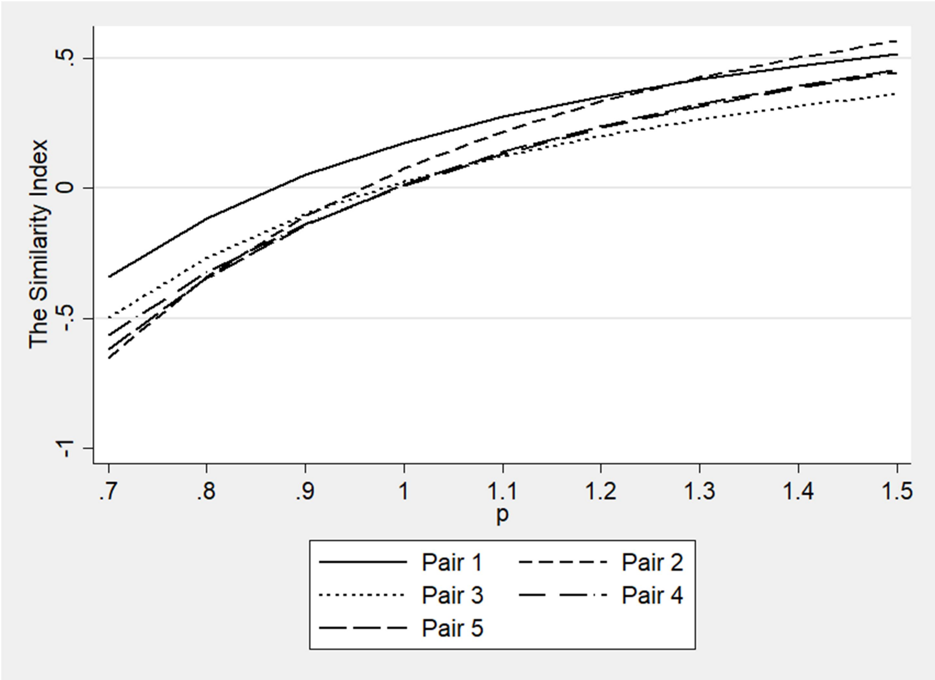

Figure 3-3: Simulated ESI of Arbitrary Country Pairs Sampled from Actual Dataset

Source: Author's calculation

It is important to set the appropriate Minkowski parameters, but this chapter has not been able to deal with. It is left as a further study since it requires ex-ante and ex-post analyses to be carried out.

3.2.3 Quality Heterogeneity of Products

Despite existence of quality heterogeneity, the new index does not account product differentiation within a same product category yet. Even if two countries export very different products in quality, similarity indexes including the new one will indicate high similarities only if the two share a similar export structure in quantity. Schott and Hallak (2011) show an extent of quality heterogeneity of exports across countries within a same product category. Many IIT literature including Greenaway et al. (1995), CEPII (1996), and Biesebroeck (2011) try to fill the gap by dichotomizing products in a same category by unit price. Azhar and Elliot (2006) distinguished among others since they apply the concept of Grubel-Lloyd to unit prices so that measurement of quantity and quality share the same methodology. Yet all these concentrate on classifying intra- and inter-industry trade, no integrated index concerning bilateral overlap of quantity and quality simultaneously.

I suggest a tentative measure of quality that can cooperate with quantities. Notice that existing concepts of similarity standardize each quantity as a share of a certain group so that each quantity (or volume) lay between zero and one. Thanks to the advance in trade statistics, we can access huge dataset and figure out the price distribution. By calculating a cumulative distribution (or estimating a kernel density distribution) of unit prices with quantity weights, one can get a relative position for each unit price datum. Specifically, an inverse cumulative distribution of unit values of product j gives the relative quality of country's export of that product. Through this process, x_j and m_j, having px_j and pm_j as their price, can be mapped with its relative quality u_j and v_j.

For simplicity, we assume the case of ESI. Then, for product j, taking the inverse cumulative probability distribution function $g_j(\cdot)$ suffices to get $u_j = g_j(px_j)$ and $v_j = g_j(pm_j)$.

Now, the quality gap of product j, d_j is takes into account for evaluating true distance between x_j and m_j. Notice that d_j can take various forms such as $|u_j - v_j| + \gamma$[4] or $\frac{\max\{u_j, v_j\}}{\min\{u_j, v_j\}} - 1$. Since ESI measures similarity, a conjugate distance $\overline{d_j}$ of d_j can be take into place of d_j to guarantee consistent polarity.

Following this instruction, ESI can be extended as follows:

$$S_i = 1 - \frac{1}{2}\left[\sum_{j \in i}\left\{\left|\frac{x_j}{\sum_{j \in i} x_j} - \frac{m_j}{\sum_{j \in i} m_j}\right| \overline{d_j}\right\}^p\right]^{\frac{1}{p}}. \quad (3\text{-}9)$$

For giving comparison with the original definition, p is assumed to be 1 and $\overline{d_j} = -|u_j - v_j| + 1$. Then, (3-9) can be expressed as follows:

$$S_i = 1 - \frac{1}{2}\left[\sum_{j \in i}\left\{\left|\frac{x_j}{\sum_{j \in i} x_j} - \frac{m_j}{\sum_{j \in i} m_j}\right| \left(1 - |u_j - v_j|\right)\right\}\right]. \quad (3\text{-}10)$$

To see how the quality gap works in the index, consider there are three countries and tree commodities having following generalized exporting quantity and price information.

4 γ is inserted to avoid zeroing distance in quantity.

Table 3-1: Example for Quality Heterogeneity

	Country 1		Country 2		Country 3	
	Quantity	Price	Quantity	Price	Quantity	Price
Commodity 1	0.5	1.0	0.5	0.5	0.3	0.8
Commodity 2	0.25	0.5	0.25	1.0	0.3	0.4
Commodity 3	0.25	0.5	0.25	1.0	0.4	0.4

Source: Author's calculation

If price is ignored, country 1 and country 2 share an identical export structure while country 1 and country 3 have some differences. However, price vectors of country 1 and country 2 are different. To take account price heterogeneity, each similarity is discounted by the difference of price level. For example, for commodity 1, there is full similarity between country 1 and 2. In minimum operator expression, its commodity-wise similarity will be 0.5. However, when it comes to price, their similarity decreases. To take account those difference, calculate similarity of price. If there is no difference, the similarity will be 1. In this case, we simply assume absolute difference of prices (0.5) to be discounted from 1. Thus, in the original definition, similarity between country 1 and 2 will be 1 while similarity between country 1 and 3 is 0.8. However, if we adopt formula (3-9) to consider quality heterogeneity, the first one becomes 0.5 which is lower than the second pair (0.69).

Still there are alternative methods for accounting similarity of prices. In the example, we calculated similarity instead dissimilarity. In fact, all distance metrics of Minkowski family measure dissimilarity of vectors. In general, a similarity can be measured by a conjugate concept of dissimilarity. However, since the generalized similarity concept should have hierarchical structure, dissimilarity concept may dismiss true dissimilarity.

Notice that sample for the distribution estimation may vary by purpose of analysis. For example, in case of comparing exports of two countries to the specific market, one may confine quality (or unit price) space as a set of all existing qualities in the world market as I will do further.

3.3 Application to Export Similarity Index

3.3.1 Data and Method

In this chapter, all trade data are based on the Harmonized System and comes from UN COMTRADE. The consideration of quality requires consistent quantity data. But accessing detailed trade data with consistent quantity units are difficult in general. Thus, I gathered and cleaned dataset in following way.

First, HS chapters from 25 to 97 are only included to confine ourselves to consider manufacturing sector where quality varies widely. For a given time and HS sub-heading (6 digit) product, I collapsed export values by quantity units and chose the quantity unit that has mostly used in terms of value. I filtered the all dataset with chosen set of quantity units which defined over distinct year and product. This procedure inevitably entails a loss of information since there is no regulation of usage of various units by countries. The loss is around 5 percent for China and Japan after year 2000. But much fluctuates in case of Korea (up to 35%). To preserve most information, time span of 17 years 2000-2016 are used. Harmonized System has been revised every four or five years by World Customs Organization, and each revision follows different nomenclature systems. Thus, the dataset is a combined dataset through 4 revisions (rev. 1996, 2002, 2007, and 2012).

In using trade statistics, import statistics is more commonly used because of its relation with tariff. However, in this chapter, export statistics is used due to the limitation of data availability. Usually, the number of reporting countries is smaller than of partner countries. For example, a developed country's exports to small or developing countries may be correctly recorded as an export even if the partner country doesn't disseminate any trade statistics.

3.3.2 Export Similarity of China, Japan, and Korea

Generally, export structure of a country is related with income level represented by GDP per capita (Hausman et al., 2007). However, Rodrick (2006) points out that export structure of China is exceptionally sophisticated compared to other countries with similar income per population. It is widely accepted that China, Japan, and Korea are important competitors each other. As evidence, they share similar export structure which concentrated on machinery and ICT products. First, to measure similarity, the original definition of ESI is applied to three countries over export values.

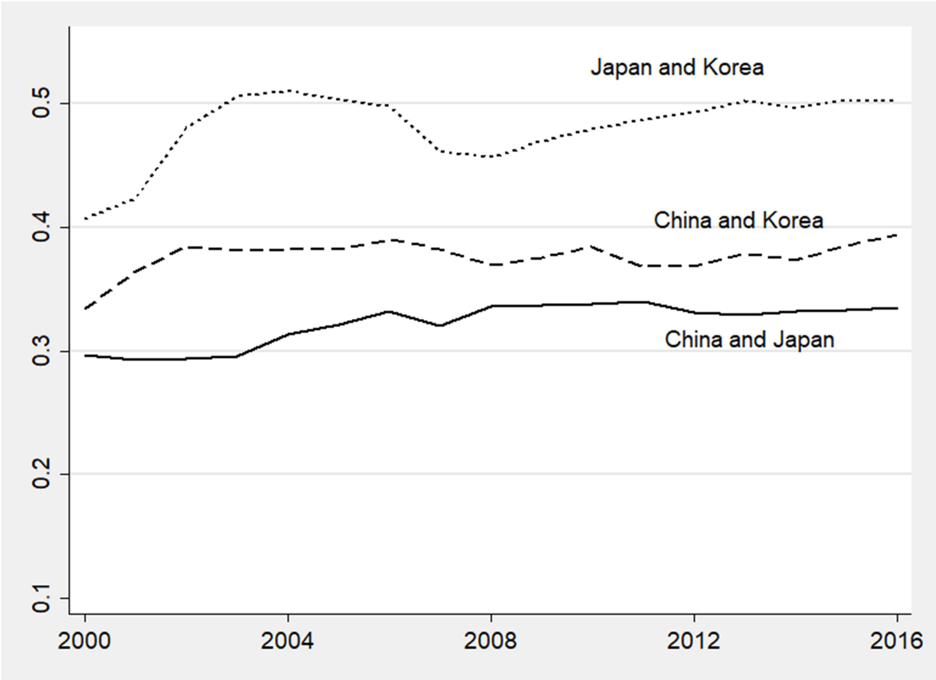

Figure 3-4: Export Similarity of China, Japan, and Korea in Manufacturing

Source: Author's calculation from UN COMTRADE

Figure 3-4 shows consistently high similarity between Japan and Korea while the other pairs stay relatively low. It is a predictable figure, as similarity is positively related to the difference in income levels between the two countries. This result can be understood about the half of export of Japan and Korea share a same domain since they share a similar income level. On the contrary, China seems to have a very different export structure because of the difference in income level with Japan.

However, upward trends in Figure 3-5 are notable since it suggests that China is gradually imitates developed economies.[5] As of 2016, Chinese exports have substantial overlapping range with Germany, which is larger than the overlap with Japan. This observation justifies *Made in China 2025* policy of Chinese government.

[5] The reference countries are a bit different from the previous chapter. Due to data availability and conformity, the U.S. is replaced by Italy.

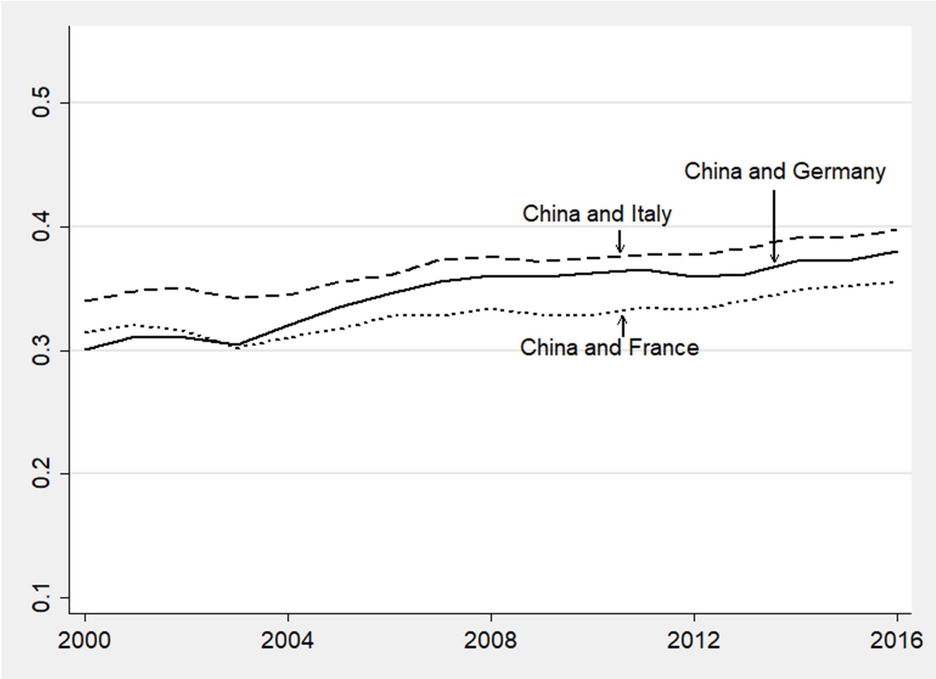

Figure 3-5: Export Similarity of China and Selected Countries in Manufacturing

Source: Author's calculation from UN COMTRADE

The case of Japan in Figure 3-6 shows relatively stable trends. Export structures of developed economies are stable and trend analysis is not that meaningful result in general. Since Japan has a strong machinery industry, the export structure is most similar to that of Germany. Especially, both have exceptional advantage in automobile exports which accounts for a large share of the machinery industry. Similarity between Korea and the others fluctuated and ranged between cases of China and Japan as in Figure 3-7. Interestingly, the export structure of Korea is most similar to that of Germany as Japan.

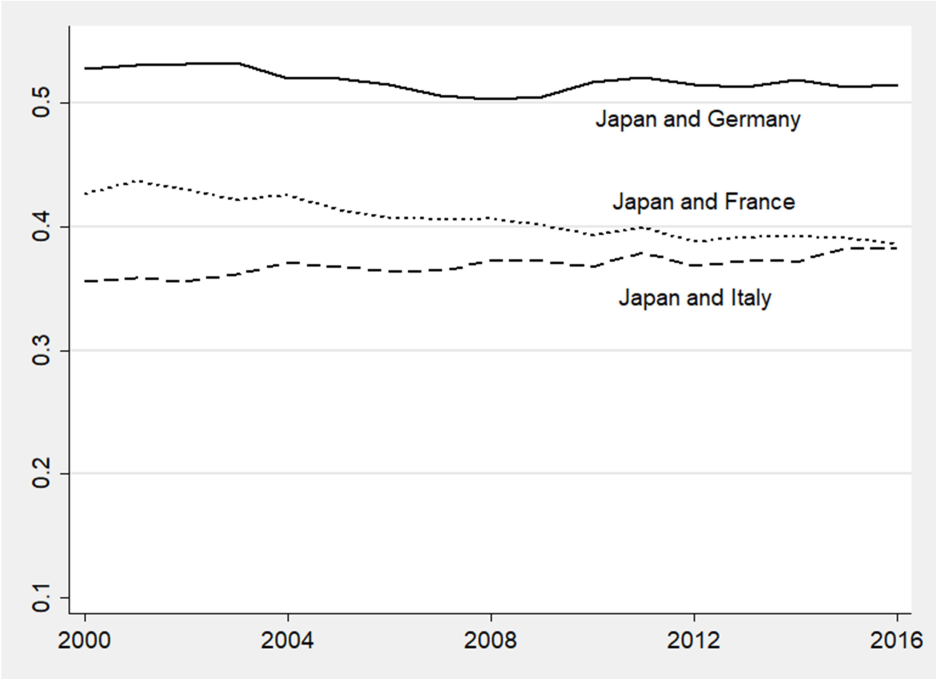

Figure 3-6: Export Similarity of Japan and Selected Countries in Manufacturing

Source: Author's calculation from UN COMTRADE

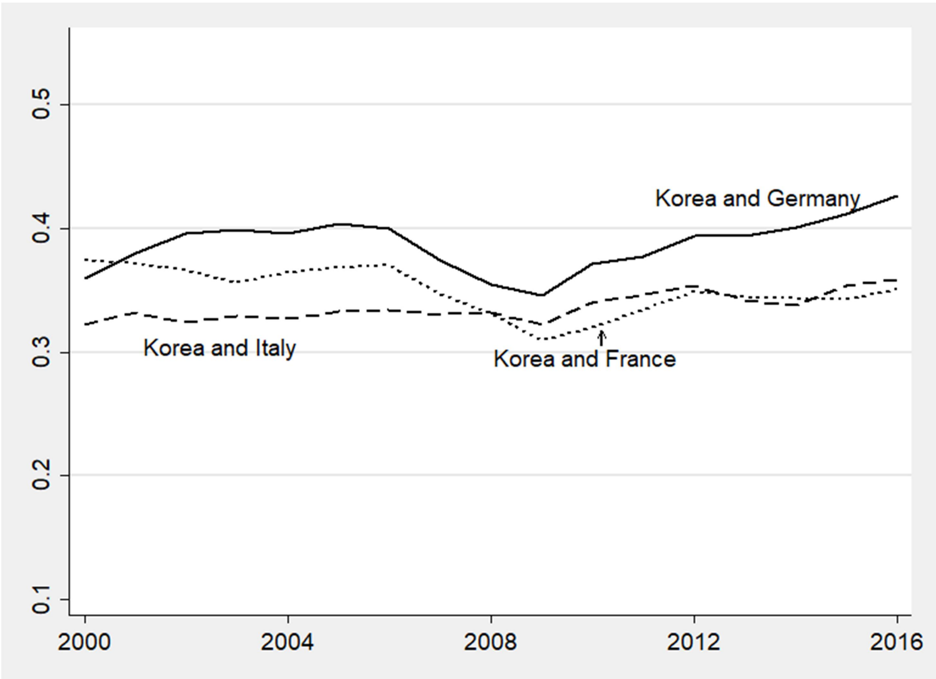

Figure 3-7: Export Similarity of Korea and Selected Countries in Manufacturing

Source: Author's calculation from UN COMTRADE

According to the results so far, bilateral similarities among CJK are determined by income level, and all the three have high export similarity with Germany. However, further verification is needed since those results did not consider heterogeneity in quality. Thus, by using the new method suggested in the previous section, additional analysis is presented in the following. Table 3-2 gives a comparison between the original result and the result considering quality heterogeneity[6].

Before describing the results, it is worthy to remember that the similarity with price heterogeneity is calculated over quantities and the similarity itself does not have a polarity about price. Also, due to data availability, data without quantity information omitted.

Table 3-2: Average Similarities of Country Pairs in Manufacturing Export

	ESI with Original Formula				Modified ESI with Heterogeneity			
	2000-2001	2002-2006	2007-2011	2012-2016	2000-2001	2002-2006	2007-2011	2012-2016
China and Japan	0.295	0.311	0.334	0.332	0.160	0.232	0.321	0.311
China and Korea	0.349	0.384	0.376	0.380	0.162	0.221	0.226	0.212
Japan and Korea	0.415	0.499	0.470	0.499	0.180	0.180	0.169	0.181
China and Germany	0.306	0.323	0.361	0.369	0.157	0.145	0.142	0.157
China and France	0.317	0.314	0.330	0.345	0.139	0.133	0.141	0.140
China and Italy	0.344	0.350	0.374	0.388	0.133	0.147	0.158	0.146
Japan and Germany	0.529	0.523	0.510	0.514	0.201	0.159	0.152	0.155
Japan and France	0.431	0.419	0.401	0.389	0.210	0.167	0.138	0.142
Japan and Italy	0.357	0.364	0.371	0.375	0.154	0.152	0.148	0.136
Korea and Germany	0.370	0.399	0.365	0.405	0.208	0.239	0.219	0.230
Korea and France	0.373	0.365	0.328	0.346	0.262	0.245	0.249	0.278
Korea and Italy	0.327	0.329	0.334	0.349	0.347	0.358	0.356	0.360

Source: Author's calculation from UN COMTRADE

Consideration of price heterogeneity gives different results. First, similarity between Japan and Korea has been lower than other pairs. This suggests that Japan and Korea share similar export structures but have very different price structures.

China's catch-up shown in Figure 3-5 much dampened when heterogeneity comes to

[6] For the sake of readability of the text, the figures were omitted. Notice that the table contains sufficient information. Figures considering heterogeneity can be found in Appendix A.

the index. However, it is notable that China and Japan have a similar export structure even quality heterogeneity comes in. Interestingly, Japan also shares a similar export structure with Germany but not in price. Between Korea and Italy, the similarity has been highest and even higher than of in Figure 1. This can be happened since export spells without quantity or invalid quantity units only included to calculate numbers for Figure 3-4 to 3-6.

Manufacturing is a huge sector and has many missed quantity data. Machinery, defined by SITC 7, is a best candidate for a detailed application since it is the main venue for export of CJK and reference countries. However, there are still many missing observations due to hardship of standardization of quantity measurement. Imagine how one can standardize the unit of various machines. Thus, automobile (SITC 78 in rev.3), a sub-sector of machinery, is chosen for our detailed exemplar analysis.

First, without concerning price heterogeneity, it seems that Japan and Korea have similar portfolios as the similarity is over 60 %. Export of China has around 30% overlapping with Japan and Korea. Since there are only about 70 HS codes for automobiles, those numbers are relatively low. However, it is noteworthy that China's export structure gradually became similar to that of Japan and Korea.

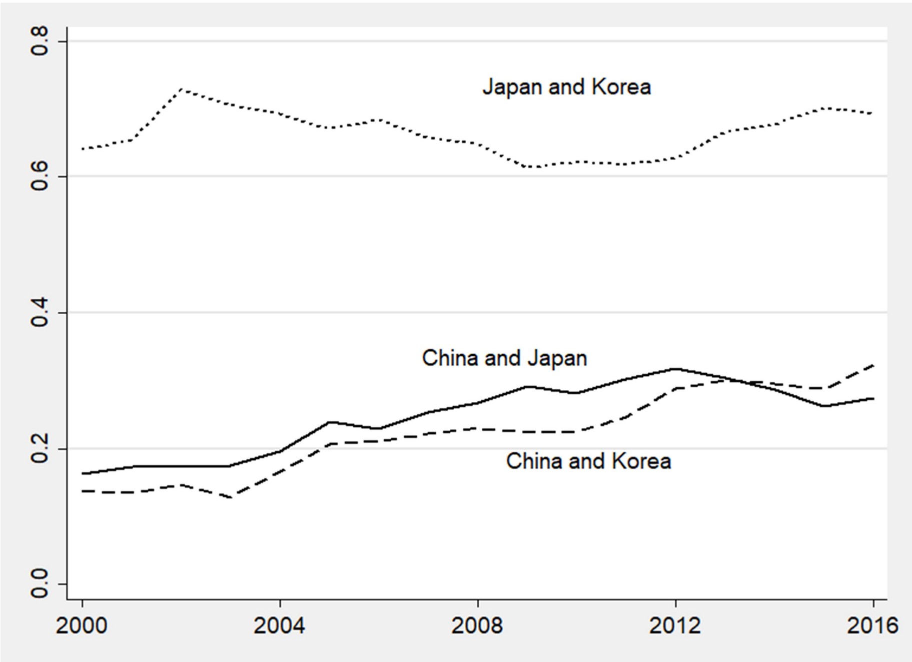

Figure 3-8: Export Similarity of China, Japan and Korea in Automobile

Source: Author's calculation from UN COMTRADE

It seems that China has been achieved a significant catch-up with three Euro countries. The similarity with Germany, which did not reach 20% in the early 2000s, is close to 40% in 2016. Actually, in 2000, the share of gasoline mid-sized cars in China's automobile exports was only 0.3%. However, it increased significantly to 4.6% in 2016. In the early 2000s, export of low value added products such as container and bicycle, which belonged to automobile in given classification system, was the majority. However, considering shrunken share (around 10% in 2016) of those low-value-added products, it is difficult to predict that China is exporting qualitatively similar products to the European countries. Because China's automobile export structure has changed more than half of the past 15 years, similarity with Germany's export structure has only increased by 20%.

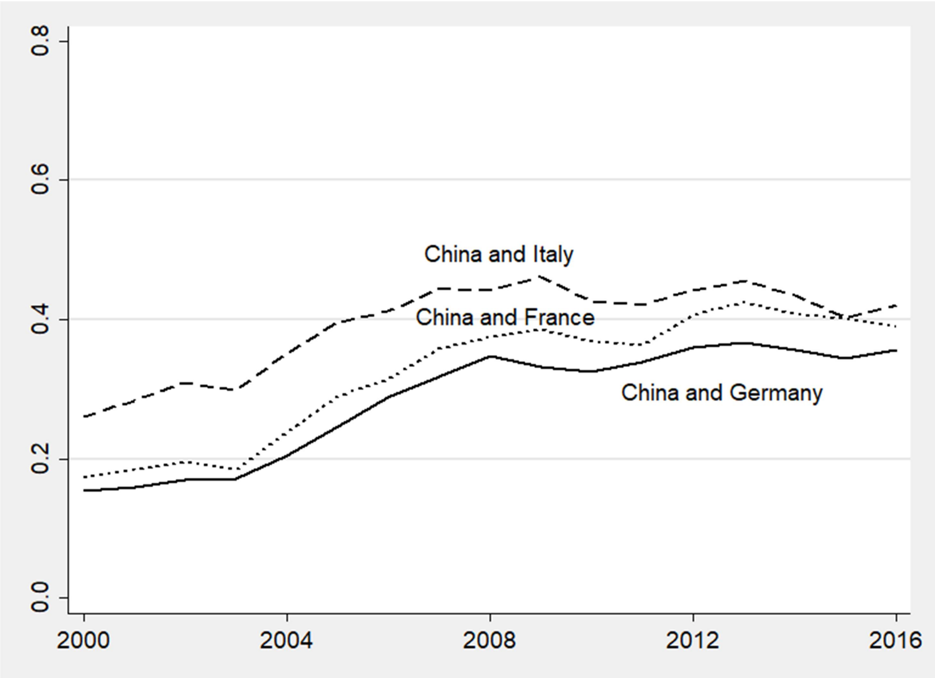

Figure 3-9: Export Similarity of China and Selected Countries in Automobile

Source: Author’s calculation from UN COMTRADE

Both Japan and selected European countries are heavy car makers. The exports of automobiles are expected to be highly similar. The similarities with Germany were more than 70% until the midst of the 2000s. However, the trend of similarity between Japan and Germany has been steadily declining, as the case of Japan and Italy. This is due to the Japanese automakers taking different strategies from its competitors in Germany and France.

As is well known, Germany and France automakers focus on diesel engines which accounts for about half of domestic demand[7]. However, Japan has an extremely low demand on diesel vehicles and exports are also focusing on gasoline or hybrid vehicles.

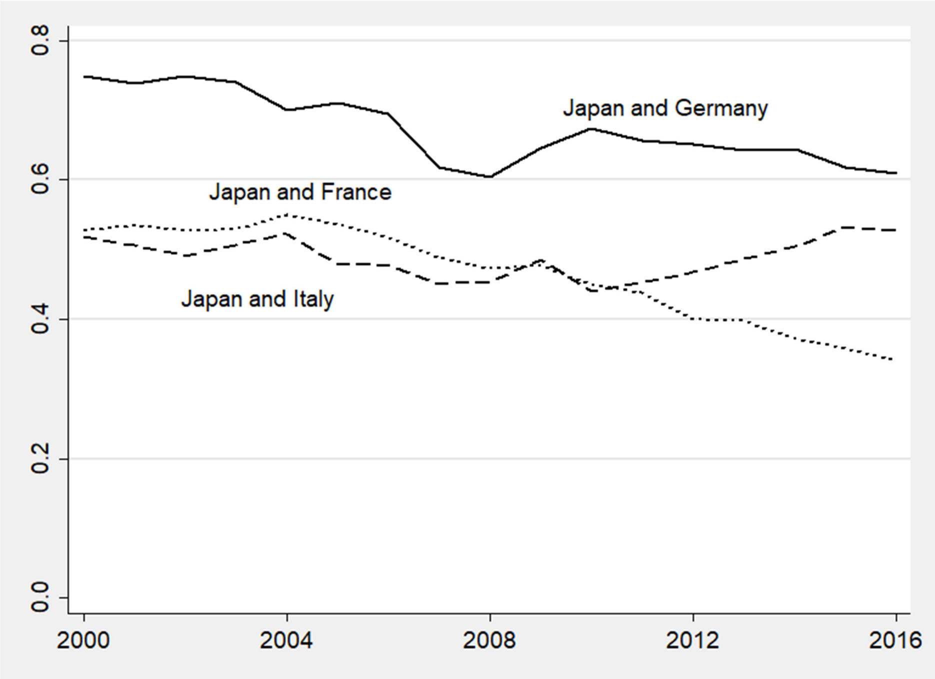

Figure 3-10: Export Similarity of Japan and Selected Countries in Automobile

Source: Author's calculation from UN COMTRADE

It is interesting that Korea is not more volatile than Japan, and it is also remarkable that the similarity with Germany increases. This also can be explained by the strategy of Korean automakers represented by Hyundai and KIA. From the 2000s, the firms have invested in diesel engines and introduced high performance diesel engines for passenger cars in the late 2000s.

7 Germany mechanic Rudolf Diesel first invented diesel engine in late 19c.

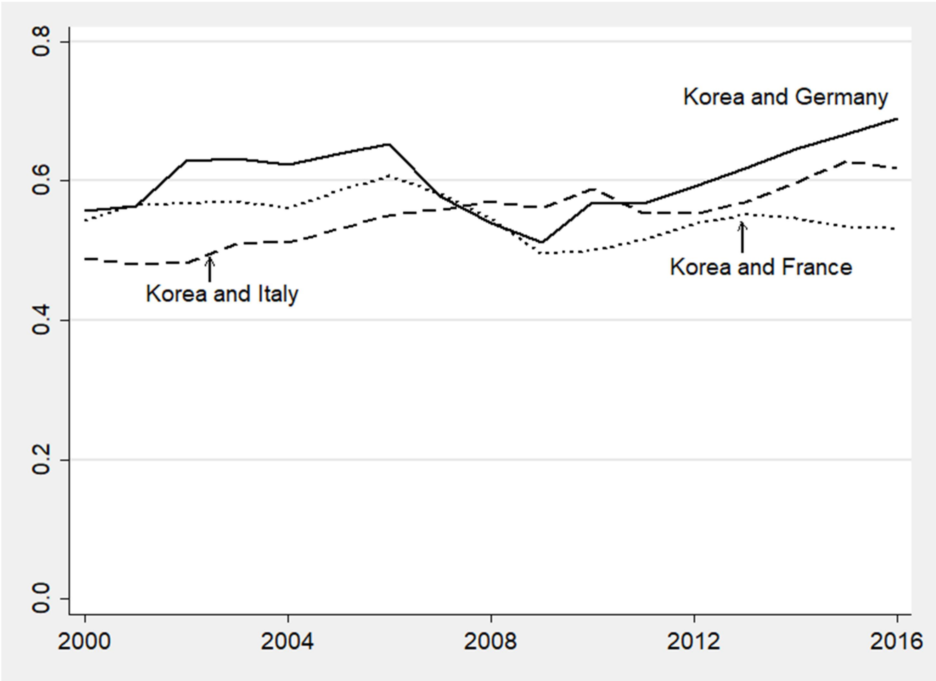

Figure 3-11: Export Similarity of Korea and Selected Countries in Automobile

Source: Author's calculation from UN COMTRADE

As mentioned above, automobiles use relatively uniform unit of quantity, which is advantageous for similarity analysis. How much will the similarity be different considering the quality heterogeneity reflected in the price? Table 3-3 gives a comparison between the original result and the result considering quality heterogeneity by using the new index introduced in the previous section[8].

If heterogeneity comes into the index, the similarity between Japan and Korea is significant and systematic difference in unit price distribution. Using the original calculation method, the average overlap between Japanese and Korean exports in 2002 to 2006 is 69.7%. It becomes 27.7% when quality heterogeneity is take account. However, since 2012, the figure has increased sharply to 39.5%. The difference between the results from the old and the new methods is reduced accordingly. Considering that Japan is one of major incumbent in the premium market, this change of similarity suggests that Korea is reducing the quality gap with Japan in automobile exports.

The similarity between China and the European countries lowered when the

[8] For the sake of readability of the text, the figures were omitted. Notice that the table contains sufficient information. Figures considering heterogeneity can be found in Appendix A.

heterogeneity is considered. In case of Japan, similarity with the reference countries did not change much with consideration of quality heterogeneity. However, the similarity with Italy is largely affected by the quality heterogeneity, and additional causes need to be identified. In the previous analysis, Korea has over 60% of its export structure with Germany. However, when it comes with the new index, it was the most similar to France. This is considered to be a reasonable result since the price difference between Korea and Germany is still large.

Table 3-3: Average Similarities of Country Pairs in Automobile Export

	ESI with Original Formula				Modified ESI with Heterogeneity			
	2000-2001	2002-2006	2007-2011	2012-2016	2000-2001	2002-2006	2007-2011	2012-2016
China and Japan	0.167	0.203	0.279	0.289	0.064	0.117	0.200	0.221
China and Korea	0.136	0.172	0.230	0.299	0.193	0.259	0.353	0.299
Japan and Korea	0.647	0.697	0.632	0.674	0.256	0.277	0.273	0.395
China and Germany	0.157	0.216	0.332	0.357	0.232	0.245	0.244	0.289
China and France	0.179	0.245	0.370	0.406	0.212	0.249	0.282	0.296
China and Italy	0.272	0.353	0.439	0.431	0.348	0.376	0.381	0.401
Japan and Germany	0.744	0.719	0.640	0.633	0.505	0.613	0.559	0.559
Japan and France	0.531	0.532	0.465	0.374	0.384	0.522	0.519	0.432
Japan and Italy	0.512	0.496	0.457	0.504	0.247	0.346	0.401	0.352
Korea and Germany	0.561	0.636	0.553	0.642	0.359	0.293	0.221	0.384
Korea and France	0.554	0.578	0.528	0.540	0.452	0.445	0.393	0.658
Korea and Italy	0.485	0.517	0.567	0.593	0.613	0.616	0.541	0.577

Source: Author's calculation from UN COMTRADE

To sum up, it is shown that Japan has the most similar export structure to Germany, considering quality, and Korea is most similar to France, not Germany or Japan. Also, catch-up of China is quite inflated without consideration of price proximity.

3.4 Determinants of Bilateral Trade Pattern: Diversity and Similarity

3.4.1 Role of Diversity and Similarity in Export

So far, diversification and similarity of export among countries were studied. Those factors are differently correlated with bilateral trade volume. This section is inserted to integrate results in chapter 2 and 3.

As depicted in following figures, diversity is positively correlated with export volume in all three countries. In other words, a country can export more by diversifying its export structure. However, this pattern has weakened over time especially in China. There are possible reasons. A country generally offshores its production to another country that has different factor endowments. As a result of offshoring, exporting country's FDI and exports of intermediate goods such as materials and parts are increased. Thus, increased mobility of production might weaken the role of diversity in determining the volume of export.

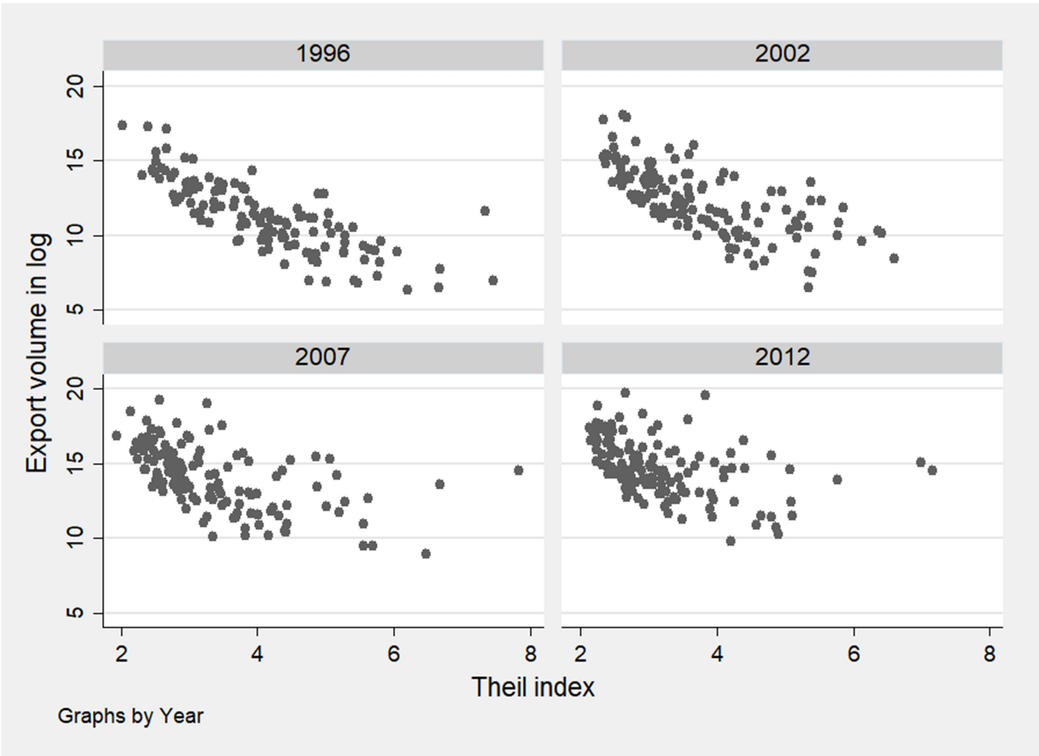

Table 3-4 China's Diversification and Volume of Export

Source: Author's calculation from UN COMTRADE

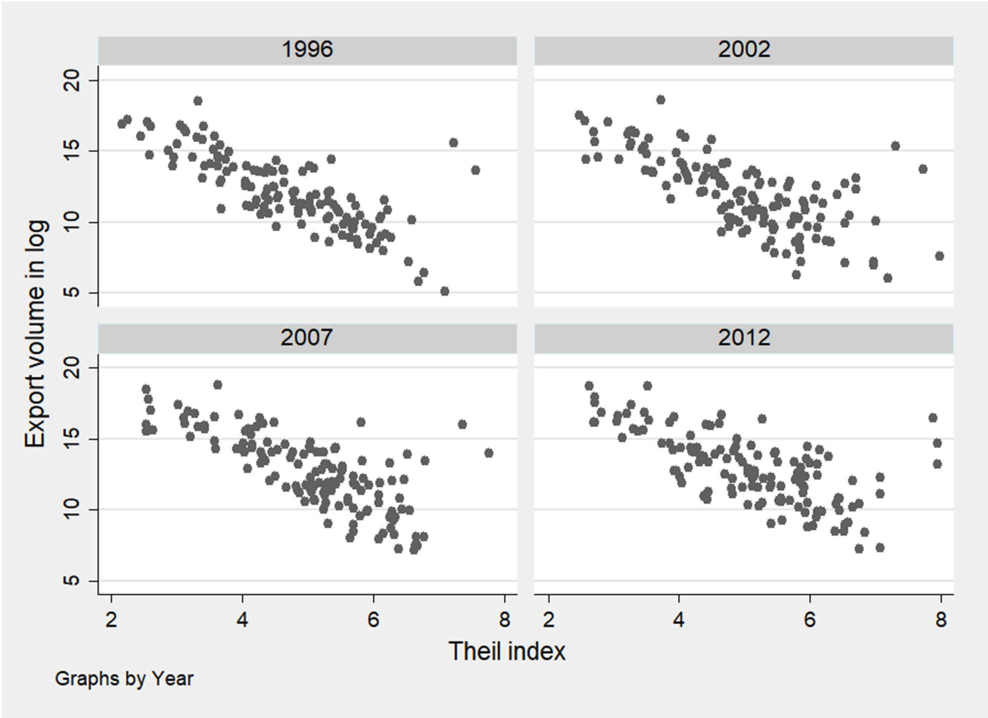

Table 3-5 Japan's Diversification and Volume of Export

Source: Author’s calculation from UN COMTRADE

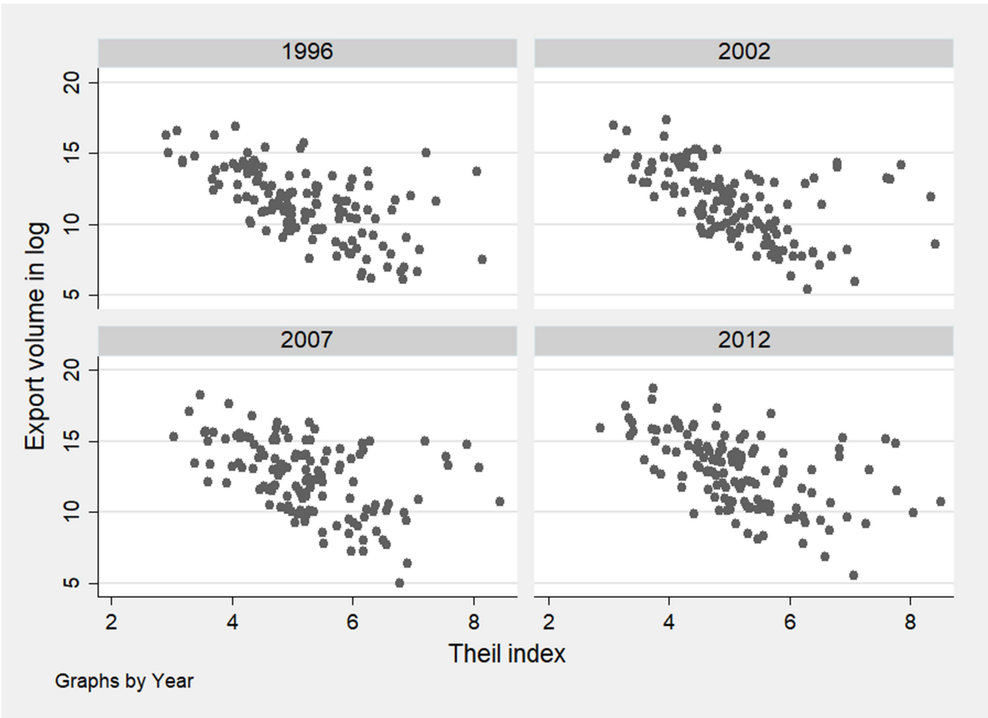

Table 3-6 Korea's Diversification and Volume of Export

Source: Author’s calculation from UN COMTRADE

Similarity also affects trade volume of countries. If two countries share similar factor endowments, they may trade more diversified commodity. Thus, export similarity can affect the volume of bilateral trade.

I calculated bilateral similarities between the three countries and 180 partner countries. The similarity concept is same as ESI which introduced in this chapter. However, I calculated over bilateral dataset so that each similarity stands for similarity between import and export. In this case, ESI=1 means that the two countries have perfectly same structure of import and export. This similarity is frequently referred to as the extent of intra-industry trade.

If there is not enough observation to calculate similarity, I dropped the pair as well as outliers (ESI over 0.95). Both the diversity and similarity have a certain relationship with trade volume. Correlation coefficient between export volume (in log) and the Theil index is most strong (-0.549). Also, the coefficient between export volume and bilateral trade similarity is big enough (0.531). Interestingly, correlation between the Theil index and similarity was not that high.

When quality heterogeneity is coming into account, the result is not changed despite overall level of similarity decreased.

Table 3-7 Correlation Coefficients among Variables

First variable	Second variable	Correlation
Export volume	The Theil index	-0.549
Export volume	Bilateral Trade Similarity	0.531
The Theil index	Bilateral Trade Similarity	-0.182
Export volume	Bilateral Trade Similarity with Quality Heterogeneity	0.487
The Theil index	Bilateral Trade Similarity with Quality Heterogeneity	-0.194

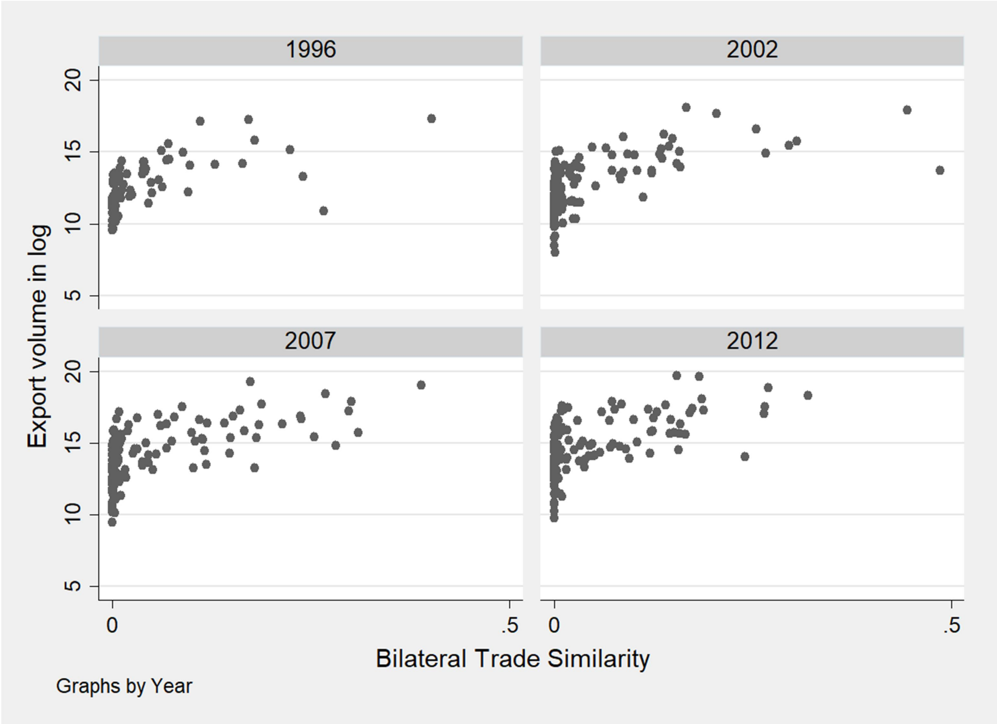

Table 3-8 China's Bilateral Trade Similarity and Volume of Export

Source: Author’s calculation from UN COMTRADE

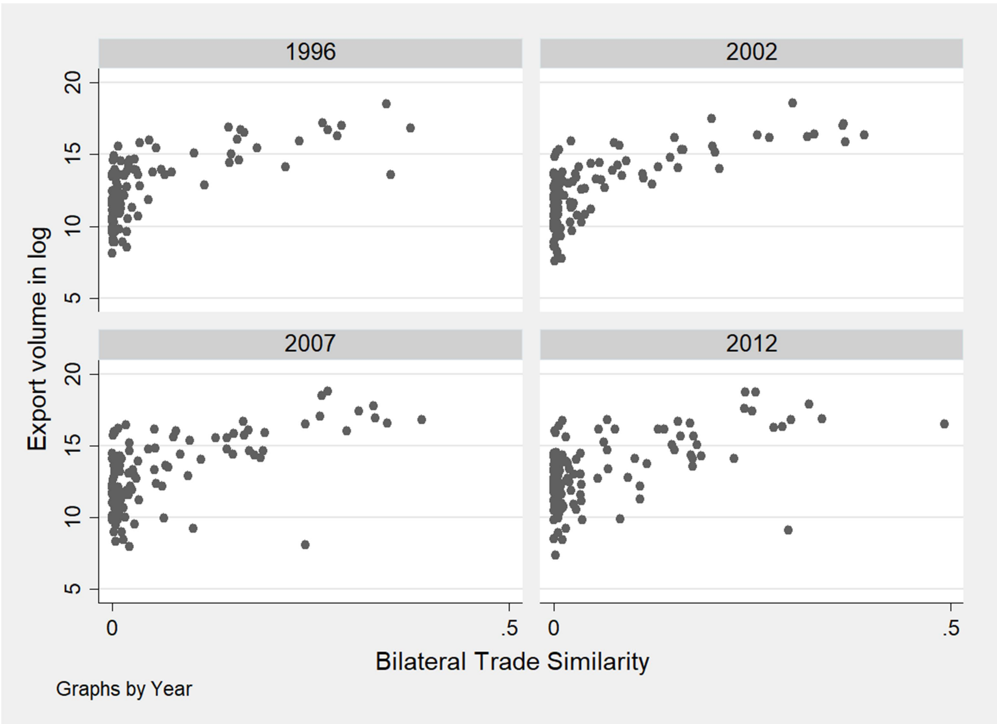

Table 3-9 Japan's Bilateral Trade Similarity and Volume of Export

Source: Author’s calculation from UN COMTRADE

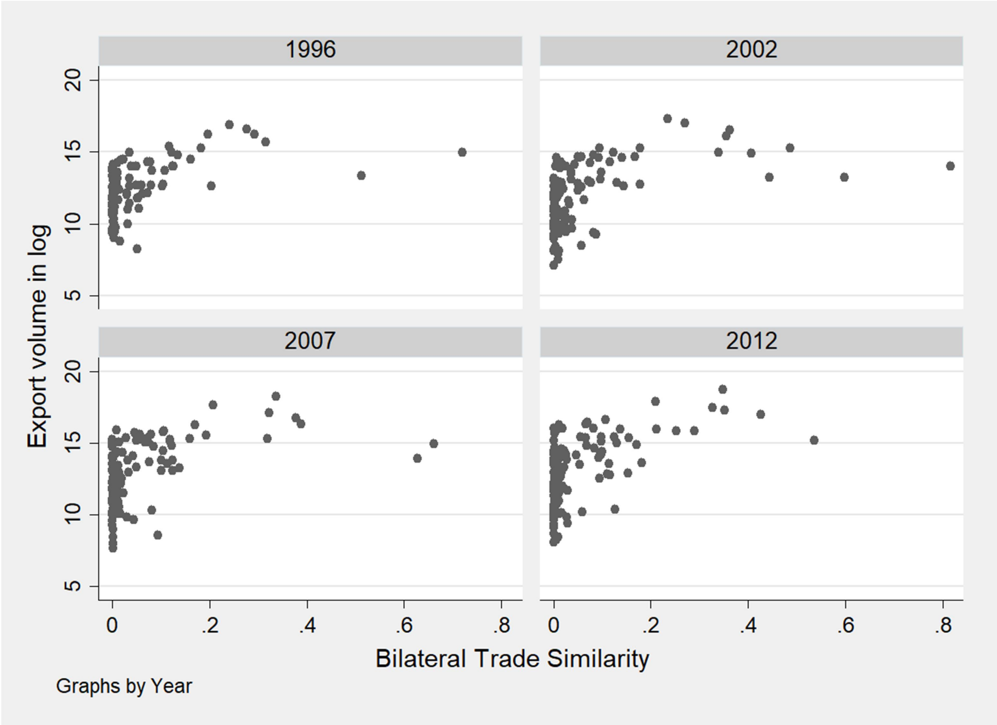

Table 3-10 Korea's Bilateral Trade Similarity and Volume of Export

Source: Author's calculation from UN COMTRADE

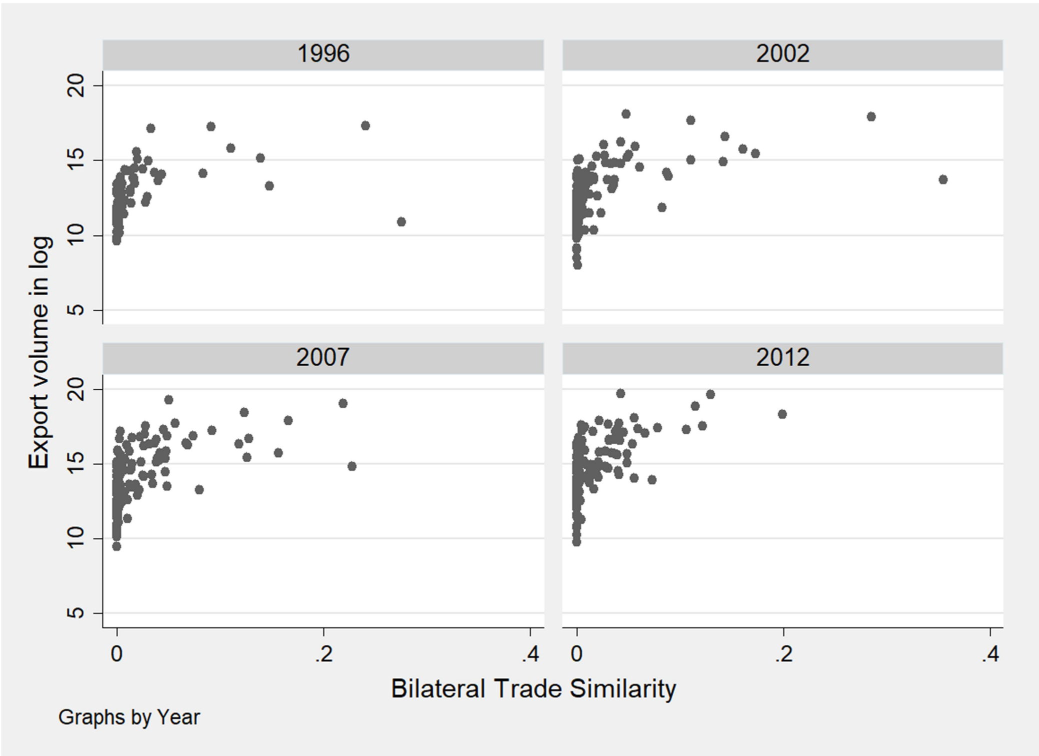

Table 3-11 China's Bilateral Trade Similarity and Volume of Export (with Quality)

Source: Author's calculation from UN COMTRADE

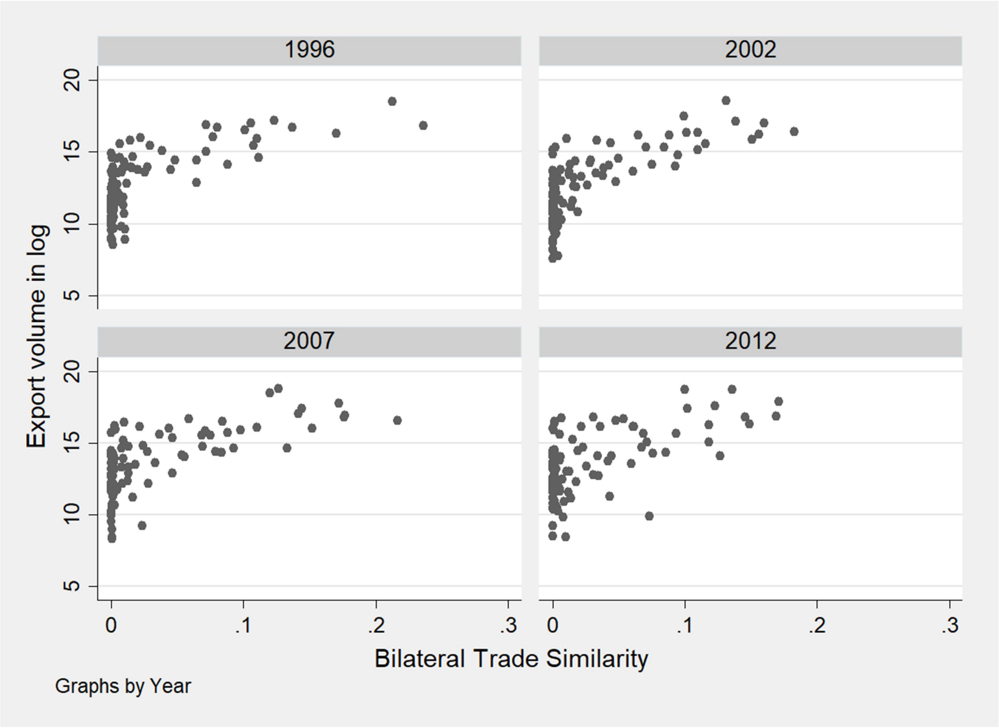

Table 3-12 Japan's Bilateral Trade Similarity and Volume of Export (with Quality)

Source: Author’s calculation from UN COMTRADE

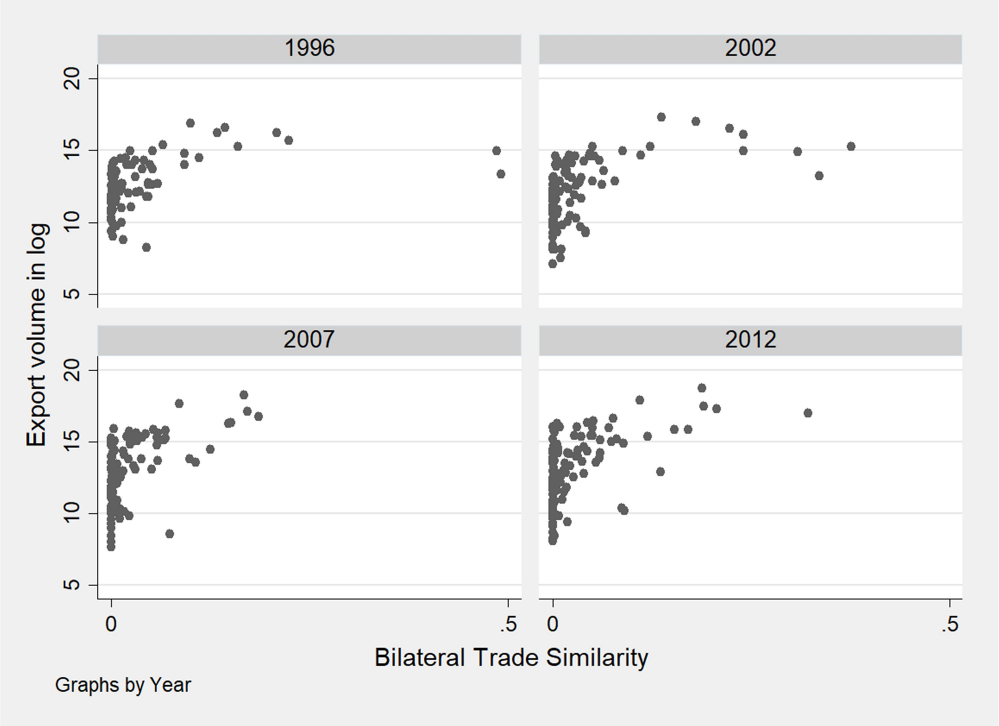

Table 3-13 Korea's Bilateral Trade Similarity and Volume of Export (with Quality)

Source: Author’s calculation from UN COMTRADE

3.4.2 Determinants of Diversity

Diversity of trade structure generally depends on factor endowments and intra-industry trade (Romalis, 2004). Regolo (2013) suggests a pair of countries can easily diversify their trade pattern if they share similar endowments by extending the model of Romalis (2004). Regolo (2013) used difference of endowments as determinants of trade diversification. More specifically, physical capital, human capital, and natural resource (land) are considered as endowments and relative abundance were included as independent variables to determine diversification level measured by the Theil index which used in chapter 2.

Based on Regolo (2013), I test determinants of bilateral export diversity of East Asian countries. As the previous paper detests theoretical backgrounds and robust empirical results, we confine the range of countries and add a new factor-bilateral similarity between countries considering quality heterogeneity.

The concentration measure of export from country i to country j, CX_{ij}, is measured by the Theil index. CX_{ij} is regressed on variables representing bilateral differences of factor endowments. Econometric specification is as follows.

$$ln(CX_{ij}) = \beta_1 DIFF_{ij}^{K/L} + \beta_2 DIFF_{ij}^{H/L} + \beta_3 DIFF_{ij}^{T/L} + u_{ij} \quad (3\text{-}11)$$

$$where\ \ DIFF_{ij}^{E/L} = \left| ln\left(\frac{E}{L}\right)_i - ln\left(\frac{E}{L}\right)_j \right|\ for\ E \in \{K; H; T\}.$$

Since we confined the observation, fixed effects of countries are omitted. u_{ij} is an error term which is not correlated with the regressors.

Regolo (2013) also shows positive correlation between transport costs and export diversification. Transport costs can be measured by traditional variables such as distance between countries, border contiguity, use of common (official) language, and so on.

To extend formula (3-11), variables of trade cost is added as following:

$$\begin{aligned} ln(CX_{ij}) = \alpha + \beta_1 DIFF_{ij}^{K/L} + \beta_2 DIFF_{ij}^{H/L} + \beta_3 DIFF_{ij}^{T/L} + \beta_4 dist_{ij} \\ + \beta_5 contig_{ij} + \beta_6 comlang_{ij} + \beta_7 DIFFGDPpc_{ij} + u_{ij} \end{aligned} \quad (3\text{-}12)$$

To test the role of factor endowments and similarity in diversification, data from various sources were used. Data availability on disaggregated export at HS sub-heading level gives a panel of 130 trading partners between 1996 and 2010. Data after 2011 dropped due to the human capital data. Trade data comes from UN COMTRADE. To calculate similarity with consideration of quality heterogeneity, I dropped data without valid quantity information.

As in Regolo (2013), real capital stock per worker, K/L, from Penn World Table (9.0) is considered as a proxy of physical capital endowment. Relative abundance of human capital, H/L, is measured by average years of schooling provided by Barro and Lee (2013). Arable land per person from World Bank (WDI) takes into account for measuring natural resource endowment (T/L).

Variables about transport costs are from CEPII which is the most common source for gravity based models. $dist_{ij}$ is the logged value of the distance between the main cities of country i and j. $contig_{ij}$ is 1 only if country i and j share the same border and 0 otherwise. $comlang_{ij}$ is also 1 only if country i and j share an official language and 0 otherwise.

To control difference of preference induced from different income level, absolute difference GDP per capita between two countries (based on log) is take into account as $DIFFGDPpc_{ij}$.

Table 3-14 Factor Endowments, Trade Similarity, Transport costs, and Concentration of Exports.

		Dependent variable: $ln(Theil_{ij})$					
Expected sign		(1)	(2)	(3)	(4)	(5)	(6)
$\mathrm{DIFF}_{ij}^{K/L}$	(+)	-0.009	-0.012	-0.008	-0.003	-0.303	-0.288
		(0.43)	(0.64)	(0.42)	(0.15)	(7.67)**	(7.46)**
$\mathrm{DIFF}_{ij}^{H/L}$	(+)	0.163	0.125	0.157	0.112	-0.026	-0.033
		(4.23)**	(3.33)**	(4.15)**	(3.04)**	(0.65)	(0.86)
$\mathrm{DIFF}_{ij}^{T/L}$	(+)	0.065	0.077	0.072	0.075	0.069	0.067
		(4.57)**	(5.55)**	(5.07)**	(5.46)**	(5.39)**	(5.31)**
sim_{ij}	(-)		-1.875		-0.967	-1.521	-0.714
			(5.55)**		(2.49)*	(4.83)**	(1.99)*
$dist_{ij}$	(+)			-0.220	-0.093		-0.114
				(2.81)**	(1.14)		(1.51)
$contig_{ij}$	(-)			-0.436	-0.238		-0.215
				(2.74)**	(1.50)		(1.47)
$comlang_{ij}$	(-)				0.125		0.111
					(4.07)**		(3.94)**
$DIFFGDPpc_{ij}$	(+)					0.339	0.330
						(8.24)**	(8.31)**
Constant		1.300	1.345	1.300	0.198	1.322	0.300
		(42.40)**	(43.88)**	(42.36)**	(0.70)	(46.46)**	(1.15)
R^2		0.11	0.18	0.15	0.24	0.30	0.35
N		393	393	393	393	393	393

* p<0.05; ** p<0.01

Consistently with the prediction of Regolo (2013), almost coefficients on the bilateral endowments differences are positive and also significant. However, coefficients on difference of physical capital are negative and even significant in column (5) and (6). Since the three exporting countries are already physical capital abundant internationally and physical capital can be moved easily, difference of physical capital endowments does not weaken export diversity of the three countries.

Column (1) shows that if an exporting country reallocates his existing exports towards a partner country having more similar human capital per worker by one standard deviation, its export diversification in this market will be decreased. Since the Theil index measures inversed diversity, the index will be increased by 19.8%. Notice that the standard deviation of the Theil index is 1.22 and 19.8%=0.16*1.22. In the same way, if differences of natural resource endowments increase by one standard deviation from its mean, the Theil index increases by 7.9%.

The observed effects are substantial. Recall the example of Regolo (2013), if India were to increase its relative human capital stock per worker to the value in Japan, ceteris paribus, the Theil index of Indian exports to Japan would decrease substantially. However, those kind of change is rarely happens in the real world.

Colume (2) introduces our new concept- similarity between export and import. In all specifications, the coefficient for similarity is substantial and significant. Also, notice the inclusion of similarity variable consistently enhances the goodness of fit. The estimates suggest that increase in intra-industry trade reflexed in similarity measure would enable to increase diversity between countries. This part can be extended further by using more independent similarity concepts to the diversity. Although correlation coefficient between similarity and diversity is not that high and only similarity also considers price vectors, there would be a caveat from using same vectors.

Also in the same line of Regolo (2013), trade costs were related with trade diversity. However, since we confined the scope, only the coefficient for common language is significance.

3.5 Concluding Remarks

CJK have passed through different economic development paths. It is known that the export structure of CJK has been synchronized. This seemingly conflict facts have attracted much attention including various qualitative surveys on China's rapid catch-up. Despite trade data already contains adequate information on the synchronization phenomena, as mentioned earlier, existing concepts of bilateral similarity have some limitations. Several similarity measures used Minkowski distance with parameter 1 without explicit justification. Also, existing concepts do not consider heterogeneity in quality.

In this chapter, a new index is introduced to relieve two limitations of existing indices. Explicit introduction of the Minkowski parameter and the additional consideration of quality heterogeneity can be considered as theoretic contributions since it includes the effectiveness of the new index. However, it has not been able to deal with finding the appropriate Minkowski parameters. The consideration of quality heterogeneity is applied to analyze the similarity of export structure of CJK.

Empirically, the export structure of CJK was evaluated from the perspective of similarity. As a result of evaluating the similarity of manufacturing exports by country pairs using traditional ESI, several pairs of countries showed particularly high similarities. Japan has a similar structure with Korea and Germany. Especially as of 2016, Chinese exports have substantial overlapping range with Germany, which is larger than the overlap with Japan. It seemingly justifies *Made in China 2025* policy of Chinese government.

However, consideration of price heterogeneity gives different results. First, similarity between Japan and Korea has been lower than other pairs. The similar pattern observed that between Japan and Germany. It suggests that those countries share similar export structures and have very different price structures. In case of China, the prominent catch-up much dampened when heterogeneity comes to the index.

The confined results limited to automobile also have implications. Using the original calculation method, the average overlap between Japanese and Korean exports in 2002 to 2006 is 69.7%. It becomes 27.7% when quality heterogeneity is take account.

It is shown that Japan has the most similar export structure to Germany, considering quality, and Korea is most similar to France, not Germany or Japan. Also, catch-up of China is quite inflated without consideration of price proximity.

Chapter 4: What Has China Learned from Processing Trade?

4.1 Introduction

Chinese exports in early 1990's were specialized in labor-intensive products (Lardy, 1994), as classical theory would predict. From the 1990's, the utilization of processing trade and special economic zones attracted a vast amount of foreign direct investment (FDI) and reformed export structures. ICT products, such as smartphone or laptop computer, are their representative export products now. This can be explained in the realm of new trade theory, which emphasizes the importance of product differentiation, economies of scale, and firm heterogeneity (Dixit and Norman, 1980, Melitz, 2003). Factor mobility and economies of scale allow China to produce almost any kind of product in the world. The biggest obstacle to China, faced with the reality of being a leading manufacturing center, is a lack of accumulated technology. FDI and consequent production activity captured by processing trade may enhance overall productivity through technology transfer and knowledge spillover. If there were no experience in the manufacturing of smartphones under provision of foreign companies, for example, China would not be able to have the original brands it has now.

Rodrik (2006) claims China has achieved a significantly higher level of sophistication compared to other developing economies. This is due to foreign enterprises and processed exports (Xu and Lu, 2009). Schott (2008) finds a higher unit value of processing trade than others.

Despite of the facilitative effect and the contribution to trade stability (Fernandes and Tang, 2015), there is another strand of literature insisting on the inefficiency of processing trade compared with ordinary trade. Joining firm balance sheet data and trade data, Dai et al. (2016) argue for relatively low total factor productivity (TFP) of processing trade. Manova and Yu (2016) also point out the low profitability of processing trade measured by value added. Koopmans et al. (2008) develop a calculating method for foreign shares in exports of China in support of the low profitability of processing trade.

There has been less interest in the external effects of processing trade. Literature emphasizing the low profitability of processing trade often ignores knowledge transfer from foreign enterprises and the positive externalities of processing trade. There has been less attention to the factors of processing export productivity. Thus, the objective of this chapter is to analyze the effect of China's processing trade on China's export development. Specifically, there are two research questions which will be answered in 4.2 and 4.3, respectively.

1. **Theoretically, does processing trade policy help to improve productivity?**
2. **Empirically, what China has learned from processing trade?**

Before the investigation, we first check the stylized facts about processing trade. And we adopt the model developed by Hausman et al. (2007), which relies on cost discovery externality. Hausman and Rodrik (2003) suggest discovering costs of domestic production activities are incurring great social externality in developing countries.

In our modified setting, entrepreneurs can achieve higher level of productivity on average by using processing trade. As in Hausman et al. (2007), an entrepreneur can choose between imitation and self-discovery. However, individual productivity account into the final output even if he did an imitation. Imitation outputs are varying over individual. Also, individuals can choose another option of processing trade which guarantees a fixed outcome but also entails some uncertainty. The model predicts that overall productivity can be enhanced with processing trade in terms of average. Also, processing trade can affect the future by shifting frontier entrepreneurs' productivity in some cases. The model implies that the high productivity of processing exports may have effects on the productivity of ordinary exports.

This research relates to the literature of processing trade in China since it shares a similar dataset (Schott, 2008, Fernandes and Tang, 2015, Manova and Yu, 2016). Our approach is unique in emphasizing the role of the productivity gap in productivity catch-up. Also, there is another related strand of literature on export sophistication and economic growth. Though our scope does not include economic growth, the base philosophy that "what a country exports matters (Hausman et al., 2007)" is the same. In contrast to the majority of this literature, we refine manufacturing down to hundreds of sub-sectors to analyze the interaction of enterprises.

The remainder of this chapter will be organized as follows. Section 4.2 provides background with a theoretic framework. In 4.3, the empirical analysis is addressed to examine the effect of processing trade in China. Concluding remarks may be found in 4.4.

4.2 Background

In this section, we will briefly see the characteristics of processing trade in China and will introduce a theoretic framework for examining the overall effect of processing trade on overall productivity.

Table 4-1: Composition of China's Trade by Mode and Type of Enterprise in 2014

Unit: per cent

	SOE	Foreign enterprises		Privately Owned Enterprises	Other	Total
		Foreign Joint Ventures	Wholly Owned Foreign Enterprises			
Ordinary Trade	12.5	6.2	9.2	23.1	2.8	53.8
Processing and Assembling Trade with Customer-Supplied Materials	1.0	0.7	2.0	0.5	0.2	4.4
Processing Trade with Imported Materials	1.1	5.8	17.4	3.2	0.8	28.4
Inbound/Outbound Goods in Bonded Warehouses	1.3	0.7	0.3	1.3	0.1	3.6
Storage of Transit Goods in Bonded Warehouses	0.9	0.6	2.7	2.7	0.0	6.9
Others	0.6	0.2	0.2	1.9	0.0	3.0
Total	17.4	14.3	31.9	32.6	3.9	100.0

Source: China Customs

4.2.1 Processing Trade and Foreign Enterprises in China

First, we define "processing trade" by regime of trade. China Customs classifies each type of trade into 19 regimes (or modes) by its nature. There are two important regimes of processing trade: processing and assembling trade with customer-supplied materials and processing trade with imported materials. In the first case, most processing firms in China hardly manage their profit levels because their only added value, processing fees, are determined by ordering organizations outside of China. As for a firm in the second case, a processing firm can handle their profits by choosing trading partners. Ordinary trade is the opposite concept of processing trade. The three regimes account for about 87 percent of total trade in 2014. Other regimes will be omitted as we cannot access detailed information about the processing. China Customs also compiles the trade statistics by 8 types of enterprise. In this chapter, "foreign enterprise" is defined as all types of enterprise with foreign capital[9].

Not surprisingly, foreign enterprises conducted about 80 percent of processing trade in 2014. Wholly owned foreign enterprises are more likely to concentrate on processing trade with imported materials. Privately owned enterprises contribute only 11.1 percent of processing trade while their contribution to ordinary trade is 43 percent. Also, the three regimes mentioned before account for 86.5 percent of total trade.

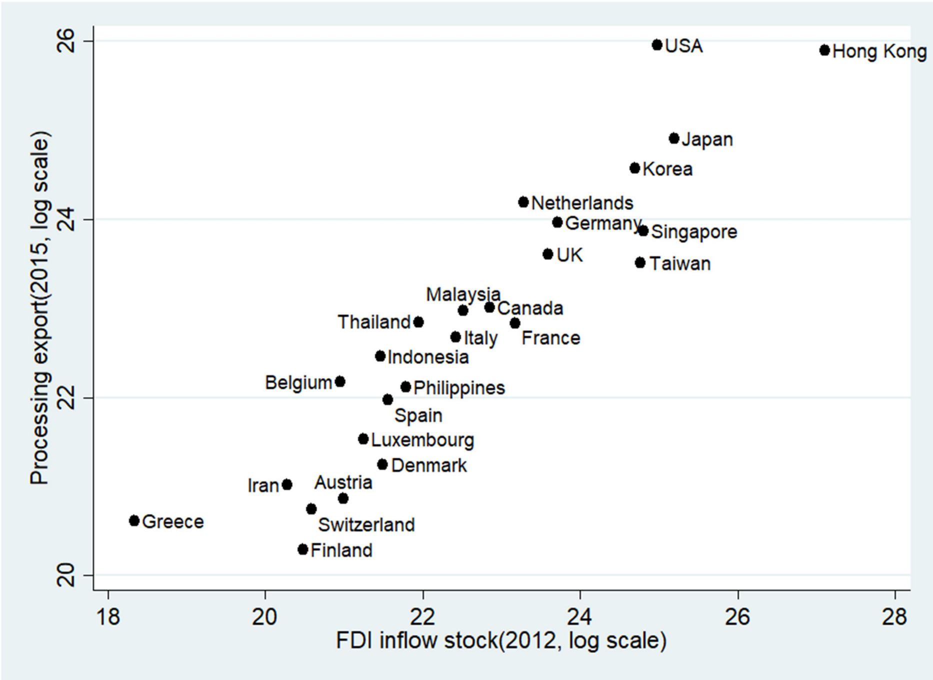

Figure 4-1: FDI Stock and Processing Exports

Source: UNCTAD, China Customs

Inward foreign direct investment in China is believed to promote manufacturing export performance (Zhang and Felmingham, 2001, Long, 2005, Zhang, 2015). Figure 4-1 shows a positive relationship between FDI stock and processing export performance.

4.2.2 Role in Trade Balance, Structural Characteristics

The share of processing trade in total trade is gradually decreasing due to the emergence of ordinary trade. However, its importance in the balance of trade has been maintained. Figure 4-2 shows that trade surplus from processing trade overtook the total trade

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[9] China-foreign contractual joint ventures, China-foreign equity joint ventures, and foreign wholly-owned enterprises

surplus in most of the time. The demand-driven nature of processing trade allows processing firms to take less risk than other firms.

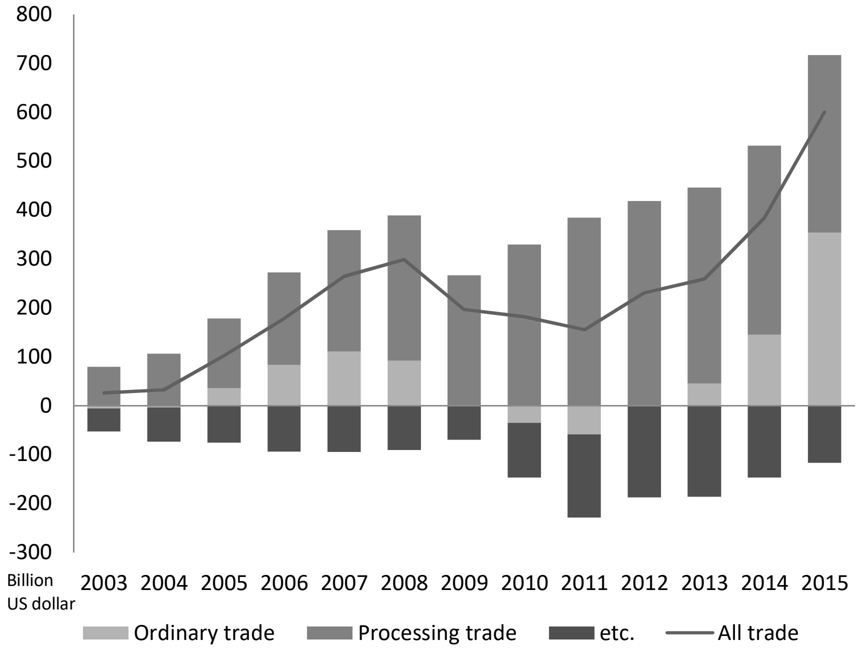

Figure 4-2: Trend of Trade Balance by Trade Regimes

Source: China Customs

Structurally, processing trade is concentrated on a few products and is different from ordinary trade as depicted in Figure 4-3. Over 65 percent of processing trade falls into the category of "Machinery and transport equipment (SITC 7)," which requires more technology than the others. Also, 19 out of 5200 Harmonized System 6-digit products accounts for half of total trade while 171 products take the same share in ordinary trade.

To summarize, most processing trade is related with foreign enterprises and their home countries. The role of processing trade in the balance of trade is substantial, though its composition is highly concentrated on specific sectors and commodities.

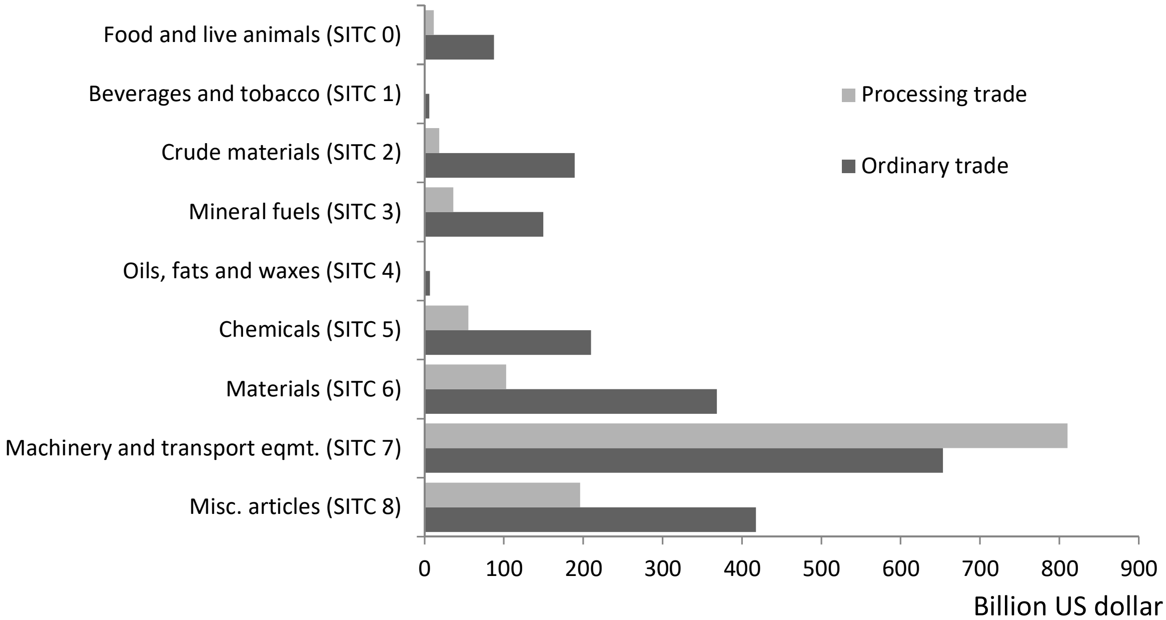

Figure 4-3: Composition of Processing and Ordinary Trade by SITC 1 Digit Industries

Source: China Customs

4.2.3 A Simple Model: Hausman, Hwang, and Rodrik (2007) Revisited

In this section, we bring a simple model modified from Hausman et al. (2007) in order to see the effects of processing trade on the productivity of the Chinese economy. Following the original model, all production activities can be divided into two sectors: the traditional and the modern sector. In the traditional sector, there is no uncertainty to entrepreneurs while the entrepreneurs in the modern sector face cost uncertainty. In other words, in the traditional sector, outcomes are homogeneous and individual productivity does not affect to the output. But, in the modern sector, individual productivity matters since there should be some discovery procedure to produce a new good. The traditional sector only work for clearing wage level. Thus we concentrate on the modern sector.

Let $N = \{1,2,3,\dots\}$ be a (finite or infinite) universe of all potential varieties that a country can produce in the modern sector. Unit price of all goods are same and each good only can distinguished by its required productivity of production. A function θ maps each good in N into the closed non-negative interval $[0, h]$ which called "the production space" in Hausman et al. (2007). h means the upper bound of productivity. The required productivity level for i, denoted by θ_i, can identify good inversely. Thus θ is injective but not surjective.

Let assume marginal cost for production of good i is given as follows:

$$c_i = \frac{b}{\theta_i} w \tag{4-1}$$

where $\frac{b}{\theta_i}$ is the number of labor force and w is the wage. Even if there exist two goods, let's say good 1 and good 2, identical to every consumers, they are heterogeneously identified in our model as $\theta_1 \neq \theta_2$. A good only can be produced by entrepreneurs with appropriate productivity. Each entrepreneur (investor) has intrinsic level of productivity but never know before it discovered. Let $M = \{1,2,\dots,m\}$ be the finite set of entrepreneurs in a country. They are potential exporters who can be characterized by their productivity. Different from the map θ given as a state-of-nature, a productivity of investor is given by probability distribution. Suppose investor j decided to enter the market. His own (potential) productivity θ_j is revealed soon after his fixed cost sunk. For convenience, we assume the distribution of productivity is uniform in $[0, h]$.

Let assume m_t numbers of entrepreneurs invest to the modern sector at time t. At the time t, their fixed cost sunk and they do not know their available outcomes because they do not know their productivity. At the beginning of time $t+1$, individual j knows his productivity θ_j. Naturally he will stick with the best project (product) that he can afford. Thus, his output is also identified with his productivity. Without loss of generality, exit cases of investors are ruled out in our model.

We will distinguish $\widehat{\theta_j}$, productivity of "realized" outcome of j, and θ_j since we allow imitation. In the early version of the model (Hausman and Rodrick, 2003) assumes that it is possible to imitate all products perfectly. Hausman et al. (2007) adopt imperfect imitation which depends on the maximum level of revealed productivity in an economy. Both allow that any follower can imitate former product regardless of his original productivity. However, intrinsic productivity matters also for a simple imitation. We assume each investor who engaged at time t will face two choices at the beginning of time $t+1$. And his outcome depends on his own productivity. Then, the revealed productivity of j can be expressed as follows:

$$\widehat{\theta_j} = \max\{\alpha\theta_j + \beta, \theta_j\} \tag{4-2}$$

In (2), we assume a discount parameter of imitation α lays in $[0,1)$ and every imitation gives a constant level of outcome represented by β. Naturally, $\beta \in (0, h)$. Figure 4-4 shows how production frontier changes by imitation. One can think α and β are positively associated with maximum level of revealed productivity, $\widehat{\theta_{max}}$ of the economy. Hasuman et al. (2007) assume $\alpha = 0$ and β is strictly increasing in $\widehat{\theta_{max}}$. We simply assume β is non-decreasing in $\widehat{\theta_{max}}$.

Overall revealed productivity level of an economy is as following:

$$E(\hat{\theta}) = Prob(\theta_j \geq \tilde{\theta}_1)E(\hat{\theta}|\theta_j \geq \tilde{\theta}_1) + Prob(\theta_j < \tilde{\theta}_1)E(\hat{\theta}|\theta_j < \tilde{\theta}_1) \tag{4-3}$$

$$E(\hat{\theta}) = \frac{\tilde{\theta}_1}{h}\frac{\beta + \tilde{\theta}_1}{2} + \frac{h - \tilde{\theta}_1}{h}\frac{\tilde{\theta}_1 + h}{2} = \frac{h}{2} + \underbrace{\frac{\beta^2}{2h(1-\alpha)}}_{additional\ productivity\ acquired\ by\ imitation} \tag{4-4}$$

where $\tilde{\theta}_1 = \frac{\beta}{1-\alpha}$.

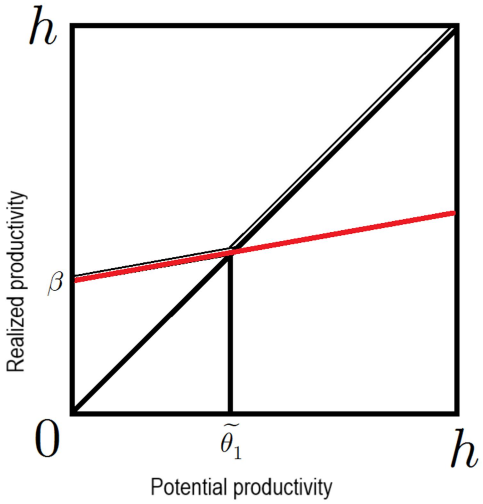

Figure 4-4: Productivity Frontier with Local Imitation

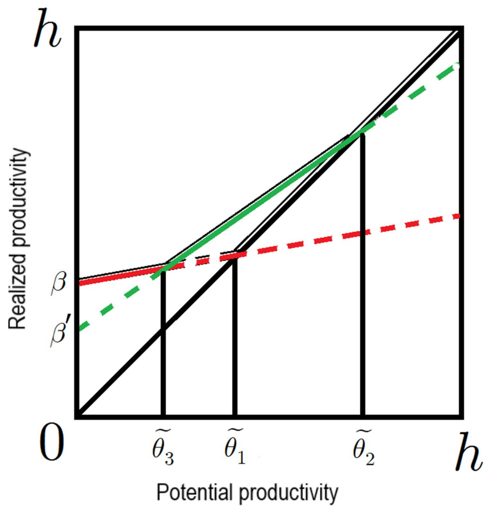

Figure 4-5: Productivity Frontier with Processing Trade

Note that additional productivity from imitation does not affect the maximum productivity $\widehat{\theta_{max}}$ directly. Now we introduce another imitation "processing trade". Every processing trade have a relationship with foreign affiliates. It is risky business compared with local imitations. Similar to the case for local imitation, we assume investor j who engaged in processing trade will get his outcome $\alpha'\theta_j + \beta'$ and the fixed outcome β' is smaller than β. We can expect that α' and β' is much related with outside of the country so those are set exogenously in the model. In Figure 4-5, the production frontier changed compared to Figure 4-4.

Hypothesis 1: The productivity level of processing firms reflected in the export basket will be higher than the local imitators but lower than local frontiers. In formula, $\beta' < \beta$ and $\alpha' < 1$.

Set $\tilde{\theta}_2 = \frac{\beta\prime}{1-\alpha\prime}$ and $\tilde{\theta}_3 = \frac{\beta'-\beta}{\alpha-\alpha'}$ then we can get expected productivity of an economy as following:

$$E(\hat{\theta}) = Prob(\theta_j \geq \tilde{\theta}_2)E(\hat{\theta}|\theta_j \geq \tilde{\theta}_2)$$

$$+ Prob(\theta_j \in [\tilde{\theta}_3, \tilde{\theta}_2))E(\hat{\theta}|\theta_j \in [\tilde{\theta}_3, \tilde{\theta}_2)) \quad (4\text{-}5)$$

$$+ Prob(\theta_j < \tilde{\theta}_3)E(\hat{\theta}|\theta_j < \tilde{\theta}_3)$$

$$E(\hat{\theta}) = \frac{\tilde{\theta}_3}{h}\frac{\beta + (\beta + \alpha\tilde{\theta}_3)}{2} + \frac{\tilde{\theta}_2 - \tilde{\theta}_3}{h}\frac{\alpha'(\tilde{\theta}_3 + \tilde{\theta}_2) + 2\beta'}{2}$$

$$+ \frac{h - \tilde{\theta}_2}{h}\frac{\tilde{\theta}_2 + h}{2}. \tag{4-6}$$

Substracting (4) from (6) gives the additional productivity from processing trade as following:

$$\frac{1}{2}\underbrace{\left((1-\alpha')\tilde{\theta}_3 - \beta'\right)}_{I}\underbrace{(\tilde{\theta}_1 - \tilde{\theta}_2)}_{II} \tag{4-7}$$

Notice term I and II are always negative by definitions. Thus, the model states that the additional (average) productivity gain from conducting processing trade depends on its size of leverage (I) and coverage (II).

Hypothesis 2: The share of processing trade decided leverage and coverage of processing trade. In other words, share of processing trade will be large if the level of productivity achievable by processing trade is relatively high or the productivity coverage of processing trade is wide.

Does processing trade not affect to the productivity of local firms? No, it is also possible by shifting β. Let $F(\hat{\theta})$ and $F'(\hat{\theta})$ be the cumulative distribution of $\hat{\theta}$ without / with processing trade, respectively. Then $F'(\hat{\theta})$ first-order stochastically dominates $F(\hat{\theta})$ as additional term (7) is non-zero. Thanks to the theorem of maximum of independent and identically distributed random variables, the cumulative distribution function of $\widehat{\theta_{max}}$ is a permutation of individual cumulative distributions. It suffices to state that expected maximum productivity $\widehat{\theta_{max}}$ with processing trade dominates the opposite case. Thus, productivity of local firms will be affected by processing trade especially in terms of catch-up.

Hypothesis 3: Experience of processing exports will facilitate the productivity catch-up of ordinary exports.

4.3 Empirics

4.3.1 Definition of PRODY and EXPY

We adopt an index called EXPY (Hausman et al., 2007) as a proxy variable for measuring average $\hat{\theta}$, a revealed productivity of a country. The underlying idea and construction of the index are as follows. We assume that rich countries export more sophisticated (productive) products than others. Each product can be ranked by average wealth of exporting countries. First, we construct a product-wise index by calculating average per-capita GDP of exporting countries. For a given commodity, a value-share of a country divided by the sum of value-share of all countries can represent a revealed comparative advantage[10] of the country in the commodity market. Weighted according to comparative advantage, we can calculate the average per-capita GDP by product, called PRODY. In a formula, it can be expressed as:

$$PRODY_i = \sum_c \left(\frac{x_{ic}/X_c}{\sum_c (\frac{x_{ic}}{X_c})} GDP_c \right) \quad (4\text{-}8)$$

where x_{ic}: export of good i of country c, X_c: total export of country c.

Now we define productivity level associated with the export variety of a country as:

$$EXPY_c = \sum_i \left(\frac{x_{ic}}{X_i} PRODY_i \right). \quad (4\text{-}9)$$

Typically, firms with high productivity export. In Hausman et al. (2007), EXPY is used as a proxy of $\widehat{\theta_{max}}$. We use as the proxy of $\hat{\theta}$. In our setting, every investor is exporter. Also productivity varies over firms and sectors.

I apply EXPY by trade regimes and subsectors. Since there is no discrimination of consumers' preference for the trade regime, we assume that each commodity has unique PRODY at the same time. By confining the range of EXPY, we can calculate an average productivity of processing or non-processing firms in a given sector.

4.3.2 Data and Methods

In this chapter, all trade data are based on the Harmonized System 6-digit level and a time span of 9 years between 2007 and 2015. The Harmonized System has been revised every four or five years by the World Customs Organization, and each revision follows different nomenclature systems. We combined data under the 3rd revision (2007-2011) and the 4th revision (2012-2015). Data with invalid nomenclature are eliminated to maintain the

[10] This is a bit different from the Revealed Comparative Advantage index proposed by Balassa (1965).

consistency of product codes across countries. The trade data for this study come from various sources. The first is UN COMTRADE. Trade data from China with trade regimes and types of enterprise are from China Customs. Since UN COMTRADE data is missing for Taiwan and Korea, I fill the gaps with data from Trade Map and Korea Customs. And data from Macau is deleted in the full set since it distorts PRODY and EXPY.

In using trade statistics, any trade flow is measured by the import and the export country. Choosing import statistics is more common for analyses because of the relation with tariffs. Nevertheless, I will use some export statistics together with import statistics to utilize the China trade statistics with extra information about trade regime and type of enterprise. To calculate PRODY and EXPY, along with trade data, real GDP per capita data from Penn World Table 9.0 database was used. All values of trade data were measured in current US dollars and GDP is PPP-adjusted at 2011 US dollars.

Classifications of trade statistics divide broadly into two categories: product- and industry-based. They have different origins and most trade statistics are product-based. Industry-based classifications are advantageous in analyzing interactions within industries. However, industry classifications such as the International Standard Industry Classification do not have a direct concordance to the Harmonized System. The Central Product Classification can bridge these two, but with many $n{:}n$ correlations. Therefore, I divide the modern sector into subsectors by using a product-based classification. Specifically, the first three digit codes of the Standard International Trade Classification revision 3 are considered as a subsector since they have roots in the Harmonized System, but are time-consistent over our time span. There are 262 subsectors in total and each subsector comprises 20 Harmonized System 6-digit products on average.

4.3.3 Static Analysis

Table 4-2 shows some descriptive statistics of EXPY. China's productivity level has been gradually increased, similar to the world mean[11]. When it comes to the relative position, the famous argument of Rodrik (2006), "China is special," still looks valid. Figure 4-6 shows

[11] The years between 2007 and 2012 have fewer observations due to data availability. In those years, a revision of the HS was newly enforced in the relevant countries. Adopting a new system entails a lack of time oc casionally since each country should change its own tariff lines conforming to the new HS. Thus, there is a syste matic bias caused by omission of low-income countries for those years.

China's high EXPY conditional on the income level. However, as in Xu and Lu (2009), the consideration of trade regimes alleviates deviation of China's EXPY from the conditional mean. The persistent gaps between processing and ordinary exports are observed. China exports more sophisticated products by processing exports. Also, between processing and ordinary exports, there is not a significant difference of shares in total exports.

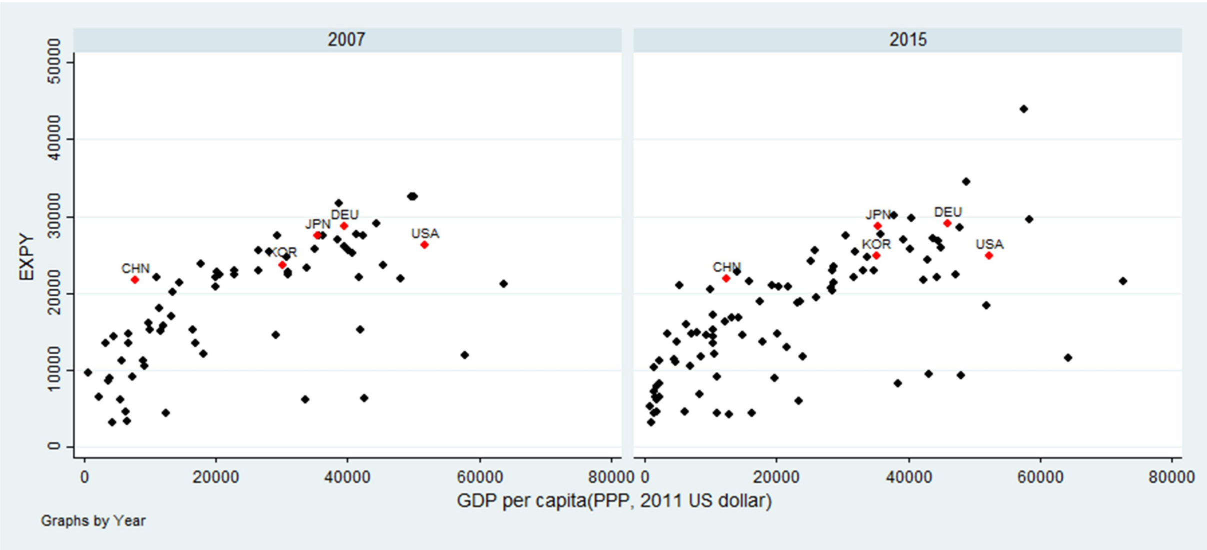

Figure 4-6: Position of Countries in GDP-EXPY distribution

Source: Author's calculation

Table 4-2: Descriptive Statistics of EXPY

World					China				Share of processing export (%)
Year	Mean *EXPY*[12]	Min *EXPY*	Max *EXPY*	Obs	EXPY: total export	EXPY: ordinary export (A)	EXPY: processing export (B)	Gap (B-A)	
2007	25,360	6,530	44,858	78	27,671	25,485	29,505	4,020	53.4
2008	20,355	4,924	42,196	111	25,187	23,415	27,097	3,682	50.5
2009	18,860	4,180	38,299	133	23,121	20,987	25,052	4,065	52.6
2010	17,899	2,150	39,345	139	23,815	21,727	25,808	4,081	50.7
2011	19,856	2,331	65,192	139	24,844	22,807	27,017	4,210	47.7
2012	25,239	11,431	46,066	96	27,696	26,020	29,226	3,206	46.6
2013	25,662	8,827	67,212	112	27,092	25,250	28,634	3,384	44.1
2014	24,203	6,674	72,871	122	27,276	25,869	28,631	2,762	42.4
2015	25,684	7,068	84,839	97	28,519	26,708	30,770	4,062	39.5

Source: Author's calculation

[12] Simple mathematics can prove the equivalence of Mean EXPY and MEAN GDP.

Share of processing trade in Figure 4-7 varies over industries and its distribution over EXPY is inversed U-shape. In other words, share of processing trade is low in the top and the bottom level goods. This supports our first hypothesis and Figure 4-5 which guesses processing trade will work for entrepreneurs with intermediate level of productivity.

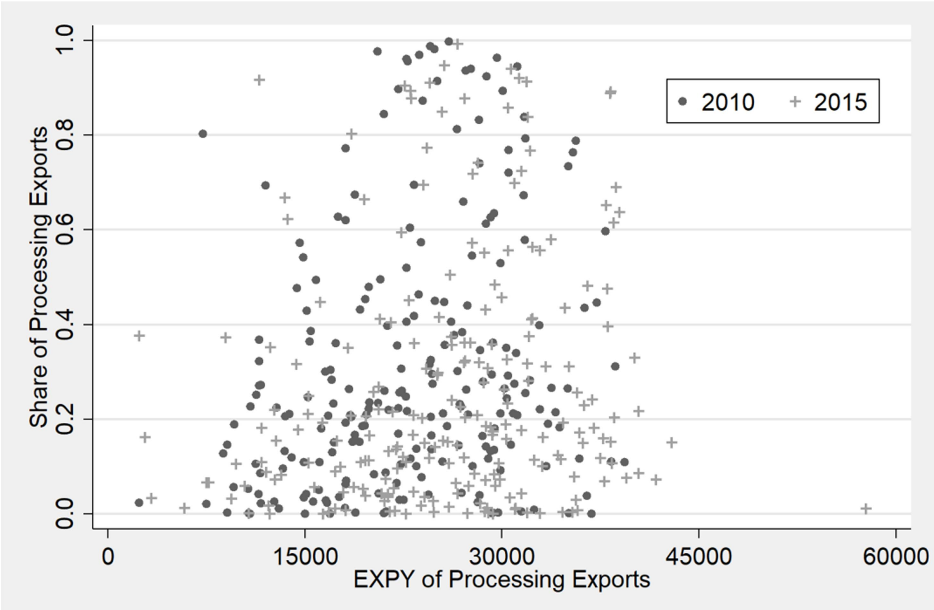

Figure 4-7: Share of Processing Export and EXPY

Source: Author's calculation

The competitiveness of a sector relates with productivity and capabilities. If non-processing firms in a sector are competitive, processing firms are likely to attain high productivity since they might access production factors more easily: skilled workers, quality intermediate goods, infrastructure, institutional supports, etc. But our second hypothesis claims a slightly different side.

The model predicts a low productivity of ordinary exports, far from the processing exports, will generate a leverage (or an incentive) of processing trade. Leverage and coverage are divided mathematically in the formula (4-7). But there is a positive correlation between two if we consider α' as a constant. Since a coverage is hard to measure, only EXPY ratio ($EXPY^{processing}/EXPY^{ordinary}$) is accounted to verify the second hypothesis. To control the overall productivity and related environments, sectoral EXPY and RCA of ordinary exports were included in regressions.

Table 4-3 shows regressions in which the share of and processing exports, is regressed on the ratio and other regressors. The table shows both OLS and FE results since Hausman tests point out a systematic difference in coefficients in all the regressions. Ratio enters with a positive coefficient that is statistically significant in all FE specifications. The estimated coefficient is distributed between 0.034 and 0.054. This result implies that there is a positive relationship between relative productivity of processing export and share of processing exports.

Table 4-3: Share of Processing Exports in Total Exports – OLS and FE estimates

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable : Share of processing exports in total exports					
	OLS	OLS	OLS	FE	FE	FE
Ratio	-0.021	-0.080	-0.025	0.034	0.052	0.045
	(0.66)	(2.59)**	(0.81)	(2.11)*	(3.52)**	(2.91)**
EXPY	0.152		0.140	-0.015		-0.018
	(8.60)**		(7.92)**	(1.19)		(1.48)
RCA		-0.012	-0.010		-0.062	-0.062
		(7.30)**	(6.49)**		(11.18)**	(11.21)**
Constant	-1.214	0.400	-1.065	0.413	0.344	0.529
	(6.45)**	(12.31)**	(5.67)**	(3.16)**	(19.88)**	(4.18)**
R^2	0.04	0.03	0.06	0.00	0.07	0.08
N	1,868	1,868	1,868	1,868	1,868	1,868

Source: Author's calculation, * p<0.05; ** p<0.01

Productivity of ordinary export is a significant factor only in OLS classifications. A high RCA or ordinary export was a negative factor in almost specification. Those observations imply that if China has a large export market for their ordinary exports, share of processing export will be relatively low. Their own level of productivity is less important to the processing export.

It is interesting to see that $EXPY$ turned out not to be that significant. Intuitively, a frontier ordinary exporter may shift the overall level of productivity. But in case of China, regional difference may hamper dispersion of cost discoveries.

4.3.4 What Has China Has Learned from Processing Trade?

By proving hypotheses 1 and 2, we show that the productivity of processing exports is systematically higher than that of ordinary exports. The gap is large when the productivity of ordinary exports is lower than the world average.

Hypothesis 3 addresses the learning effect from processing exports on ordinary exports. To test the hypothesis, we set $EXPY_t^{ordinary}$ as our dependent variable. All regressions include the lagged difference $EXPY_t^{processing} - EXPY_t^{ordinary}$ as a covariate. This difference can be interpreted a quality gap. If this quality gap positively affects the productivity of ordinary exports in dynamics, the higher productivity of processing firms transfers to other firms in the sector. Regressions selectively include lagged value of processing or ordinary exports, or both. These variables can be understood as measures of quantitative experience. We expect positive signs for all regressors. As our variables have an intrinsic autoregressive data generating process, we use GMM (Arellano Bond estimator) for panel regression. For a robustness check, we also conducted OLS and FE.

As expected, the productivity gap becomes significant in all regressions. Especially in the GMM setting, the size of coefficients is bigger than in the other regressions, suggesting that the higher productivity of processing exports is pulling the productivity of ordinary exports with a time lag. The quantitative variables of export experience are not consistently significant. The lagged value of processing exports is significant in OLS and fixed-effect setting, but not in GMM.

Table 4-4: China's productivity of ordinary export – OLS, FE, and GMM estimates

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable : China's EXPY of ordinary export						
	OLS	OLS	FE	FE	GMM	GMM
L(agged).	0.890	0.887	0.087	0.085	0.257	0.252
dependent	(72.31)**	(71.49)**	(3.28)**	(3.19)**	(2.22)*	(2.14)*
var.						
L.productivity	0.095	0.099	0.015	0.015	0.307	0.305
gap	(4.72)**	(4.88)**	(0.53)	(0.56)	(3.08)**	(3.06)**
L.processing	66.793	126.091	233.496	226.898	309.905	305.111
export	(2.15)*	(2.97)**	(2.16)*	(2.10)*	(0.89)	(0.88)
L.ordinary		-119.104		-198.345		22.301
export		(2.05)*		(1.17)		(0.05)
Constant	1,516.113	2,460.343	22,579.408	25,556.789		
	(3.03)**	(3.62)**	(14.55)**	(8.56)**		
R2	0.79	0.79	0.46	0.46	0.38	0.25
N	1,663	1,663	1,663	1,663	1,435	1,435

Source: Author's calculation, * p<0.05; ** p<0.01

4.4 Concluding Remarks

China's processing trade has led the sophistication of Chinese export, but there have been contrary views: the pros and the cons. Researches highlighting the positive aspects of processing trade indicate that processing trade actually improves productivity. On the other hand, studies suggesting negative implications point to low productivity of processing trade enterprises.

To give fair analysis the effect of China's processing trade on China's export development, this chapter introduces the elements of processing trade to the Hausman model and analyzes the effects of processing trade export on China's export structure.

First, the model theoretically reconciles contrary arguments about processing trade. Firms engaged in processing trade are not a pioneer. Since we cannot consider allocation of profit, their “real” productivity measured by value-added may be lower. However, their productivity measured by sophistication level of their exporting product is systemically higher than the others. If doing a processing trade better to the entrepreneurs in terms of productivity, processing trade will enhance overall productivity of the economy simultaneously.

Also, the empirical evidence supports the existence of learning effects. According to the analysis, processing trade entails a learning effect by changing the maximum productivity of a sector. Experiences of processing trade export in the previous period had a positive impact on the ordinary export.

Although many papers point out the low financial profitability of processing trade, processing firms indeed contribute productivity enhancement in the industry by knowledge spillover. Despite the rapid growth of labor costs, processing trade in China has maintained its volume. More than its volume, “what exports by which regime” is now important for making appropriate trade policies.

Chapter 5: Conclusion

This thesis is motivated by the question: how trade has been evolved in East Asia as an important factor of economic development? It is evident that a developing country cannot catch up developed economies without changing its production structure. The classical theory suggests that the changed production structure is reflexed in export structure. Therefore, it is important to analyze the development of the trade structure for tracking an economic development path.

The outline of the thesis is as follows. In order to see the direction of overall exports development, export diversification is analyzed first. Specifically, the patterns of export commodity and partner diversification of the three countries are examined. The sources of the diversification, intensive margins and extensive margins, are also decomposed. This decomposition does not give sufficient information about the direction of the change. Thus, the next chapter analyzed how the export structure of the country is similar to other countries. In this process, considerable limitations of existing similarity indexes found. To tackle the problem, a new generalized index is suggested. As a result, the theoretical development became the main content of the chapter. Finally, the role of processing trade on China's trade is presented in the next. Since China has attracted vast amount of FDI and processing exports account almost exports of high tech product, structural change of China may affected by processing trade. Thus, the role of processing trade on overall economy is examined both theoretically and empirically in the chapter.

The thesis has following three main objectives.

1. **Decompose the extent of export growth of East Asian countries**
2. **Develop a bilateral similarity index improving and generalizing existing concepts**
3. **Analysis the effect of China's processing trade on China's export development**

The result for the first objective suggests that the export growth of East Asian countries mainly driven by intensive margins. Countries have specialized export varieties and partners in general. In case of China, the number of trading partners has been increased and the portfolio also has been diversified. However, China fails to diversify its export structure to high income market. As for the second objective, I developed a generalized index and its effectiveness is demonstrated. By using the new concept of similarity, the duplicity of seemingly resembling export structures are re-examined considering quality of each product. The results support the persistent gap of export structure of countries. The last result shows the vital role of processing trade in China. Theoretically, allowing processing export shifts the productivity frontier of mid-productivity agents. Empirically, share of processing export in total export also high in products that requires mid-level of productivity. Learning effect of processing trade also examined. Processing export experience induces ordinary export.

This thesis may contribute to international trade literature. Theoretically, the thesis generalized existing similarity indices on international trade literature. The generalization is twofold: the explicit adoption of Minkowski parameter and consideration of quality heterogeneity. For the role of processing trade, the thesis extended the model of Hausman et al. (2007). The modified model diversified the result of imitation according to the productivity. Processing trade is added into the action set of entrepreneurs so that each agent has three possibilities after entering the market: imitation, pioneering, and processing trade in cooperation with a foreign affiliation. Empirical results may relate to economic development literature. Export growth path of the three countries and bilateral export structure similarity considering heterogeneous quality are examined. Role of processing trade is also empirically tested.

The remaining part of the conclusion chapter describes summary of findings, policy recommendations based on the results, and limitation and future research plan.

5.1 Summary of Findings

5.1.1 Summary of Chapter 2

A country can more easily diversify export portfolio of products in the importing countries that have similar income level of the exporter. One might think that China and Japan would diversify in various markets since they have plenty environments for production. However, the diversification pattern of export over product reflects economic development level of exporting countries.

Regional diversity pattern shows China’s exceptional diversification. But China still has a bit concentrated export structure in machinery which is the core sector of advanced countries in manufacturing. This phenomenon implies limitation of outside demand driven export growth of China.

The decomposition of the Theil index supports intensive margin as the key of export growth for China, Japan, and Korea. Utilization ratio over product-destination pairs bolsters China's rapid expansion of export markets. It turns out the actual contribution of new product-destination pairs to be very small even though a conservative concept is used.

Inside intensive margin of export, China also has shown high survival rate especially in developed markets. This reflects China has been on the path of high income market-oriented export evolution.

5.1.2 Summary of Chapter 3

Several similarity measures used Minkowski distance with parameter 1 without explicit justification. Depending on market structure and quality heterogeneity, a result regarding similarity of export, even any other economic concepts that can be applied, may mislead the interpretation. To tackle this problem, a generalized measure of similarity is given. As an example, the extended concept of similarity is applied to ESI and a simulation with various Minkowski parameters is given to verify usefulness of parameter. It shows Minkowski parameter can change the order of similarity among pairs and cautious choice is needed.

Heterogeneity in quality also accounted in the generalized parameter. For simplicity, a cumulative distribution from actual data has chosen to proxy relative quality of a country's export of given product. It is possible to alternate the methodology. Kernel density is a good candidate and digging the technology-quality curves may enhance the accuracy of analysis. There is no consideration of value-added due to the lack of data. A methodology combining trade data with value-added information will greatly enhance the comparison. Nevertheless, the generalized measure of similarity can be applied to any micro level data such as a firm level dataset.

5.1.3 Summary of Chapter 4

Processing trade in China has been prevalent, despite rapid economic growth and consequent structural changes. This study examines the role of the processing trade, especially as it relates to exports productivity and export variety. Our model predicts that high productivity of processing exports, which can be characterized by leverage and coverage, may enhance the productivity of the sector. An empirical analysis gives firm support to the model. It also shows a learning effect of processing exports to the productivity of ordinary exports.

5.2 Policy Implication: Export and Economic Development

China, Japan, and Korea implemented export-led economic development strategies in different times. Thus, analyzing export structure gives insight for evaluating the result of economic development strategies. The results of the thesis give policy evaluations of the three countries. Especially for Korea, I suggest some policy implications.

5.2.1 Export and Economic Development in China

First, the export structure of China can be characterized by 1) high level of export diversification, 2) low diversification of export items for high-income countries, and 3) high dependency of processing trade and technology learning through processing trade export.

Since the 1990s, when open door policy began to fully implied, China's exports have increased significantly. At that time, the government encouraged FDI inflow and processing trade as a package. Even though recent Five Year Plans (12^{th} and 13^{th}) does not support processing trade, the tax benefits for processing trade (customs tax exemption and VAT rebate) are continuing. Then, what did China gain through processing trade? First, it has improved average productivity of export. The thesis also theoretically demonstrated it in the same vein of Rodrik (2007). Companies that are engaged in processing trade are not very productive as opponents of processing trade insist. But, they are more productive than local imitators as they could adopt advanced foreign technology, and the results produced through processing trade are more sophisticated than when it was not.

In the long run, the experience of processing trade is transferred to ordinary trade. However, there is a limit to accepting new technology through processing trade. This is supported by the fact that China's export portfolio is concentrated on specific products to high income countries. On the other hand, China has diversified its regional export portfolio successfully except to high income countries. This can be interpreted as a result of high productivity achieved through export experience to high income countries, especially via processing trade.

5.2.2 Export and Economic Development in Japan

Japan’s export structure can be characterized by 1) concentration on major varieties and markets 2) high stability over the past 20 years. Exports only account for about 10% of Japan's GDP, which is lower than China or Korea. Thus it seems to be less significant to Japanese economy. But there are some implications as follows.

Low diversification level of exports indicates that Japan is concentrating on its main products and markets. As mentioned in Introduction, added values in exports are solely from Japan inside. This structure is advantageous for strengthening competitiveness of domestic industry, but it is vulnerable to domestic risks. However, in Japan, there are still many materials and component firms that serve as a middleman for the industry. Thus, to keep the export competitiveness, long-term R&D should be continued.

5.2.3 Export and Economic Development in Korea

In case of Korea, the export structure can be characterized by 1) low product and partner diversification and 2) low exports survival ratio. The low diversification can be understood as an intrinsic limitation of small economy. Diversification level was consistently related with the size of economy. Furthermore, China has diversified export items relatively easily through processing trade thanks to the relatively abundant labor forces. Low survival ratio is due to rack of product competitiveness or a low relational stability.

What are the policy implications from these observations? First, low product diversification of Korea is inevitable. In fact, the diversification of Korea is not that low compared with other successful small economies. Small economies tend to intensify the competitiveness of their main industry to reduce the risk due to the lack of diversity. In case of Korea, there are several major sectors like semiconductor, chemical, steel, automobile and shipbuilding. However, still it is hard to rebalancing industrial structure since each sector substantially contributes to the economy, especially to the employment side.

This problem cannot be solved without strengthening service sector. Although the employment of service industry accounts more than 70 percent of the total employment, nominal contribution to the GDP is less than 60 percent. This imbalance hinders labor mobility between manufacturing and service sector. Thus, reinforcing competitiveness of service sector should take precedence over the others.

To maintain comparative advantage in manufacturing sector, diversification of existing products is needed. For example, currently Korea has enough competitiveness in automobile manufacturing. However, very limited segments availability binds its growth in the world market. This limitation is due to high dependency of the mid-stream firms. Thus, both demand and supply firms need to diversify their trade portfolios to activate production ecosystem.

The low survival rate of export is related with the low diversity of export. Generally, exports tend to be path dependent due to the high sunk cost. In order to diversify exports in the long run, the survival rate of new export product should be high. Actually, the low export diversity is the result, and its cause is the low survival rate of new export. Then, how can we improve survival rate? Current export structure is star-dependent. Exports are concentrated on major corporations and items, and exports of the others are poor in survival rate and share. However, as of the 2010s, Korea's SME export policy is considered to be comprehensive and effective. Thus, the low export survival rate can be understood as a result of the low competitiveness of SMEs (in a comprehensive sense). In order to solve this problem, it is necessary to establish a culture that encourages start-up.

On the other hand, regional diversification of exports is considered to be a somewhat feasible policy goal. The results of the utilization ratio analysis indicate that Korea still has potential new export ties. Diversification of exports may reduce the economic risk of exports and it needs to be encouraged through various measures such as RTAs.

China has been chasing after processing trade. Japan is leading the world in fields such as materials and machinery based on basic science and technology. Korea cannot implement a strategy similar to China or Japan. Japan is concentrating on characterization based on accumulated technology.

Korea's industrial policy is not as strong as before. The role has to change as the age changes. It should aim at coordinating the entire industrial ecosystem rather than fostering a specific industry or enterprise. For example, the authority may act as coordinators to prevent companies from making excessive investments that seek short-term profits. Reducing friction costs and adjustment costs is also an important government role.

5.3 Limitations and Future Research

Due to the data availability, only annul trade data is used over the thesis. Especially, the survival analysis conducted in chapter 2 can be extended with more frequent dataset and it will give more accurate estimates of hazard function. Also, China and Japan are quite huge economy which can be dissected into regions. All analyses in chapter 2 can be more robust by using regional data.

In chapter 3, the variation of Minkowski distance is extensively described. However, the economical meaning of Minkowski distance which relates the economic understanding of L_p space should be added as a future research. If one can find a sector that showing a dramatic change of similarity indexes by choosing the parameter, it will be helpful. Also, it observed that specific standardization and distribution function preserve the order of similarity. Mathematical property, such as axiomatic approach, of similarity indexes are still not given and will be worthy if one finds.

For measuring the heterogeneity in quality, a cumulative distribution from actual data has chosen to proxy relative quality of a country's export of given product. It is possible to alternate the methodology. Kernel density is a good candidate and digging the technology-quality curves may enhance the accuracy of analysis. There is no consideration of value-added due to the lack of data. A methodology combining trade data with value-added information will greatly enhance the comparison.

Chapter 4 deals processing trade of China. Recently, some Chinese scholars research with micro level dataset which generated by matching micro trade data and firm activity data. By using more detailed data will guarantee the reliability of analysis. Also, due to the length of data, Allerano-Bond estimation is used and but showed a less significant result. Other appropriate control variables or instrumental variables can enforce the regression results.

A.Data Appendix

Trade statistics

Trade statistics data is mainly comes from UN COMTRADE database which is a public database. In many countries, trade statistics are collected by customs with product base. WCO (World Customs Organization) controls the product classification for customs and trade statistics. Since 1992, HS (Harmonized System) is the standard replacing SITC (Standard International Trade Classification). HS is a hierarchical classification having 4 levels: section, chapter, heading, and sub-heading. In the thesis, most of the empirical analysis work was done using sub-heading data which provides most disaggregated information.

HS also called as a nomenclature since WCO regularly revise their HS system. From 1992 (provisional from 1988), they revised HS system in 1996, 2002, 2007, 2012, and most recently 2017. The reason of changing can be summarized into two: the emergence of new products, the death of existing products. For example, recent emergence of environment friendly automobiles is reflected in HS 2017. There are new detailed sub-heading codes for electronic automobiles that were classified as other automobiles under a single sub-heading.

Countries compile trade statistics complying HS system but in more detailed level. For example, Korea uses HSK (HS of Korea) consists of 10 digits while Japan uses only 9 digits. China and the U.S. use system with 10 digits. However, each country authoritatively defines their detailed system which called "national tariff lines" since the decisions directly related with tariff and customs tax income of countries. Thus, there is no correlation among codes with a same digit. Due to this limitation, considering sub-heading level HS data is the best choice for analyzing disaggregated dataset.

Although countries should be on the same line of the HS system, there are exceptions. First, countries alike the U.S. has many non-HS codes under the chapter 99. Since WCO cannot regulate detailed activities, there are many non-HS codes specially designed for the importing countries. We cannot capture those kinds of trade and to eliminate this uncertainty, I dropped the supercode "999999" which includes all the non-regular HS codes.

Table: Value and share of super-code (value in billion dollars)

country	2000		2005		2010		2015	
	value	ratio	value	ratio	value	ratio	value	ratio
China	2.2	0.5%	3.6	0.3%	19.9	0.7%	7.6	0.2%
Japan	22.4	2.6%	34.0	3.1%	52.0	3.6%	47.7	3.8%
Korea	0.0	0.0%	0.0	0.0%	0.1	0.0%	0.1	0.0%

Source: Author's calculation from UN COMTRADE

Conversion of trade statistics

There is a conversion issue in using historical trade data. In most cases in the thesis, I do not used converted data. For example, in case I can divide periods appropriately, I used different nomenclatures for comparison. UN COMTRADE provides converted dataset for a longer time series analysis. However, the conversion is conducted based on the worldwide level ignoring specific structure of each country. Thus I constructed converted dataset concerning the characteristics of country. Following is the detailed methodology of my conversion inspired from Schott (2011).

Let assume there exist M, a set of nomenclatures. In case of HS, each revision can be denoted as a integer so that $M = \{0,1,2,3,4,5\}$ and $\#(M) = 6$. But, I set $M = \{0,1,2,3,4\}$ since there is no available annual trade data complying the 5th revision. Each nomenclature is valid for a distinct continuous period which starts from the January 1st and ends in the December 31st. A year h^m is the first year the nomenclature m is used[13]. Similarly, a year t^m is the last year for the nomenclature m. Let x_{ij}^{t} be the volume of product i exported by country j at time t. Notice that $x_{ij}^{h^m}$ and $x_{ij}^{t^{m-1}}$ shares same notation for product. However i may indicate different product since nomenclature is different.

Now, by using trade data in year h^m and t^{m-1} combining full correlation information from m to $m-1$, one can get a detailed conversion. There are four cases of correlation. 1) 1:1, 2) n:1, 3) 1:n, 4) n:n. As every conversion is conducted from a new one to the old one, the case 1) and 2) are trivial cases. In case of 3), product i under the

[13] The period can be set differently. If continuity is the first concern, a short period is preferred. However, for the stability, a long period-even all years in a nomenclature can be included.

nomenclature m has multiple counterparts $C_i^{h^m} = \{i^1, i^2, \dots, i^K\}$. Naturally, a new product i should be divided by relative trade volume of i^k. The last case is more complex but the same logic can be applied. Firstly, group new codes that are connected in the bipartite correlation graph. This grouping also includes product codes in a nomenclature that are not related directly to a same product in the other nomenclature. The grouping automatically works for the old codes. After a grouping, remove n:1 and 1:n relationships. Then remaining codes has n:n relationships. Now a new product i is correlated with a number of product. In this case, also relative trade volume of the old code is used. Because when I convert a trade dataset with a new code and weights of the new code automatically applied. Therefore, the conversion should be started from the last available nomenclature to the backward direction.

Factor endowments, transport costs

In chapter 3, Physical capital, human capital, and natural resource (land) are considered as endowments and relative abundance were included as independent variables to determine diversification level measured by the Theil index which used in chapter 2. Also, Transport costs can be measured by traditional variables such as distance between countries, border contiguity, use of common (official) language, and so on.

To test the role of factor endowments and similarity in diversification, data from various sources were used. Data availability on disaggregated export at HS sub-heading level gives a panel of 130 trading partners between 1996 and 2010. Data from 2011 dropped due to the human capital data. Trade data comes from UN COMTRADE. To calculate similarity with consideration of quality heterogeneity, I dropped data without valid quantity information.

As in Regolo (2013), real capital stock per worker, K/L, from Penn World Table (9.0) is considered as a proxy of physical capital endowment. Relative abundance of human capital, H/L, is measured by average years of schooling provided by Barro and Lee (2013). Arable land per person from World Bank (WDI) takes into account for measuring natural resource endowment (T/L). Variables about transport costs are from CEPII(Centre d'Etudes Prospectives et d'Informations Internationales) which is the most common source for gravity based models. $dist_{ij}$ is the logged value of the distance between the main cities of country i and j. $contig_{ij}$ is 1 only if country i and j share the same border and 0 otherwise. $comlang_{ij}$ is also 1 only if country i and j share an official language and 0 otherwise.

B. Additional Figures

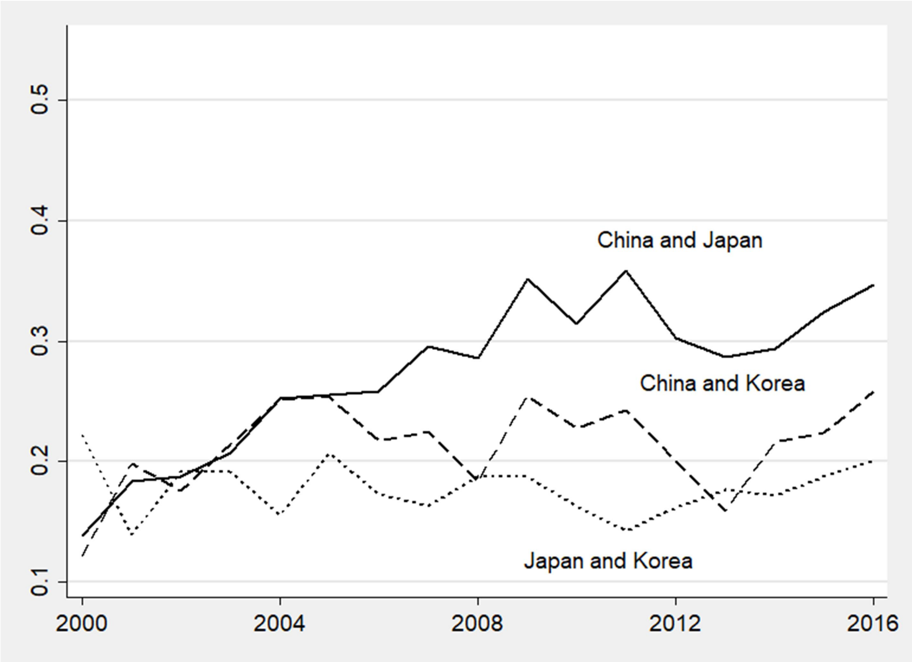

Figure B-1: Export Similarity of China, Japan, and Korea in Manufacturing with Consideration of Price Heterogeneity

Source: Author's calculation from UN COMTRADE

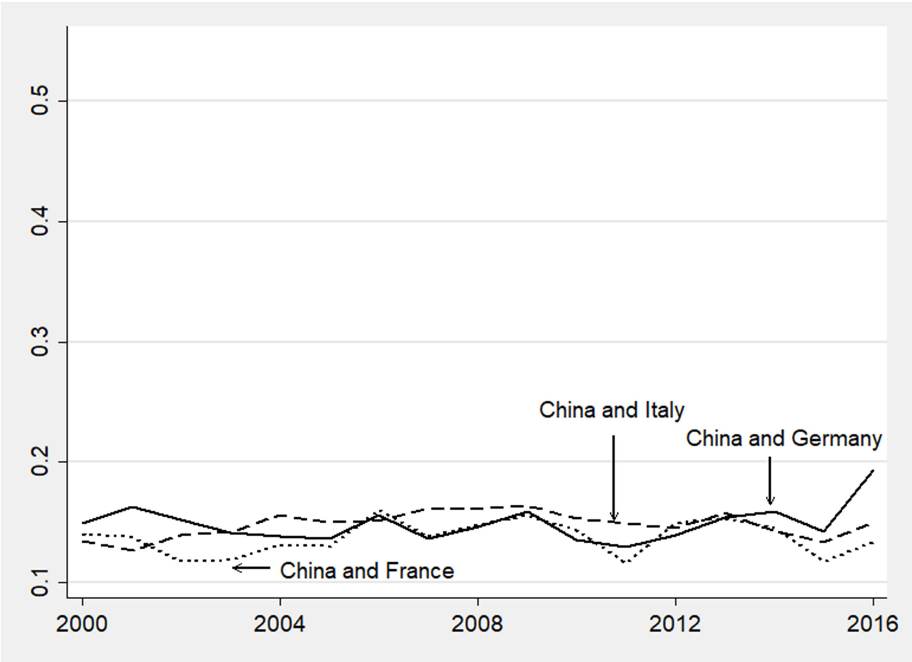

Figure B-2: Export Similarity of China and Selected Countries in Manufacturing with Consideration of Price Heterogeneity

Source: Author's calculation from UN COMTRADE

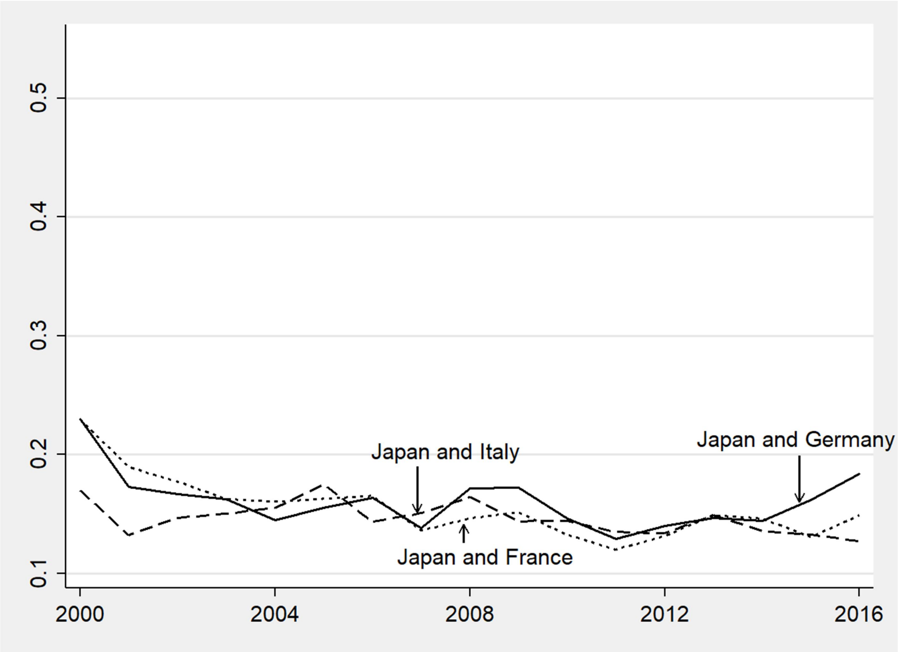

Figure B-3: Export Similarity of Japan and Selected Countries in Manufacturing with Consideration of Price Heterogeneity

Source: Author's calculation from UN COMTRADE

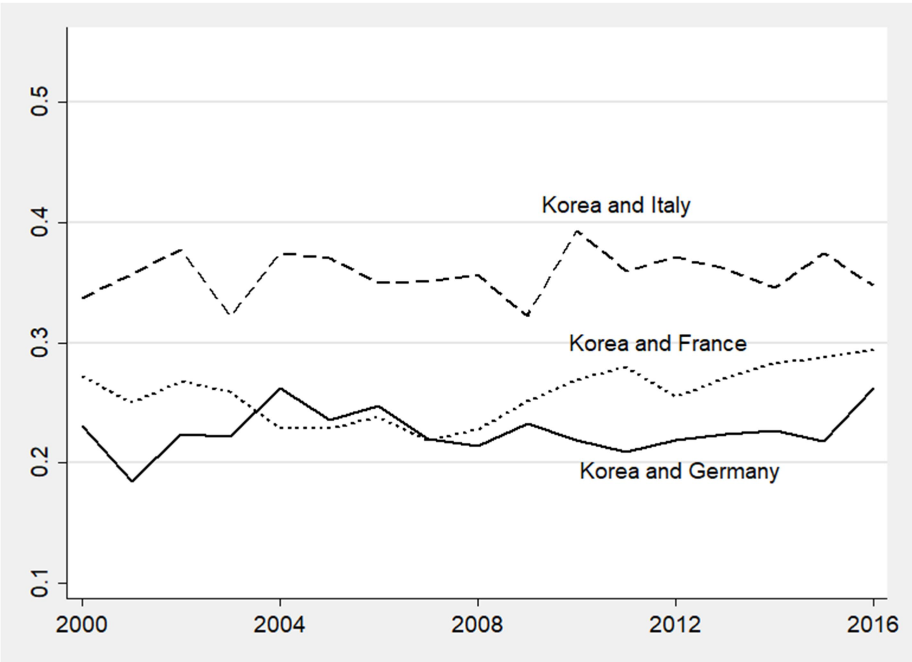

Figure B-4: Export Similarity of Korea and Selected Countries in Manufacturing with Consideration of Price Heterogeneity

Source: Author's calculation from UN COMTRADE

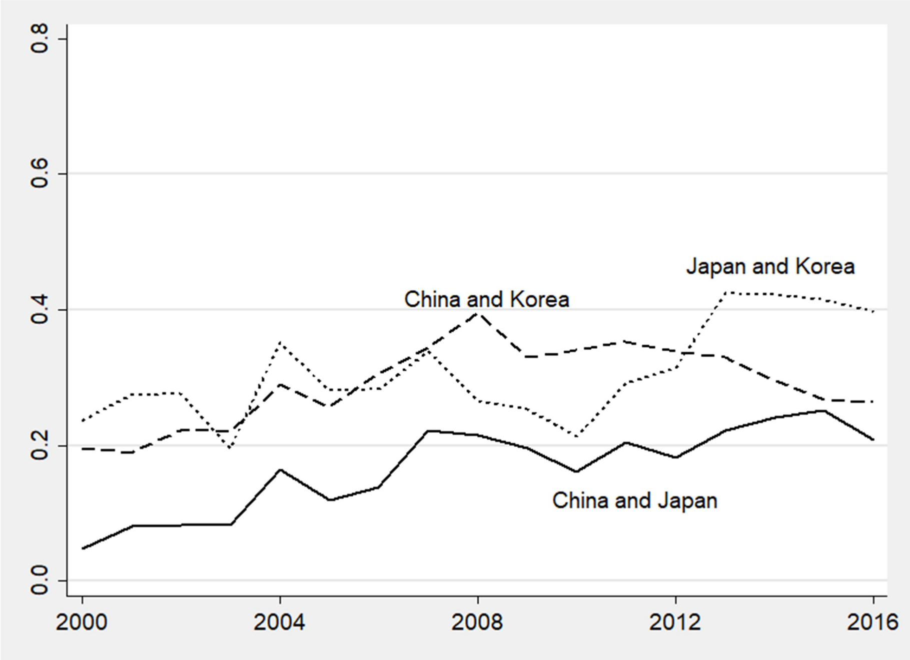

Figure B-5: Export Similarity of China, Japan and Korea in Automobile with Consideration of Price Heterogeneity

Source: Author's calculation from UN COMTRADE

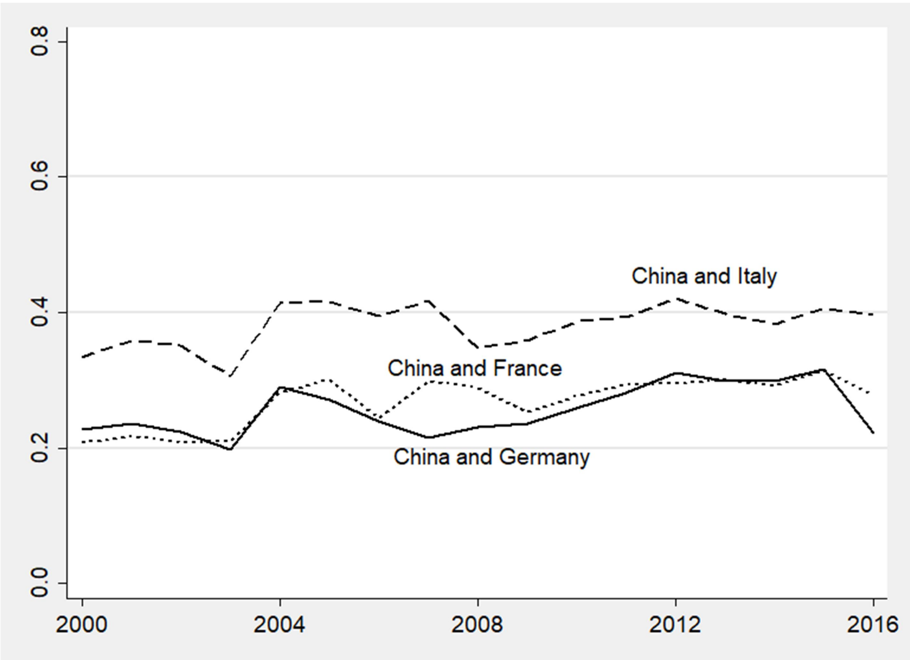

Figure B-6: Export Similarity of China and Selected Countries in Automobile with Consideration of Price Heterogeneity

Source: Author's calculation from UN COMTRADE

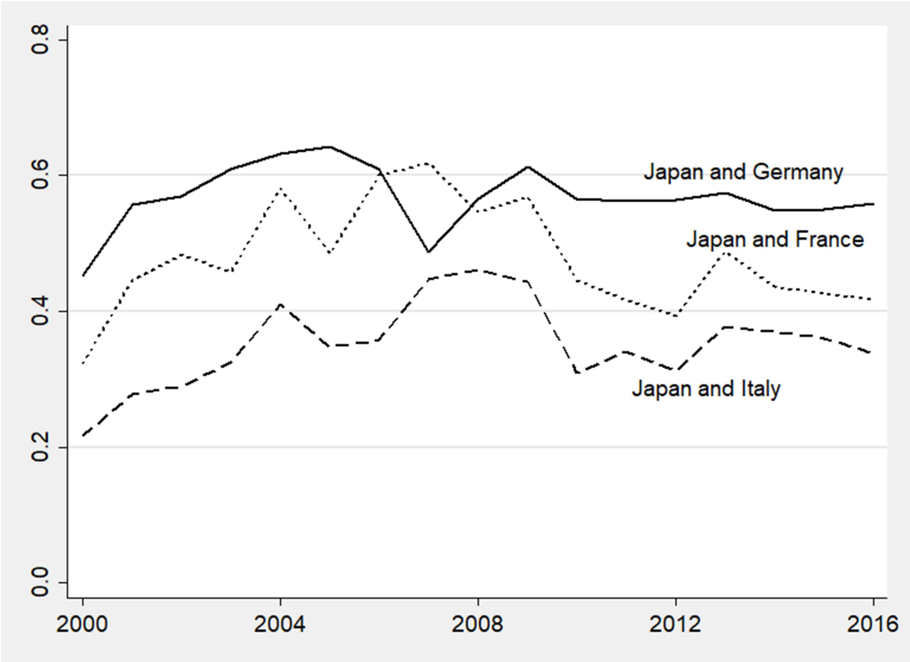

Figure B-7: Export Similarity of Japan and Selected Countries in Automobile with Consideration of Price Heterogeneity

Source: Author's calculation from UN COMTRADE

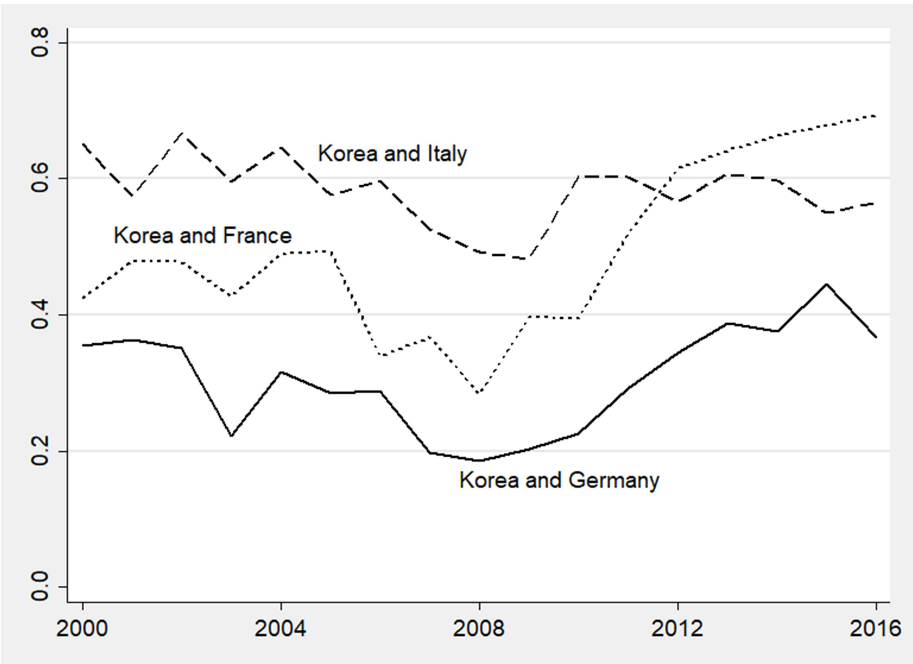

Figure B-8: Export Similarity of Korea and Selected Countries in Automobile with Consideration of Price Heterogeneity

Source: Author's calculation from UN COMTRADE

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