Technological Intensity and Export Specialization in Asia: A Comparative Analysis of Japan, Korea, China and Taiwan

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Abstract This paper examined structural changes in export specialization of Japan, South Korea, Taiwan, and China at different levels of technological intensity. The study found significant differences across these Asian economies, with most pronounced changes for exports with high technological intensity. To account for the changing export specialization, the study applied the classical Ricardian model of comparative advantages to export patterns of Japan and South Korea. We found that the export specialization of Japan was mainly determined by differences in fixed effects across industrial sectors, with changes in relative labor productivity much less important. In contrast, changes in productivity turned out an essential factor for explaining the recent export specialization of South Korea.

Keywords Technological intensity • Asia • Regression Models • OECD Classification • Manufacturing Industries • Export

Introduction

Japan is often considered a country with high technological intensity of its exports. For example, Figure 1 shows that machinery and transport equipment accounted for 59.6 percent of total Japanese exports in 2010 (United Nations 2011). However, a longer time perspective shows substantial changes in the technological intensity of the Japanese exports pattern. First, the shape has been declining since 1994, when it reached its historical maximum of 72 percent. Moreover, many Asian countries have been rapidly catching up with Japan in the technological intensity of their exports. Figure 1 shows an example of South Korea, where the share of machinery and transport equipment almost reached the Japan's level in 2010, even though the share was less than 20 percent in the mid-1970s.

This paper examines in more details recent changes in export specialization of Japan, with particular attention to exports that have relatively high technological intensity. In particular, this paper compares the export specialization of Japan with three other Asian economies: South Korea, China and Taiwan. All of these economies have challenged in recent years Japan's domination in export markets of goods that have high technological intensity. For this analysis, the paper applies an industry classification of Organization of Economic Cooperation and Development (OECD), that identified 4 major groups of manufacturing sectors with different levels of technological intensity, namely: high, medium-high, medium-low, and low technological content.

Several studies previously provided evidence that Japan had been losing its competitive advantage in exports with high technological intensity. Pilat et al. (2006) examined the export performance of OECD members, and found that Japan have lost its leading positions in exports of high-technology industries (p. 21). A similar evidence was subsequently reported by OECD (2009), and Figures 2 and 3 summarize most noteworthy findings of the OECD study. In particular, Figure 2 shows that Japan had the largest export share for the combined share of industries with high- and medium-high technology. But a careful look at the figure shows that the result was due to Japan's relatively large export share of medium-high technology; in terms of high-tech industries, Japanese export specialization was not very high, and in fact did not exceed the OECD average. In contrast, the share of high-tech industries in Korea was among the largest among OECD countries. Figure 3 pro-

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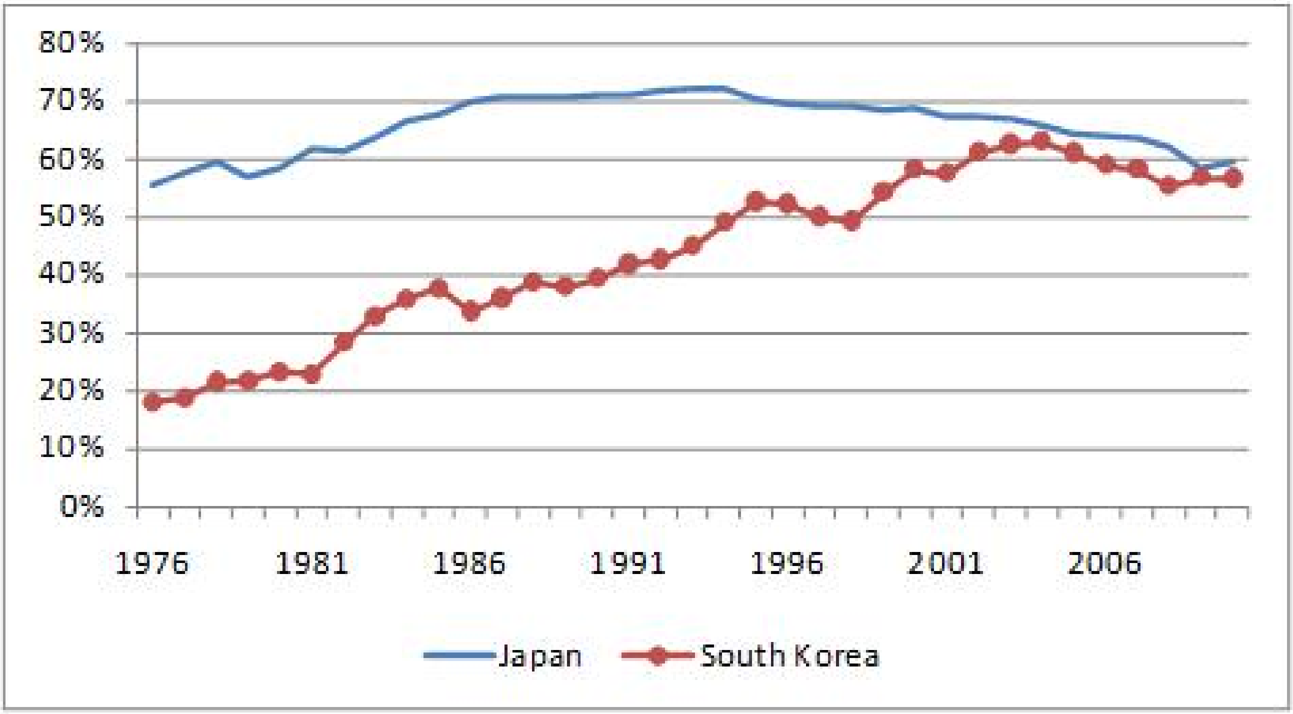
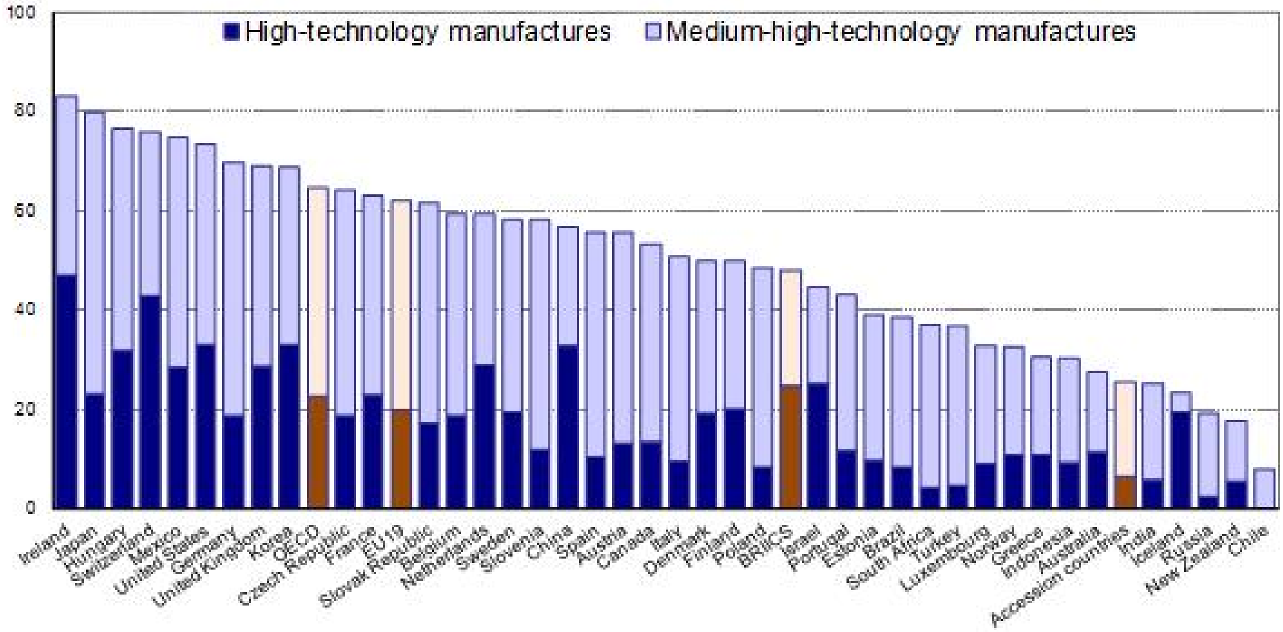
vides additional evidence on recent changes in export specialization of 40 major exporting countries in high- and medium-high technology exports during 1997-2007. The growth of Japan's high-tech exports was the lowest among these 40 countries, with just 2 percent annual growth. In contrast, high-tech exports in South Korea and China were expanding by 29 and 18 percent respectively, with China producing the fourth fastest growth among 40 countries.



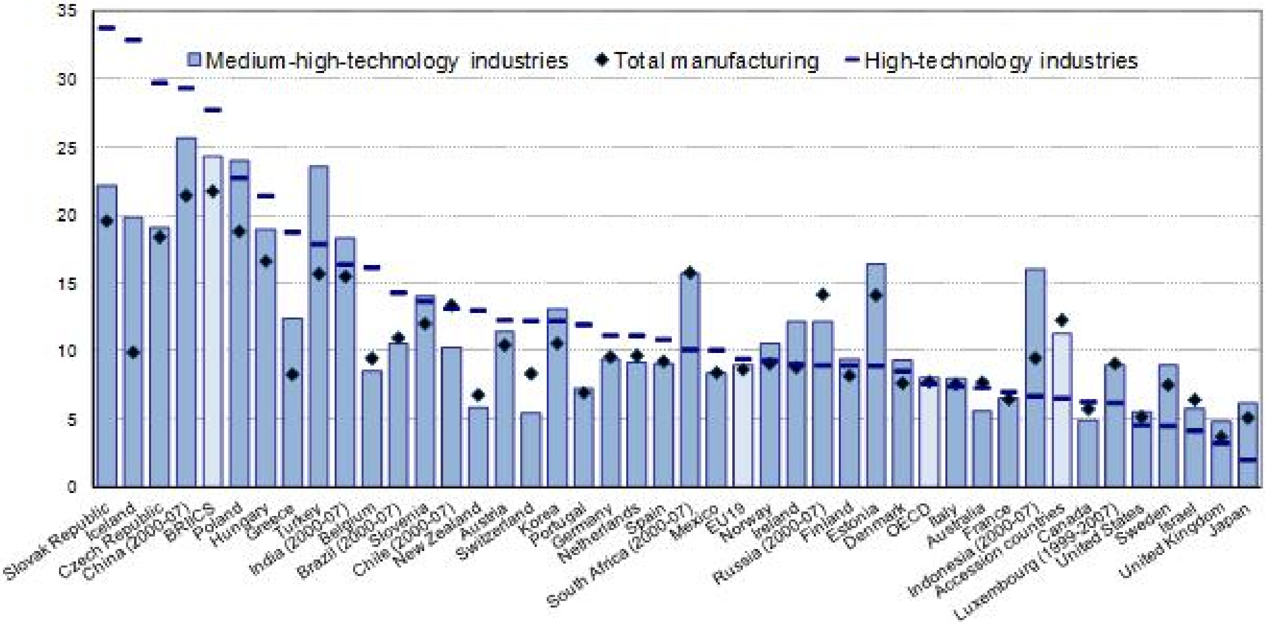
Source: COMTRADE database, United Nations (2011)

Fig. 1 The share of machinery and transport equipment in total exports



Source: OECD (2009)

Fig. 2 Share of high-and medium-high-technology in total exports (2007, %)



Source: OECD (2009)

Fig. 3 Average growth of high-and medium-high-technology exports, 1997-2007 (%)

Compared with previous literature, the study makes two contributions. First, we explores in more details differences in the performance of four major exporting economies in Asia, and provide additional evidence that Japan is losing its lead in high-tech exports, while South Korea, China and Taiwan are have been rapidly catching up, and in fact surpassed Japan in the share of high-tech exports. Second, the paper provides a conceptual explanation for these changes in export specialization. Using the classical Ricardian theory of comparative advantage, the paper analyzes whether changes in labor productivity may account for these recent changes in export specialization, and provides evidence that labor productivity did not have the same impact on determining the export specialization of Asian economies.

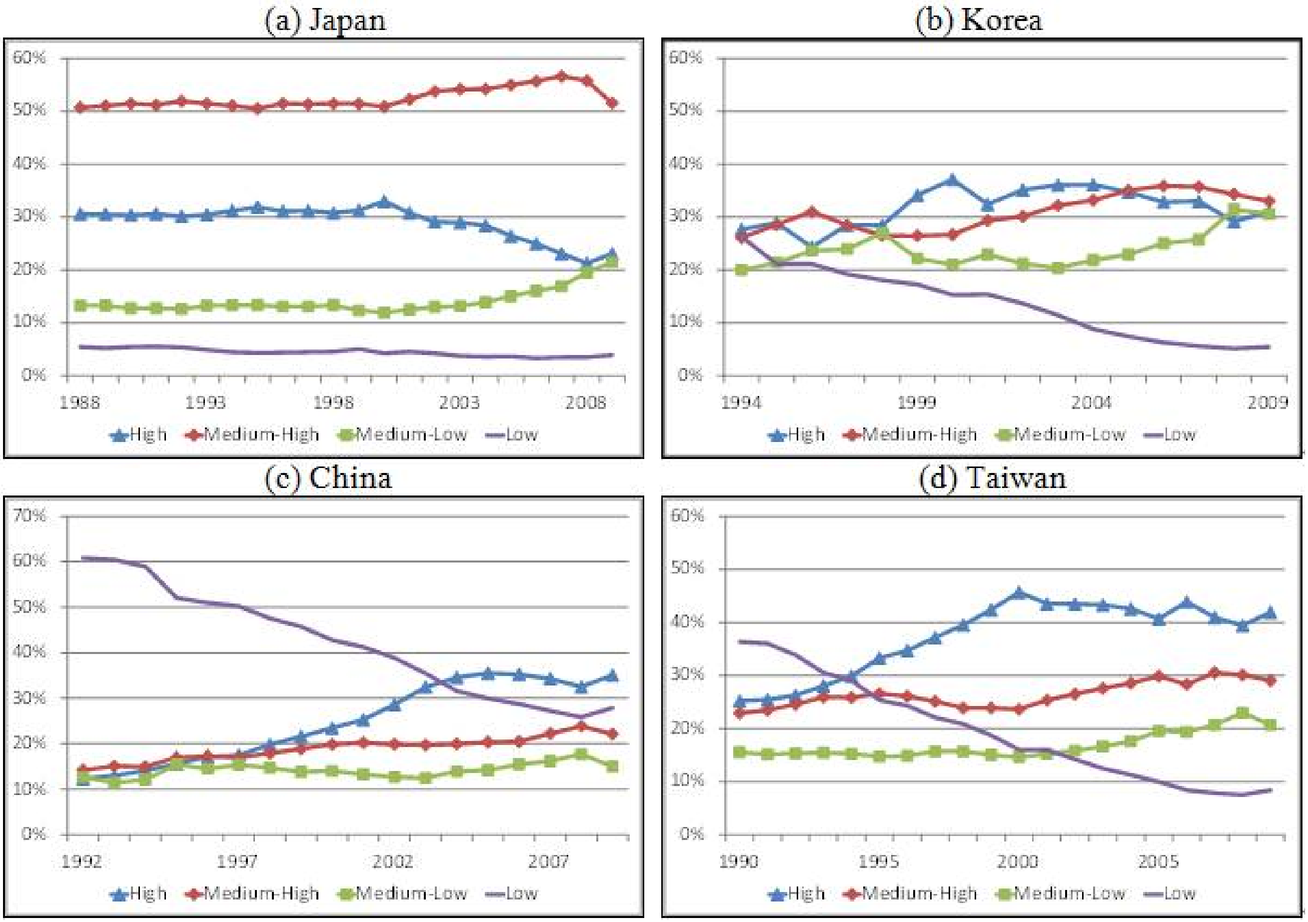
Complete data for export shares and relative labor productivity are available only for Japan and South Korea, but even this reduced sample of countries provided sufficient evidence that dynamic changes in labor productivity were much more important in South Korea, while fixed factors over the study period played the most important role in Japan. Overall, we found that Japanese export specialization remained little changed since the mid-1990s, with a prominent role played by medium-high sectors, while high-tech sectors were losing their share of export markets. In contrast, the export specialization of South Korea, China and Taiwan stated from relatively low technological level in the early 1990s, but went through a rapid transformation, with high-tech sectors quickly gaining top positions in the export specialization of these countries.

Sectoral Classification and Data Sources

In this paper we used a standard OECD classification (Hatzichronoglou 1997) that divides manufacturing sectors into four groups, with different levels of technological intensity (high, medium-high, medium-low, and low). Table 1 provides more details about the composition of these four groups. In particular, high-tech sectors comprise not just any kind of machinery and transportation equipment, but only computers, TV, communication equipment, precision equipment and aircraft, while motor vehicles are classified only to medium-high technology. On the other hand, the composition of industries with low technological intensity includes sectors with clearly limited technological requirements (such as food, textile, wood and paper products). Data for this study were taken from two sectoral debases, compiled by OECD: STAN Indicators database (OECD 2012a) and STAN Bilateral Trade Database (OECD 2012b). While the first database covers only OECD member countries, the second database contains comparable trade flows for much larger sample of countries, including China and Taiwan.

Recent Changes in Export Specialization by The Level of Technological Intensity

Using the OECD technology classification in Table 1, we calculated export shares of high-medium-high, medium-low, and low sectors in Japan, South Korea, China and Taiwan. As shown in Panel (a) of Figure 4, Japan traditionally had the highest share of medium-high exports, and the share stayed mostly constant over time (at about 50 percent of Japanese exports). The share of high-tech exports was also relatively stable at 30 percent, but started to decline since the late 1990s, and dropped to 20 percent of Japanese exports in recent years. The declining share of high-tech exports was compensated by increased share of medium-low exports, with both sectors converging in recent years. Finally, the low-tech exports of Japan did not change over time, and stayed close to about 5 percent of total exports.



Source: author's calculation, using STAN database (OECD 2012)

Fig. 4 Export shares by technological intensity

In contrast, the export specialization of South Korea went through much more radical changes during 1994-2009 (Panel (b) of Figure 4). Most notably, the share of low-tech exports dropped from almost 30 percent to only 6 percent, and the level became not much different from the corresponding share in Japan. Conversely, high-tech exports have rose to 32 percent, and have surpassed the share of exports with medium-high and medium-low technological intensity, with each of these three categories accounting for about 30 percent of the total exports.

The drop in the export share of low-tech sectors was even more rapid in China (shown in Panel (c) of Figure 4), where it dropped from 60 to less than 30 percent during 1992-2009. Similarly to South Korea, high-tech sectors have gained in recent years the largest share of Chinese exports, with relatively less significant changes in the share of medium-high and medium-low exports.

Finally, changes of export specialization of Taiwan were to a large degree very similar to South Korea and China (Panel (d) of Figure 4). In the early 1990s, low-tech exports accounted for the largest share of Taiwan exports (at around 36 percent). In subsequent years, the share of this sector dropped steeply to only 10 percent, which is once again very close to the traditional level for Japan. On the other hand, the share of high-tech exports rose particularly quickly in the 1990s. It exceeded 40 percent in 2001, and stayed close to this level in subsequent years.

Table 1 OECD Classification of Manufacturing Industries based on Technology

High-technology Industries
• Aircraft and spacecraft • Pharmaceuticals • Office, accounting and computing machinery • Radio, TV and communications equipment • Medical, precision and optical instruments
Medium-high Technology Industries
• Electrical machinery and apparatus • Motor vehicles, trailers and semitrailers • Chemicals excluding pharmaceuticals • Railroad equipment and transport equip • Machinery and equipment
Medium-low Technology Industries
• Building and repairing of ships and boats • Rubber and plastics products • Coke, petroleum products and nuclear fuel • Other non-metallic mineral products • Basic metals and fabricated metal products
Low-technology Industries
• Other manufacturing • Wood, pulp, paper, paper products • Food products, beverages and tobacco • Textiles, textile products, leather and footwear

Figure 5 contrasts changes in exports shares of high-tech industries in Japan, South Korea, China and Taiwan. The most notable change is the decline in the relative standing of Japan. In the early 1990s, Japan had the largest share of high-tech exports, at around 30 percent. In more recent years, the Japan's share declined to around 20 percent, while it rose to 30 percent of total exports in South Korea and China, and exceeded 40 percent in Taiwan. Overall, Japan turned from the leader in high-tech exports to the laggard among 4 economies over a relatively short period of time. In the remaining part of this paper we will examine possible causes of this rapid transformation in the export specialization of Japan and South Korea.

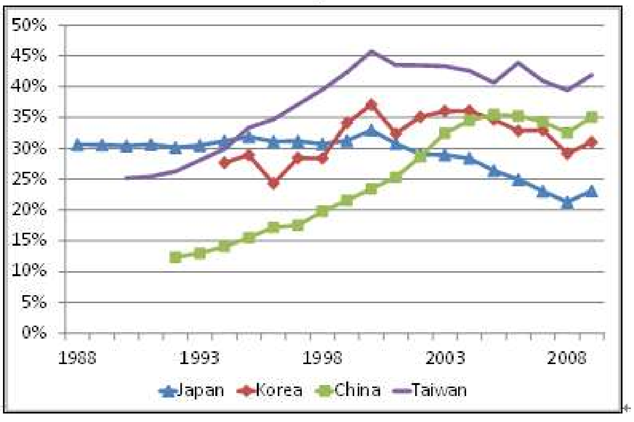


Fig. 5 Export shares by technological intensity

Regression Models

This paper considers the changes in relative labor productivity as a source of varying export specialization over time. Data for both trade and productivity are available for Japan and South Korea, with respective sample periods 1988-2009 and 1994-2009. Manufacturing sectors were aggregated in 4 groups with different technological intensity (as classified in Table 1). labor productivity for each of these groups was calculated as a relative index, with respect to the productivity of the total manufacturing sector. In consequence, sectors with relatively high productivity levels have indices in excess of unity. Changes in this productivity index for Japan and South Korea are shown in Figure 6.

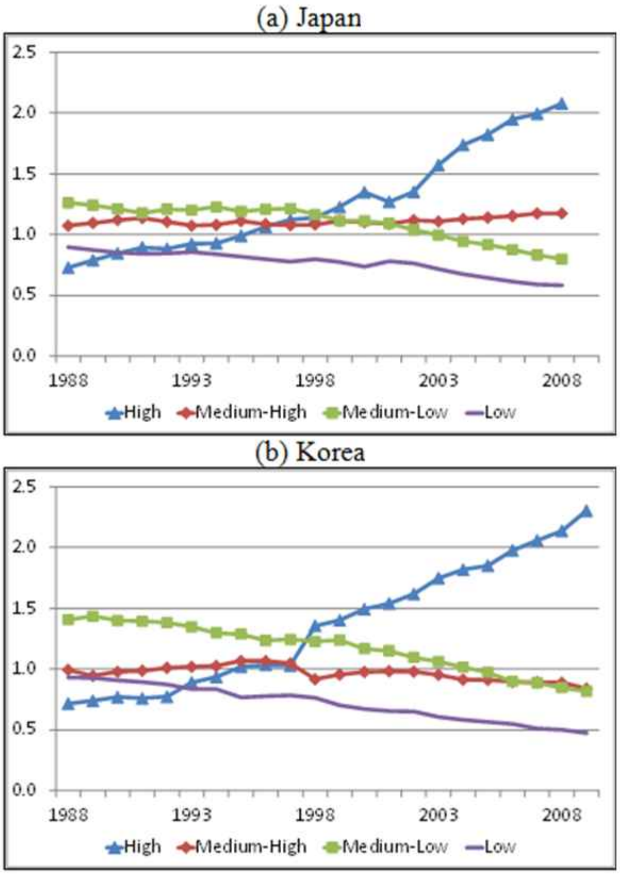


Fig. 6 Relative labor productivity by sector (total manufacturing=1)

For both countries, sectors with low technological intensity consistently had productivity much less than the productivity of the total manufacturing. Moreover, the relative productivity of this sector declined over time, especially in South Korea, where it reached 0.5 in recent years. In contrast, the relative productivity of high-tech sector was increasing in both countries, and became more than twice as large as in the total manufacturing. The relative productivity advantage for high-tech sector became particularly evident in recent years. On the other hand, the productivity of medium-high technological sector stayed close to the level for the total manufacturing, while medium-low technological sector experienced a modest decrease in relative productivity, especially in South Korea.

The analysis in this paper examined how much the export specialization in Japan and South Korea changed in response to the variation in relative labor productivity. In Model 1, export share for *i*th manufacturing sector (*i*=1, ..., 4) depended only on the relative productivity level of this manufacturing sector:

$$Export\ share_{i,t} = \beta_0 + \beta_1 LP_{i,t} + \varepsilon \quad (1)$$

with β_0 and β_1 denoting regression parameters, $LP_{i,t}$ is relative labor productivity of i^{th} manufacturing sector at time t, and ε is the standard regression disturbance.

In Model 2, each of 4 manufacturing sectors are identified by separate dummy variables that account for fixed effects. These fixed effects estimate sector-specific levels of export specialization that remain stable during the sample period. By extending Model 1 with these fixed effects, we obtain Model 2

$$Export\ share_{i,t} = \beta_{High} + \beta_{Medium-High} + \beta_{Medium-Low} + \beta_{Low} + \beta_1 LP_{i,t} + \varepsilon \quad (2)$$

Models 1 and 2 have important conceptual differences in explaining export specialization. Model 1 includes only dynamic, time-varying changes in relative labor productivity. According to the model, export specialization varies in response with changing sectoral productivity, with a principal prediction that increased productivity in a particular manufacturing sector will allow to reduce its costs, which would allow the sector to increase it comparative advantage (other things being equal). In contrast, Model 2 introduces a stable set of fix effects, and explains export patterns not only by the dynamics of relative labor productivity, but also by a set of constant factors that keep country's export specialization at some permanent level. It is instructive to see differences between Japan and Korea with respect to these two conceptually different models of export specialization.

Regression Results

Regression estimates for Models 1 and 2 are reported in Table 2, with Panel (a) showing results for Japan, and Panel (b) − results for Korea. In the case of Japan's export specialization, Model 1 had very low adjusted R-squared statistic (just 0.093), indicating that time-varying levels of labor productivity accounted for less than 10 percent in the total variation in Japan's export shares. However, the coefficient estimate for labor productivity had expected positive sign, and was statistically significant, with p-value of only 0.003. But once sector-specific fixed effects were added to Model 2, the explanatory power of Model 2 greatly increased, with adjusted R-squared rising to 0.992.

Table 2 Regression results

(a) Japan				
	Model 1		**Model 2**	
	Coefficient	p-value	Coefficient	p-value
Constant	3.5	0.633		
Labor productivity	20.3	0.003	-5.4	<0.001
Fixed effects for technological intensity:				
High technology		.	36.1	
Medium-high technology		.	58.5	
Low-medium technology		.	19.6	
Low technology		.	8.5	
Adjusted R-squared	0.093		0.992	

(b) Korea				
	Model 1		**Model 2**	
	Coefficient	p-value	Coefficient	p-value
Constant	11.3	<0.001		
Labor productivity	12.8	<0.001	4.4	0.0454
Fixed effects for technological intensity:				
High technology		.	24.9	<0.001
Medium-high technology		.	26.6	<0.001
Low-medium technology		.	19.0	<0.001
Low technology		.	10.7	<0.001
Adjusted R-squared	0.370		0.731	

In terms of the size of these fixed effects, the export share of medium-high technology was the highest, at 58.5 percent. In contrast, the export share of high technology had a much lower estimate of fixed effect (36.1 percent), or around one-half of the estimate for the medium-high technology.

Regression estimates for Korean export specialization turned out very different from the Japanese exports. First, the explanatory power of Model 1 was relatively higher, with the adjusted R-squared statistic at 0.370, indicating that almost 40 percent in the total variation in Korean export specialization can be explained by the dynamics of relative labor productivity. Moreover, the parameter estimate for labor productivity was positive, and statistically significant (with p-value less than 0.0001). Second, the addition of sector-specific fixed effects to the Korean model also increased the explanatory power of Model 2, with R-squared statistic rising to 0.731. But unlike Japan, the estimates of fixed effects of high-technology and medium-high technology were very close (24.9 and 26.6, respectively), indicating that Korean export specialization was not overwhelmingly concentrated in medium-high technology (like motor vehicles). Third, while the addition of fixed effects explained almost all of export specialization of Japan (with R-squared at 0.992, with very little else left to explain), the R-statistic for Korea was at the level that allows the influence of other factors, not included in Model 2 (such as, for example, technology-specific trade policies to promote Korean exports). In other words, while it was relatively simple to explain the export specialization by a set of fixed sector-specific fixed effects, the approach did not perform well for Korea, indicating a more complex set of factors that may account for Korean export specialization.

Conclusions

This paper documented changes in export specialization of Japan, Korea, China and Taiwan. In addition, it studied possible causes that might explain changes in export specialization of Japan and South Korea. Two major findings stand out.

First, changes in export specialization showed two distinct patterns. While the structure of Japanese exports stayed largely unchanged since the late 1980s, a very different pattern occurred in South Korea, China and Taiwan. Unlike Japan, these economies increased the share of high-tech exports substantially, and reduced the share of low-tech exports. Eventually, the export specialization of South Korea, China and Taiwan became very much similar to the traditional export pattern of Japan. Moreover, the share of high-tech exports in these 'catch-up' economies has even surpassed the share in Japan in recent years.

Second, econometric evidence in Section 5 shows that labor productivity played different roles i^{th} respect to export specialization in Japan and Korea. On the one hand, after accounting for fixed effects in different manufacturing sectors, productivity did not contribute much to increasing export specialization in Japan (in fact the estimate turned negative in Model 2). On the other hand, labor productivity had positive role in changing the export specialization in Korea. At the same time, the impact of sector-specific fixed factors turned out much less important in Korea compared with Japan.

In the future work, the reported results will be extended by using a more comprehensive productivity index − the total factor productivity (TFP). Compared with the simple productivity measure used here (*i. e.*, labor productivity), the TFP accounts for different productivities of capital inputs. It will be interesting to see how much the reported results in this paper may change after replacing the labor productivity with a TFP index.

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