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Abstract: This paper analyzes how division of labor has evolved in the ASEAN+3 countries and proposes an indicator of the level of integration of production in order to investigate the degree to which these countries are affected by the fragmentation of production. It is shown that while product fragmentation and supply chain trade have so far been mostly beneficial to the region, the speed at which the process is taking place may put enormous pressure on ASEAN economies in the future.

Key words: supply chain trade, product fragmentation, revealed comparative advantages

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JEL classifications: F10, F63, O10

Flying Geese and Supply Chain Trade

1. INTRODUCTION

On 11 December 2001, China officially became the 143rd member of the WTO. The event marked a milestone in the country's economy, officially ending more than five decades of isolationism. By 2005 China had established itself as one of the major players in the world trade system. Less than ten years later, China was already a world champion in the export of high-tech products.

The enormous success of the Chinese trade policy is closely linked to China's policy towards foreign direct investment (FDI)1. The first foreign investors entered the country in 1979. In 1980, four special economic zones were created in Zhuhai, Xiamen, Shenzhen, and Shantou with the aim of increasing foreign investment flows. In 1984 the country launched a policy to open 14 coastal cities and three regions as "open areas" for foreign investment with significant tax benefits and much less red tape. These policy changes came about at a time when the world trade system was experiencing the emergence of supply chain trade, or what Richard Baldwin (2011) called "globalization's second unbundling". Thanks to lower transportation and coordination costs, firms are now able to minimize costs by fragmenting production and distributing tasks around the world. This new paradigm of trade has been instrumental in China's success story.

Supply chain trade, outsourcing, and offshoring are all terms that have been used in the past to describe the phenomenon of firms spreading facilities across the world, each unit specializing in those parts of the final product that are cheaper to produce at each specific location (Grossman & Rossi-Hansberg, 2008; Deardorf, 2001). Abundance of unskilled labor makes developing countries attractive locations for low-skill tasks, while industrial nations are attractive locations for design and other high-knowledge tasks. Because production networks tend to be regional, this reorganization of production is usually referred to as "factory Asia", "factory Europe" or "factory America".

Product fragmentation enables developing countries to jump stages and move directly from low-skilled manufacturing to exporting highly sophisticated goods. The process can be extremely quick: Nowadays, developing countries can climb up the technological ladder without the hassle of having to adapt foreign technologies, let alone develop their own; it suffices to attract foreign firms with foreign knowledge and foreign technologies to jumpstart new production ventures (Baldwin, 2011). However, as Baldwin pointed out, with supply chain trade the new technology arriving in developing countries is lent technology. In other words, it is technology that belongs to multinational firms (MNFs), embedded in their plants, and it may never be transferred to the host country. Indeed, MNFs are likely to have a strong interest in keeping knowledge at home and may actually endeavor to block any possible transfer.

This characteristic of supply chain trade makes Chinese export-led growth radically different from export-led growth as pursued by Japan or Korean in the past. The path followed by Japan or Korea relied on these countries' ability to adopt and adapt foreign technologies. Copy, adapt, and innovate, that was the recipe. In the case of China, technology is rooted in plants attracted to the country by China's low labor costs. As Chinese wages rise, as is already

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[1] For the relationship between FDI and trade in China, see (Branstetter & Lardy, 2006).

happening, will these firms stay in the country or will they leave, with the same ease with which they came, to other low labor cost locations such as nearby Vietnam or Cambodia, leaving behind empty buildings and not much more? The initial ascent up the technological ladder on the broad shoulders of MNFs may be an easy task; to keep them on your side as you climb up the ladder may be another story.

If China is indeed moving up the technological ladder, pulling behind it poorer nations, supply chain trade would be simply strengthening the well-known Asian flying geese pattern of growth, whereby the production of manufactures continuously move from the more to the less advanced nations in the region in response to changes in national comparative advantages. However, if MNFs move from country to country leaving behind little in terms of technological advances, supply chain trade could be turning the flying geese pattern of growth into something more resembling a game of musical chairs. The big question for Asian nations today is whether supply chain trade and the Asian flying geese pattern of growth are in fact compatible.

This paper aims to shed some light on this question. To this end, it analyzes changes in the bilateral trade flows of China and the other ASEAN+3 countries in the last two decades and relates them to changes in the division of labor in factory Asia. The paper contributes to the growing literature on supply chain trade by offering a proxy for production integration based on estimations of the revealed comparative advantages of these countries. With this indicator the paper offers some evidence of how Factory Asia is evolving.

The rest of the paper is organized as follows: the second section covers the changing patterns of Chinese bilateral trade flows in end and intermediate goods since 2000. Section 3 discusses production integration in factory Asia with the help of an indicator of revealed comparative advantages complemented with an analysis of the comparative advantages implied in the countries per capita income levels.. Conclusions are provided in Section 4.

2. CHINA'S PATTERNS OF TRADE OF 2000-2012

Data

Data on bilateral trade flows are taken from COMTRADE. Trade flows in intermediate goods and end-products are identified with the United Nations "Broad Economic Categories" (BEC) classification. The BEC classification regroups exports according to final use, distinguishing between products for final consumption and products for industrial use. This regrouping necessarily involves some subjective judgment, and the use of the BEC data to estimate supply chain trade has not been free from criticism (see, for example (de Backer & Yamano, 2011)). In particular, BEC is suspected of underestimating the actual size of intra-industry trade. Better measures of the actual size of trade in inputs may be achieved using the World Output Input database, which provides I-O matrixes for all OECD countries and a number of other nations including China, Japan, and Korea. For other Asian countries, I-O tables are compiled by the Institute of Developing Economies IDE-Jetro. Unfortunately, most of the poorer ASEAN+3 countries are not included in either of these databases. Favoring coverage over precision, I decided to stick to the BEC classification without further data transformations. Despite its drawbacks, this approach gives a clear picture of the position of the different ASEAN countries within factory Asia and, more importantly, of how these nations have moved up or down the supply chain in the last decades.

Changing Patterns of Trade Between China and the ASEAN+3 Countries

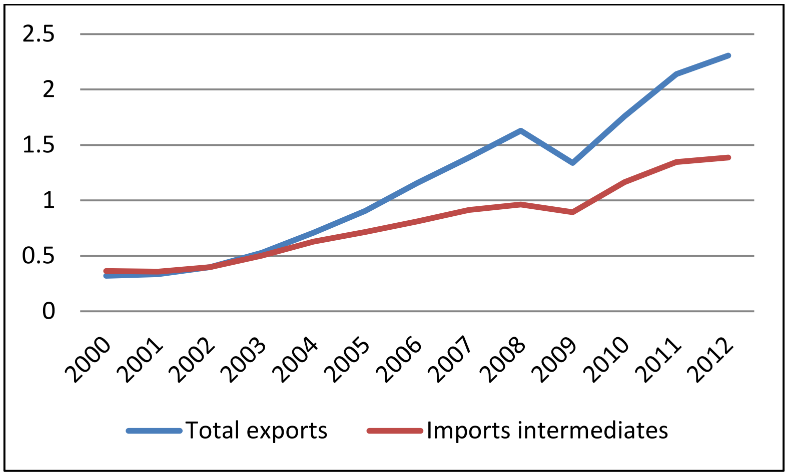
Fig. 1 shows the evolution of total Chinese exports and imports of intermediate products since 2000. If all intermediate goods were used in the production of exports, the distance between total exports and imports of intermediates could be read as a rough measure of the content of Chinese value added in total Chinese exports. If some of the intermediates were used in the production of goods for the domestic market, this measure would underestimate the real domestic value added of exports. Thus it seems legitimate to claim that distance between total exports and imports of intermediates approximates the minimum size of the domestic content of total Chinese exports. As Fig. 1 shows, during the first half of this century the content of Chinese value added in total Chinese exports was very low. The low contribution of Chinese work in total Chinese exports reflects the fact that most of the country's exports at the time were assembled products. Starting in the early 2000s, the first foreign investors - mostly from the United States and Japan - moved into the country with the intension of using China as an assembly platform for re-exports2. Intermediate goods, largely imported from Japan and the USA, were brought into the country, assembled there using cheap Chinese labor, and re-exported later-on to the firms' home countries and other nations.

However, as the graph shows, over the last few years the distance between total exports and intermediate imports has been growing steadily. Clearly, the content of Chinese value added in total Chinese exports has been constantly increasing since around 2005. What these figures suggest is that firms that were importing most of their inputs from

[2] FDI flourished in China before the 2000s, when many foreign firms entered the country lured by its growing domestic market. The 1990s FDI boom was short-lived and many of these firms left the country after a few years. This period is largely ignored here since this paper mainly focuses on supply chain trade. FDI for exports started only after China joined the WTO in 2001. Thus, first movers in this paper are first after WTO accession. A comprehensive description of how FDI evolved in China pre- and post-WTO accession can be found in (Branstetter & Lardy, 2006).

other nations by the early 2000s had started to produce some components in China by the mid-2000s or were joined there by new entrants that had decided to produce in situ at least some intermediate inputs from the start.

Figure 1: Chinese Trade Flows of 2000-2012, in Billion USD



Source: COMTRADE

This fast shift away from the pure assemblage of products into the production of some intermediates shows both China's ability to join factory Asia and the speed at which firms in the region can react to changing conditions. A very rapid learning process, both in China and among foreign firms, must have resulted in a fall of production costs large enough to enable firms - either old firms or new entrants - to move the production of at least some components to China and reap further gains from relocation in just a few years3. (Further evidence that this was the case is presented later). In other words, the increasing content of Chinese value added in total Chinese exports suggests the rapid ascent of China along the supply chain.

As the process of integration advanced, China's trade relations with industrial nations and with other regional nations also changed. By 1990, half of total Chinese exports went to four countries: Japan, the United States, Korea, and Germany. By 2012, these countries accounted for just 35% of total exports. Among the new destinations for Chinese exports, regional partners such as India, Malaysia, Indonesia and Vietnam stand out (Fig. 2).

At the same time, total Chinese imports grew an astonishing 3,200%, jumping from US $53 billion in 1990 to US$1.76 trillion in 2012, excluding fuels. Most of this growth went to regional partners. Korea, a minor source of imports two decades ago, is today the second source of Chinese imports after Japan, replacing the USA. Other regional partners such as India, Indonesia, Thailand, and Malaysia each account for more than 2% of total imports in 2012; two decades ago, China's imports from these countries had been nonexistent.

China's exports to industrial countries (within and outside of the region) consist mostly of end products whereas Chinese imports from these countries are mostly of intermediate goods (see Table 1). This is the kind of trade

[3] For theoretical links between production costs in host countries and FDI and vertical integration, see (Grossman, et al., 2006; Helpman, 2006)

structure that one would expect from a country whose comparative advantages rely on very cheap labor. And it is indeed the kind of trade structure that dominated Chinese trade flows at the beginning of the 2000s when assemblage was the norm.

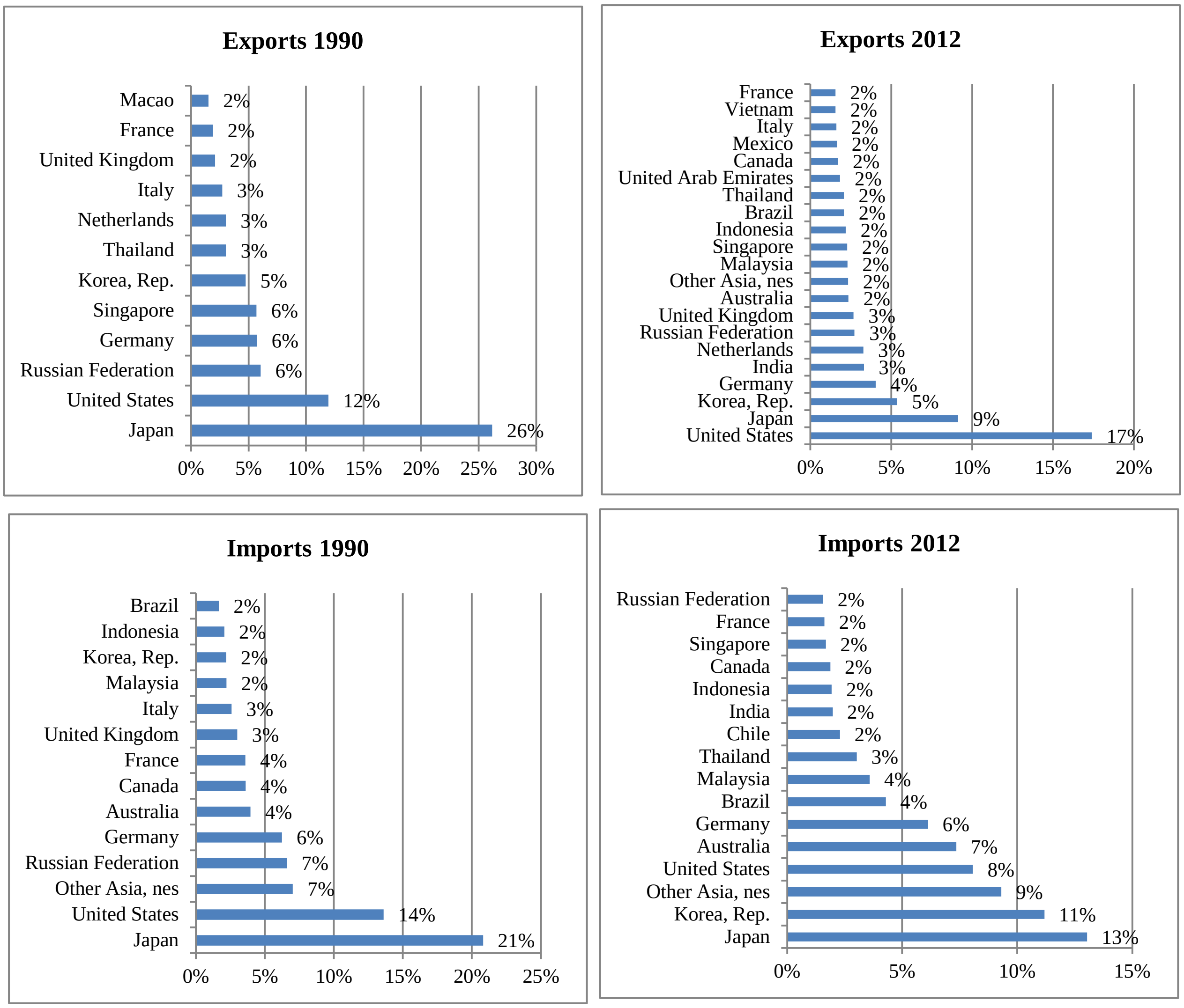
But China’s bilateral trade flows with Korea, another industrial nation, are remarkably different. In the case of Sino-Korean import and export flows, intermediate goods clearly dominate. It is likely that the difference in Sino-Korean bilateral trade flows corresponds to a different entry strategy of Korean firms in China, which could be explained by a lucky combination of a ‘cheaper’ entry-time and lower distance costs. Korean firms started a massive ‘invasion’ into China only in the early 2000s (Yoon, 2007). These firms faced lower costs than their American and Japanese counterparts largely because they could profit from the Chinese learning process that had taken place since the early 1990s. Thus, as opposed to Japanese and especially American firms, Korean firms did not use China merely as an assembly plant but could relocate to China the production of intermediate goods from the start. Growth of trade between these two partners has been astonishing: Trade between the two countries was non-existent before 1987, when Sino-Korean diplomatic relations were re-established; by 2004, China was Korea’s main trading partner. The kind of production integration suggested by this trade data is one in which China is no longer at the lowest step in the ladder but rather somewhere in the middle.

Trade flows between China and developing Asian countries further support this hypothesis. Intermediate goods represented more than 60% of Chinese imports and exports from Malaysia, Indonesia, Vietnam, or the Philippines (see Table 1). The figures are impressive: By 2012, imports of intermediates from these countries accounted for 9% of total intermediate imports (see Table 2). It seems that China is importing some sophisticated inputs from Japan and Korea, and also some less sophisticated intermediates from developing Asian countries. This is what countries in the middle of a supply chain do.

All these data strongly suggest that the rapid growth of intraregional trade in Asia actually reflects the advance of production fragmentation in the region and the re-location of different production tasks across these countries.

Figure 2: China - Bilateral Trade Flows by Partner Country,

(flows > than 2% of Total)



Source: Comtrade

Table 1: Share of Intermediate and Final Products in Total Bilateral Exports and Imports. China and Selected Partners in 1990, 2000, and 2012

		Interm	Final	Interm	Final	Interm	Final	Interm	Final
		Germany		Japan		United States		South Korea	
Exports	1990	55%	45%	58%	42%	26%	74%	92%	8%
	2000	40%	60%	39%	61%	24%	76%	72%	28%
	2012	41%	59%	46%	54%	28%	72%	66%	34%
Imports	1990	56%	44%	80%	20%	71%	29%	95%	5%
	2000	64%	36%	80%	20%	61%	39%	92%	8%
	2012	53%	47%	74%	26%	66%	34%	80%	20%
		Vietnam		Indonesia		Malaysia		Philippines	
Exports	1990	77%	23%	70%	30%	73%	27%	85%	15%
	2000	78%	22%	67%	33%	61%	39%	72%	28%
	2012	56%	44%	66%	34%	58%	42%	68%	32%
Imports	1990	70%	30%	100%	0%	98%	2%	94%	6%
	2000	73%	27%	96%	4%	88%	12%	80%	20%
	2012	57%	43%	89%	11%	89%	11%	67%	33%
		Brunei		Cambodia		Myanmar			
Exports	1990	94%	6%	56%	44%	78%	22%		
	2000	65%	35%	82%	18%	70%	30%		
	2012	39%	61%	78%	22%	73%	27%		
Imports	1990	__	__	100%	0%	81%	19%		
	2000	0%	100%	97%	3%	77%	23%		
	2012	99%	1%	46%	54%	81%	19%		

Source: COMTRADE and author's calculations

Table 2: Chinese Trade in Intermediate Goods, Selected Partners in 1990 and 2012 (% of Total)

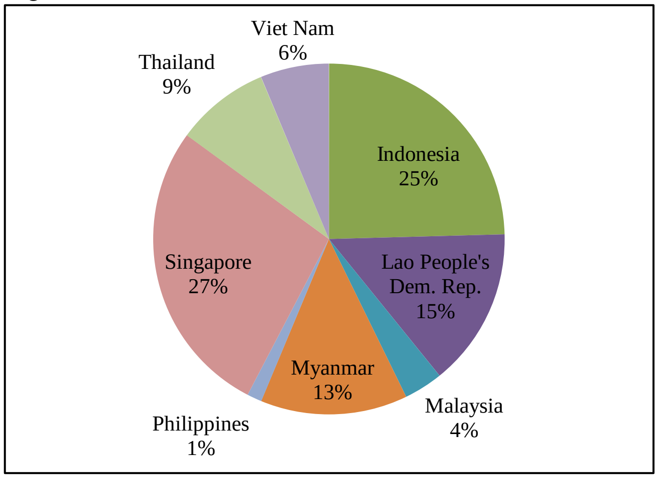
Imports			Exports		
	1990	2012		1990	2012
Japan	24%	16%	United States	6%	10%
Korea, Rep.	3%	15%	Japan	22%	9%
United States	10%	6%	Korea, Rep.	7%	7%
Germany	5%	5%	India	1%	5%
Malaysia	2%	5%	Germany	6%	3%
Thailand	1%	3%	Indonesia	1%	3%
Singapore	1%	2%	Thailand	5%	3%
Indonesia	3%	2%	Malaysia	2%	3%
Philippines	0%	1%	Singapore	6%	2%
Vietnam	0%	1%	Vietnam	0%	2%
			Philippines	1%	1%
			Myanmar	1%	1%
			Pakistan	2%	1%

Source: Comtrade

This of course would imply that as wages in China rose some jobs migrated from this country to other, low-labor-cost neighbors. Anecdotal evidence would support this hypothesis. According to different reports, South Korean companies are leaving China, attracted by cheaper labor in poorer Asian countries. “There used to be over 10,000 Korean companies in Shandong, but this has now decreased to 4,800, 2,200 of which are located in Shandong's capital Qingdao. (…) Korean businesses in industries including textiles, shoes, and jewellery have moved to Southeast Asian countries such as Vietnam and Myanmar” (ChinaTimes, 11.20.2014).

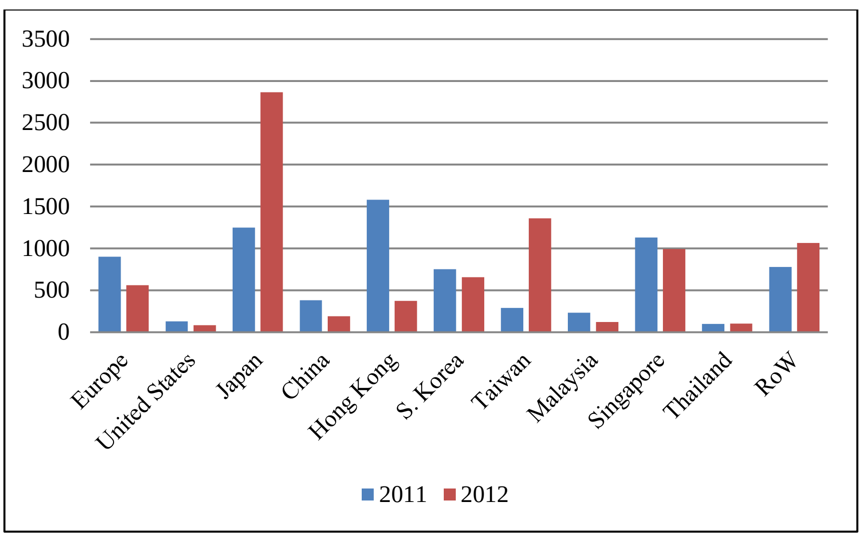
And not only Korean and Japanese firms are moving to lower income countries. Total Chinese FDI outflows totaled near 88 billion USD in 2013, up from less than 3 billion USD in 2003. 7% of this figure went to South-East Asian countries as shown in Fig. 3. From the point of view of the recipient countries, total Chinese FDI may not be very large, but in some cases it is not negligible. That clearly is the case of Vietnam, where total Chinese FDI flows, excluding FDI from Hong-Kong, was 5% of total flows in 2011 (see Fig. 4).

Figure 3: China, FDI Outflows to South-East Asia, 2013



Source: UNCTAD

Figure 4: FDI Flows in Vietnam by Geographical Origin (in Million USD)



This is exactly what development following the well-known flying geese formation should look like: as China's comparative advantages move away from cheap labor, the production of labor intensive manufactures (or tasks) is moving to countries with cheaper labor such as Vietnam. The fact that most of the firms moving production to Vietnam, Myanmar, or Indonesia are likely to be Korean or Japanese rather that Chinese has no bearing on the final effect.

Or has it? One apparent difference between the current situation and the path previously followed by Japan and Korea is the speed at which changes are taking place now. Justin Yifu Lin, former World Bank Chief Economist, reckons that China will have to shed 85 million manufacturing jobs in the coming years because of fast-rising wages for unskilled workers (Lin, 2011). This is an enormous opportunity for the poorer ASEAN countries and a huge challenge for China: Korea had forty years before it had to face the heavy competition of China; China had much less time before the arrival of Vietnam.

What will remain in China once the Korean and Japanese firms that drove growth in the past have left? Are MNFs moving from poor country to poor country leaving behind them just wreckage? Or will these countries be able to create new comparative advantages to remain competitive despite these shorter windows of opportunity? To approach this question, the next section proposes an index that illustrates the changes in the positions held by the different ASEAN countries within factory Asia in the last decade.

3. REVEALED COMPARATIVE ADVANTAGES, TECHNOLOGICAL SOPHISTICATION, AND PRODUCTION FRAGMENTATION

Methodological Considerations

The Heckscher Olin (H-O) model of trade predicts that countries would specialize in the production of those goods that intensively use the factors of production with which they are better endowed. Thus countries where unskilled labor is abundant would tend to export unskilled-labor-intensive goods whereas countries where knowledge and technology are abundant will export high-tech goods. This theoretical linkage between specialization and factor endowment has been used in the past to derive from trade statistic conclusions about factor endowments and comparative advantages. For instance, if a country had a large share of total world exports of high-tech products, analysts felt confident to assume that that country was richly endowed with skilled labor and technology. In other words, the implicit assumption was that gross trade flows were a good approximation of comparative advantages. Given the availability of trade data, different indicators of Revealed Comparative Advantages (RCA) were thus constructed (Balassa, 1965; Vollrath, 1991).

However, with production fragmentation measures of comparative advantages based on gross trade flows can be misleading. China may be exporting significant amounts of high-tech goods not because it is richly endowed with knowledge and technology but because some low-skilled elements of high-tech goods are being produced in China and re-exported later embedded in high-tech end products. Since gross trade data do not allow us to identify which parts of each good are actually produced in the different countries, the one-to-one link between trade ratios and comparative advantages no longer holds.

One way to solve this problem would be to estimate RCA indicators with value-added trade data rather than with gross trade flows. However, as stated at the beginning of this paper, value-added trade flows are not available for many of the poor Asian nations. Instead, the gross trade flows are used here to compute the RCA index but to interpret this index as an estimation of production integration in the region rather than as a measure of actual revealed comparative advantages.

In a second stage, the RCA indexes are aggregated in an index of technological content of revealed comparative advantages (TCRCA). The TCRCA index that this paper proposes aggregates the RCA indexes according to the level of technological sophistication of the different groups of products.

In the absence of supply chain trade, the TCRCA index may be read as a ranking of countries according to the level of sophistication of their production sectors: Countries with a high TRCA index would be ranked as countries with highly sophisticated production sectors whereas countries with low TCRCA would be ranked as low-tech countries. However, given the rise of supply chain trade and production fragmentation the interpretation of the TRCA index becomes more complex. The TCRCA indexes may indeed be reflecting the level of technological sophistication of the production apparatus of a country, i.e., the TCRCA indexes reflect the factor endowments of the country. They may also be reflecting the participation of the country in the production of sophisticated goods via the supply of low-tech inputs, i.e., the TCRC indexes reflect trade in tasks or supply chain trade.

To disentangle factor endowments from trade in tasks, the analysis of the TCRCA index is complemented with an analysis of the levels of technological sophistication implied by the countries' per capita income levels. This idea is owed to Lall et al. (Lall, et al., 2006). Following their reasoning, countries with lower per capita income are assumed to be endowed with abundant unskilled labor4 and low levels of technological development. If the level of technological sophistication implied by the TCRCA index does not correspond to the level of technological sophistication consistent with the country's per capita GDP, then the TCRCA index is interpreted as an indicator of production integration rather than as an indicator of factor endowments. For example, if a country with low per capita income shows a high TCRCA index, the latter is interpreted as an indicator of the country's position within factory Asia and not as an indirect indicator of abundancy of skilled labor and high technology. In a similar way, the correlation between the TCRCA and per capita income in the region is interpreted as an indicator of the degree of production fragmentation within factory Asia: High correlation indicates little product fragmentation (countries endowed with high-tech factors export high-tech goods and vice-versa) whereas low correlation indicates higher product fragmentation.

This way of using RCA as proxies for production integration has the advantage of allowing the drawing of a "map" of production integration based solely on gross trade data. This data is available for all countries in the world.

[4] The reasoning goes as follows: If unskilled labor is abundant, a country must embrace technologies that use this factor of production intensively, and wages must be low.

Data and estimation methodology

Probably the best-known measure of comparative advantages is the Balassa index of revealed comparative advantages (RCA) (Balassa, 1965). The Balassa index is defined as

$$\frac{(Xij/Xi)}{Xwj/Xw}$$

where X*ij* are exports of product *j* from country *I,*

X*i* are total exports from country *I,*

X*wj* are world exports of product *j, and*

X*w* are total world exports.

In the context of this paper, the Balassa RCA indexes are calculated for exports of manufactures at the 3-digit level of disaggregation of the Standard International Trade Classification (SITC), Revision 3. Countries are defined as specializing in a certain product group if the corresponding RCA index is larger than 1.

In a second stage, product specialization is related to technological sophistication. To this end, the paper constructs an index of the technological content of the revealed comparative advantages (TCRCA). The index, similar to the index of technological content proposed by Haltmaier et al. (Haltmaier, et al., 2007), aggregates the RCA indexes according to the technological content of the product groups in which each country appears to have a comparative advantage[5]. As is common in the literature, manufactures are grouped according to technological content using Lall's categories (Lall, 2000). The index distinguishes between seven levels of technological content, in ascending order of technology intensity:

1. Labor-intensive and resource intensive manufactures (LT1);
2. Low-skill and technology-intensive manufactures (LT2);
3. Automotive (MT1);
4. Chemicals and basic metal industrial products (MT2);
5. Engineering products MT3);
6. Electronics and electrical products (HT1); and
7. Other high-tech products.

The product groups assigned to each level of technological content are presented in the appendix in Table A1. Summary results of the number product groups in which the different ASEAN+3 countries specialize (product groups with RCA>1) per level of technological content in 2000 and 2012 are presented in Tables 2A and 3A in the appendix.

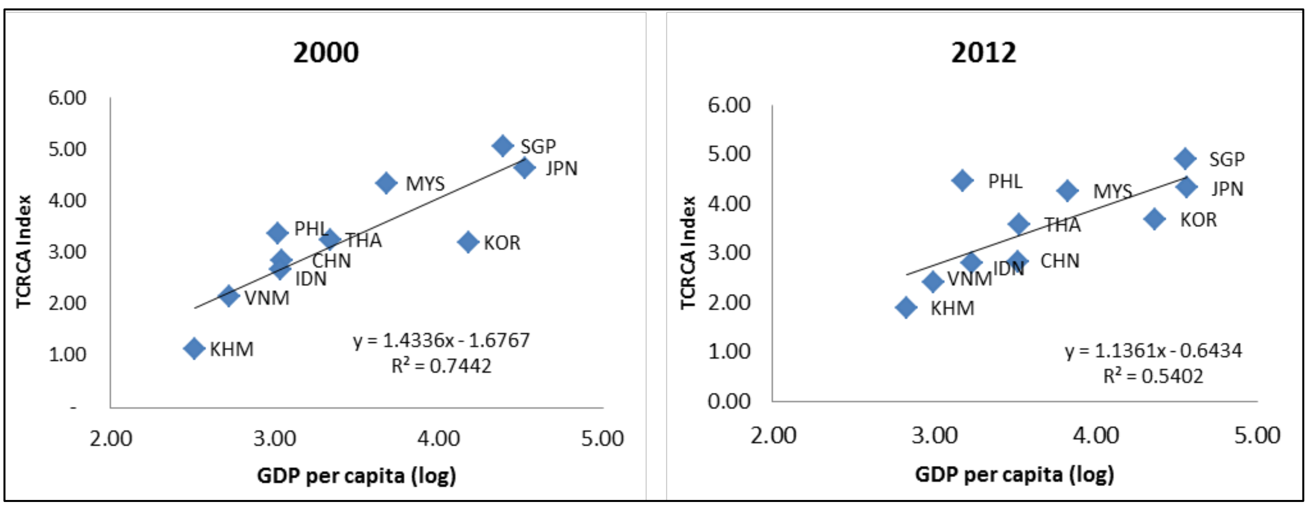
[5] Haltmaier et. al (2007) propose an index of technological content that aggregates total exports rather than the number of product groups with RCA>1. With this exception, the methodology used in this paper is the one they propose.

To construct the TCRCA index, the seven levels of technological content are assigned a value from 1 to 7, where 1 represents the lowest level of technological content and 7 the highest. The TCRCA index is simply the sum of these numbers weighted by the share of each category on the total number of export groups with RCA>1 (the weights can be derived from Tables 2A and 3A). The index varies from 1 to 7, with 7 being the highest level of technological content.

The TCRCA Index and Factory Asia

The TCRCA indexes for the ASEAN+3 countries in 2000 and 2012, plotted against the corresponding incomes per capita in log form, are shown in Fig. 4. Inasmuch as GDP per capita reflects factor endowments, the situation the graph for 2000 is an almost perfect fit of the H-O model predictions: By the beginning of this century, countries where unskilled labor was abundant – and GDP per capita was consequently low - were specializing in products with low technological content, whereas countries where unskilled labor was scarce were specializing in high-tech products. Differences in income per capita explained 74% of the variation of the TCRCA index. China, in this figure, is located very much where it should be, with a TCRCA very close to that of Indonesia and in front of Vietnam.

Figure 5: Index of Technological Content and Income per Capita, ASEAN+3 Countries, in 2000 and 2012 (See the appendix for country names and abbreviations)



A decade later, the figures look quite different and, somewhat surprisingly, China does not account for the lion share of the difference.

To begin with, in barely ten years the technological content of the regional comparative advantages moved upwards: The median TCRCA in 2000 was 3.22. By 2012, it had climbed to 3.64. More importantly, the regional disparities in technological development diminished substantially during these years: The standard deviation of the indexes shrank from 1.12 in 2000 to 0.965 in 2012. If we were to judge the 2012 picture with the H-O model in mind, we would expect the apparent equalization of technological development to be reflected in a similar trend in terms of income per capita.

This, clearly, is not the case. Although all countries in the region grew significantly more than Japan in the last 12 years, the income levels of the ASEAN countries are still hugely disparate (see Table 3). The impressive catching up that is taking place in the region is evident in the table. The income per capita of Cambodia, the poorest country in the sample, was one percent of Japanese income per capita in 2000. Barely a decade later, Japanese income per capita was 'only' 55 times larger than that of Cambodia. Other fast runners have been China, Indonesia, and Vietnam. This notwithstanding, income differentials are still huge. And this clearly is not reflected in the technological distance between countries. Japan's TCRCA was four times that of Cambodia in 2000, and only twice as large in 2012. According to the TCRCA indicator, there is practically no difference in the technological content of factor endowments of Japan and the Philippines, although Japan's income per capita is 25 times that of the Philippines.

The link between income per capita and technological development, still strong at the beginning of the century, weakened substantially in the last 10 years: Differences in income per capita explained only 54% of the TCRCA variation in 2012.

The weaker correlation between the technological development implied by the TCRCA indexes and the factor endowments that may be expected from the incomes per capita of the different countries corresponds to the surge of supply chain trade. Within the last decade, countries that were not part of factory Asia entered the picture and began to produce some of the labor-intensive inputs that factory Asia needs. This is the case for Vietnam and Indonesia, and according to the data presented here also for Cambodia. This is why the technological content of the (gross) exports of these countries no longer reflect factor endowments.

Table 3: Technological Distance and Income per Capita in Asia

	Technological distance between Japan and ASEAN countries according to TCRCA (TCRCA Japan / TCRCA others)		Catch-up in ASEAN Japan's GDP per capita/ GDP of other countries	
	2000	2012	2000	2012
CHN	1.63	1.53	30	11
IDN	1.74	1.55	31	21
KHM	4.13	2.28	103	55
KOR	1.46	1.17	2	2
MYS	1.07	1.02	7	5
PHL	1.37	0.97	32	25
SGP	0.92	0.88	1	1
THA	1.43	1.20	15	11
VNM	2.15	1.80	64	37

Similarly, the high TCCAs shown by the Philippines, Thailand, or Malaysia do not imply that these countries have already caught up with Korea or Japan. The leading dragons in Asia are not Malaysia, Thailand, or the Philippines but rather Japanese and Korean firms located in the Philippines, Thailand, and Malaysia. The technological development the index is attributing to these countries should in fact be attributed to those firms and their countries of origin. Or better still: The technological content attributed to the 3-digit SITC classification product groups was perhaps a good enough approach to the technological development embodied in these products in 2000, but this is no longer true. Because production can be fragmented, Vietnam and the Philippines can specialize in the low-tech bits of sophisticated products while Japan specializes in the high-tech bits. The 3-digit SITC classification does not capture these possibilities.

While the TCRCA index in 2012 may not be a good picture of H-O type of trade, it is an accurate description of production integration in Asia. The figures presented here show the amazing speed at which the process is taking place. China's story is well-known. The country's growth strategy that favored FDI and export-led growth from the start soon placed the country in the middle of factory Asia. Indeed, China's integration in factory Asia, as reflected in Fig. 5, has not changed much over the last 10 years. But production integration is already encompassing many other countries. Across the region, the jumps in the TCRCA indexes of the Philippines, Indonesia, Vietnam, and Cambodia suggest that these countries became part of, or increased their links with, factory Asia in a significant way between 2000 and 2012. The distance between the TCRCA of these countries and Japan shrank by more than the distance between China and Japan. What these figures are telling us is that poor nations are being rushed up the technological ladder as firms disperse production in search for cheaper labor. As shown above, the impact of the process on the income of poor countries has been enormous.

The other side of the coin of course is the fate of Asia's leading nations. If, as a result of supply chain trade, poor countries are exhibiting growing numbers of comparative advantages in the production of sophisticated products (or of parts of these products), then some jobs of the leading nations must be migrating south. Korea is a clear example of this. The country, which exhibited comparative advantages in relatively low-tech products in 2000, presents a TCRCA index which is much closer to that of Japan in 2012. This change implies a huge re-accommodation of the Korean industry. Of course KOTRA had good reasons to cry wolf: Many unskilled jobs must have left the country in favor of Chinese and Vietnamese labor markets.

The same fate of course also awaits new climbers like China. As shown in the first part of the paper, China's role in Asia has changed from assembly platform to that of a down- and up-stream exporter of intermediate goods. China is now somewhere in the middle of the supply chain, and newcomers such as Vietnam are climbing the ladder in pursuit. As the evolution of the TCRCA indexes shows, they are moving fast.

Both China and Korea seem to be withstanding the challenge well. Climbing up and staying ahead seems to be possible even at high speed as the resilience of these countries has shown so far. However, poorer countries should be aware: If they want their MNF to stay put once wages start to rise, they must become attractive in ways that do not depend on cheap labor. And judging from the evolution of the TCRCA indexes shown here, the time they will be given to stay in the race is very short.

4. CONCLUSIONS

China's position within factory Asia has changed rapidly: At the bottom of the supply chain in the early 2000s, China today finds itself somewhere in the middle of the technological ladder, importing technologically sophisticated inputs from industrial nations and less sophisticated intermediate goods from developing Asia. Furthermore, China appears to have graduated from follower goose and is now becoming a leader, pulling along other low-labor-cost countries such as Vietnam.

This looks very much like the old story of the flying geese model of Asian development. But two facts set it apart: The technology that is driving the change nowadays does not belong to any country. Technology is rootless, and it can change location at incredible speed. As a result, factory Asia is changing rapidly. Production is dispersing fast and the links of all countries in the region with factory Asia are getting stronger.

This process has resulted in rapid increases in per capita GDP and income convergence among the ASEAN countries. The speed at which this is happening however will also put strong pressure on Asian countries. With supply chain trade, countries are given a very short time to adapt their economies and stay in the race once their wages start to increase. Korea had more than 40 years to create new comparative advantages and embrace innovation as an engine of growth. China and all other countries will have much less time to do the same.

REFERENCES

Ahearne, A., Fernald, J., Loungani, P. & Schindler, S., 2006. Flying geese or Sitting Ducks: China's impact on the trading fortunes of other Asian Economies. *Board of Governors of the Rederal Reserve System, International Finance Discussion Papers*, December.

Ahearne, A., Fernanld, J., Loungani, P. & Schindler, S., 2003. China and Emerging Asia: Comrades or Competitors. *Board of Governonrs of the Federal Reserve System*, December.

Balassa, B., 1965. Trade Liberalization and ‗Revealed' Comparative Advantage. *Manchester School of Economic and Social Studies*, pp. 99-123.

Baldwin, R., 2006. *Globalisation: The Great Unbundling(s),* s.l.: Prime Minister's Office, Economic Council of Finland.

Baldwin, R., 2011. Trade and industrialisation after globalisation's 2nd unbundling: how building and joining a supply chain are different and why it matters.. *NBER Working Paper Series, Working Paper 17716*, December.

Baldwin, R. & Lopez-Gonzalez, J., 2013. Supply Chain Trade: A Portrait of Global Patterns and Several Testable Hypotheses. *NBER, Working Paper No. 18957*, April.

Branstetter, L. & Lardy, N., 2006. China's embrace of globalization. *Working paper, Carnagie Mellon University*, 7.

ChinaTimes, 11.20.2014. Korean firms leaving China, but business is still good. *China Times.*

de Backer, K. & Yamano, N., 2011. International Comparative Evidence on global value chains. In: *Global Value Chains: Impacts and Implications, Trade Policy Research 2011.* Canada: Department of Foreign Affairs, Trade and Development, pp. 103-126.

Dean, J. & Wang, F. Z., 2011. Measuring Vertical Specialization: The case of China. *Review of International Economics*, pp. 609-625.

Deardorf, A., 2001. Fragmentation in simple trade models. *North American journal of economics and finance*, 12, pp. 121-137.

Grossman, G., Helpman, E. & Szeidl, A., 2006. Optimal integration strategies for the multinational firm. *Journal of International Economics, Vol 70*, pp. 216-238.

Grossman, G. & Rossi-Hansberg, E., 2008. Trading tasks: a simple model of offshoring. *The American Economic Review*, 98/5, pp. 1978-1997.

Haltmaier, J. et al., 2007. The role of China in Asia:Engine, Conduit or Steamroller. *Board of Governors of the Federal Reserve Sytem, International Finance Dicsussion Paper*, September.

Helpman Elhanan, M. M. Y. S. R., 2004. Export Versus FDI with Heterogeneous Firms. *American Economic Review, Vol. 94, No.1*, March.

Helpman, E., 2006. Trade, FDI, and the Organization of Firms. *Journal of Economic Literature*, September, pp. 589-630.

Lall, S., 2000. The Technological Structure and Performance of Developing Country. s.l., Queen Elizabeth House, University of Oxford.

Lall, S., Weiss, J. & Zhang, J., 2006. The Sophistication of Exports: A new Measure of Product Characteristics. *World Development*, February, pp. 222-237.

Lin, J. Y., 2011. *Lets Talk Developlment.* [Online].

Melitz, M., 2003. The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry. *Econometrica, Vol. 71, No. 6*, November, pp. 1695-1725.

Vollrath, T., 1991. A theoretical evaluation of alternative trade intensity measures of revealed comparative advantage. *Weltwirtschaftliches Archiv*, June, pp. pp 265-280.

Yoon, D. R., 2007. *Korea's Outward FDI in Asia: Characteristics and Prospects.* Korea Institute for International Economic Policy.

APPENDIX

Country Names and Abbreviations:

KHM	Cambodia
VNM	Vietnam
IDN	Indonesia
CHN	China
PHL	Philippines
THA	Thailand
MYS	Malaysia
KOR	South Korea
SGP	Singapore
JPN	Japan

Table A 1: Product Groups SITC Rev 3, per Level of Manufacturing

The seven categories of technological sophistication are those defined by Lall (2000), who used the SITC Rev. 2 classification to aggregate manufactures. The correspondence with the SITC Rev. 3 classification is taken from Haltmeier et al. (2007).

LT1	LT2	MT1	MT2	MT3		HT1	HT2
611	642	781	653	711	773	716	712
612	665	782	671	713	775	718	792
613	666	783	672	714	793	751	871
651	673	784	679	721	812	752	874
652	674	785	786	722	813	759	881
654	675		791	723	872	761	
655	676		882	724	873	764	
656	677		883	725	884	771	
657	678			726	885	774	
658	691			727	891	776	
659	692			728		778	
831	693			731			
841	694			733			
842	695			735			
843	696			737			
844	697			741			
845	699			742			
846	811			743			
848	821			744			
851	892			745			
	893			746			
	894			747			
	895			748			
	896			749			
	897			762			
	898			763			
	899			772			

Table A 2: Number of Product Groups with RCA>1 per Level of Technological Content in 2000

	LT1	LT2	MT1	MT2	MT3	HT1	HT2
CHN	18	13	1	4	6	6	2
IDN	14	10	1	2	4	4	1
JPN	0	7	4	1	20	7	4
KHM	7	1	0	0	0	0	0
KOR	9	7	1	2	7	5	0
MYS	3	2	0	0	3	6	1
PHL	6	0	0	0	4	3	0
SGP	0	2	0	1	6	8	0
THA	13	7	2	1	10	6	1
VNM	13	6	1	1	2	2	0

Table A 3: Number of Product Groups with RCA>1 per Level of Technological Content in 2012

	LT1	LT2	MT1	MT2	MT3	HT1	HT2
CHN	18	11	1	2	6	7	1
IDN	11	10	1	3	5	4	0
JPN	0	8	5	3	17	4	3
KHM	7	1	1	0	0	0	1
KOR	3	7	2	2	8	3	1
MYS	2	7	0	0	6	7	2
PHL	3	1	1	0	5	6	1
SGP	0	4	1	0	8	6	3
THA	7	8	3	3	8	7	1
VNM	14	8	1	1	2	3	1

FIGURES

TABLES