International Network for Economic Research


*Working Paper 2012.7*

# Global Production Networks and Export Expansion: Cross-Sectoral Evidence from China

by

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**Abstract**

Given the rising importance of global production networks, this paper examines the link between a country's extent of production sharing and a country's export development. Using the OECD's international input-output database on intermediate goods imports, the empirical analysis is applied to China, where international production sharing is particularly pronounced. Our findings indicate that China's involvement in vertical production networks exerts a positive effect on China's manufacturing exports. An important policy implication, particularly relevant for developing economies, is that a policy promoting a more extensive involvement in global production sharing may significantly improve an economy's export performance.

***Keywords:*** Global Production Sharing, Production Fragmentation, Vertical linkages, Globalization, Export Performance, Manufacturing, China

***JEL Classification:*** F10, F14, O53

## 1. Introduction

During the last fifteen to twenty years global economic integration has proceeded with accelerating steps and moved beyond simple trade relations among countries. This deeper form of globalization has with increasing intensity interconnected national economies and has transformed the planet into a global market place and production system. There is a considerable amount of accumulated evidence showing that international trade associated with global production sharing has risen much faster than conventional trade (Bridgman, 2010; Amador and Cabral, 2009; Breda et al., 2008; Molnar et al., 2007; Kimura et al., 2007; Athukorala and Yamashita, 2006; Chen et al., 2005; Ng and Yeats, 2003; Yeats, 2001; Hummels et al., 2001).

The phenomenon of fragmentation is most importantly found in the clothing, automobile, and electronics sectors (Lall et al., 2004). However, global production sharing activities have in recent years grown substantially in other sectors as well. Particularly for the case of the East Asian region, it is argued that international trade and specialization patterns must be understood in the context of production fragmentation (e.g. Ando and Kimura, 2009; Haddad, 2007). In fact, large intra- and extra-regional production sharing networks in East Asia have been formed and expanded (Hiratsuka, 2008; Kimura et al., 2007; Bonham et al., 2007; Gaulier et al., 2007; Kimura, 2006). Nowadays, there exist extensive production sharing links between the economies of East Asia, the US, and the European Union.

More recently, the world has witnessed China's increasing integration into the global economy. This has led to the country's impressive export expansion, leaving a significant impact on the world trade system. Furthermore, China has increasingly been involved in production sharing and processing trade (Lemoine and Unal-Kesenci, 2002; 2004). Foreign-owned firms have relocated the production to China and are exporting their goods to the western markets from there. Additionally, foreign firms producing capital-intensive and high-tech products have outsourced the labour-intensive production activities (such as assembly of the components) to China. Thus, inward foreign direct investment has become increasingly important to the country and China has been transformed to a production, assembly, and export platform for foreign firms.

As fragmentation has become a prominent feature of globalization, there is a large and expanding literature on production sharing (e.g. Machikita and Ueki, 2010; Miroudot and Ragoussis, 2009; Li, 2009; Dean et al., 2009; Hayakawa, 2009; Shin et al., 2009;

Kimura, 2009). However, relatively less attention has been given to the role and quantitative effect of a country's participation in global production networks on the country's export performance. In fact, there is only a small number of empirical studies that explicitly address the question of how production sharing affects a country's export development (e.g. Cieslik, 2009; Kimura and Obashi, 2008; Bonham et al., 2007; Srholec, 2007).

Given the rising importance of China and her increasing involvement in global production sharing, the objective of this paper is to examine the implications of China's integration into global production networks for the country's export performance in manufacturing goods. Our empirical analysis takes a cross-sectoral approach. Therefore, the developments with regard to production sharing and exports are investigated for each manufacturing industry. Furthermore, the period under investigation (1995-2009) coincides with a time period of increasing economic integration among China and other international economies.

The rest of the paper is structured as follows. Section 2 briefly reviews the theoretical and empirical literature on international production fragmentation. Section 3 examines the trends and patterns of China's global production sharing. Section 4 examines the developments of the Chinese manufacturing exports and conducts a statistical analysis for the relationship between China's extent of production sharing and China's export expansion. Finally, Section 5 presents some concluding remarks.

## 2. Conceptual, Theoretical, and Empirical Background

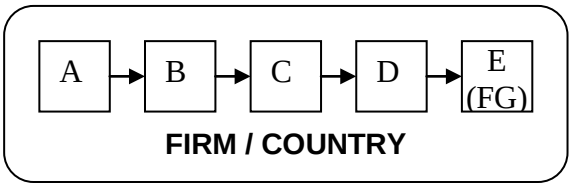
International production fragmentation can be described as the phenomenon in which the production of a final good is fragmented or sliced into several production stages which take place in different countries. The various intermediate goods, resulting from each production stage at a different location, are combined in the last stage to produce the final good. International trade in intermediate inputs plays a crucial role here, as it is an integral part of the overall production process. It constitutes a service link connecting all separate production blocks.

Figure 1 illustrates graphically the concept of international production fragmentation in the case of a sequential production process of a manufacturing good. Panel (a) of the figure shows the case of a sequential production process that takes place within a vertically integrated firm (where all stages are carried out) or within a country (the firm acquires some of the intermediate production stages only from local suppliers).

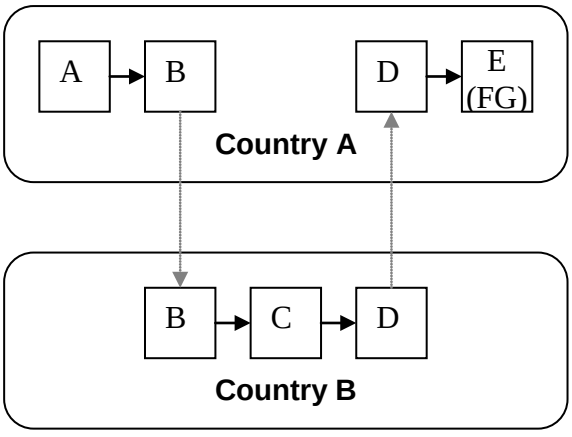
In this production process some initial raw materials (block A) are being transformed progressively through various stages into processed intermediate goods (blocks B, C, and D) and finally into the final good (final production stage E).

As shown in panel (b), with international production fragmentation only a subset of the sequential production stages are being carried out in the home country (A), while the remaining blocks are produced in another country (B). In particular, in our simplified example with two countries, country A produces the good-in-process B, which is then exported to country B (grey dotted arrow) so that intermediate sequential production stages C and D are produced in that country. From there production block D is exported to country A, where the final transformation occurs and the final consumer good is produced (stage E).

**Figure 1: An Illustration of International Production Fragmentation**




(a) The production process within a vertically integrated firm or within a country




(b) The production process with international production fragmentation

***Source:*** Author's own drawing.

As regards theoretical analyses on the phenomena of trade in intermediate products and production fragmentation, those date back to the 1980s and 1990s (e.g. Sanyal and Jones, 1982; Jones and Kierzkowski, 1990) and have since been extended and examined further with an increasing interest (e.g. Kimura and Ando, 2005; Yi, 2003; Grossman and Helpman, 2002; Arndt and Kierzkowski, 2001; Deardorff, 2001). Notably, production sharing has a number of important implications with regard to the traditional concept of comparative advantage, trade patterns, wages, and employment (Baldone et al., 2007; Molnar et al., 2007). Countries can no longer be thought of as producers of a particular final product, and hence appear to be specialized in the given commodity. On the contrary, specialization occurs in one or more segments of the overall production process (as seen in Figure 1).

The traditional comparative advantage scenario (Ricardian and H-O trade theory) still holds in this case, with the reformulation that the differences in cross-country labor productivities and in relative factor endowments are relevant for each of the individual separate production segments-blocks. More specifically, in the case where the different production segments require different labor skills, the fragmentation of the production process across different regions (countries) that exhibit different productivities and skills of their labor force generates Ricardian specialization patterns and gains from trade.

In the case where the production segments require factors in different proportions, the production fragmentation across countries that have different relative factor endowments creates H-O type of specialization. However, it has to be noted that with production fragmentation comparative advantage looses its traditional meaning as regards the production and exporting of final commodities. The above considerations show that production fragmentation can be beneficial for firms and promote economic efficiency, and may indeed constitute important motivations for production fragmentation to occur.

Though in the theoretical literature there is no complete trade theory with production sharing for predicting the effects on export performance, various models lend support for a positive impact of production networks on the exports of the participating countries. For instance, taking an HO view with 2 countries and 2 goods (where one good is fragmented), Arndt's (2001) examination reveals that with fragmentation within a free trade area leads both countries to produce and export different intermediates (production stages) of the fragmented good. Both countries continue to

produce the final good with the fragmented technology (imported intermediate goods), and the bilateral trade occurs in the components of the fragmented good. The output of this final good in both countries increases due to lower overall production costs and increased productivity, as does the export volume. An implication is that their exports of the fragmented good could also rise towards third countries, as they produce with lower costs compared to countries that do not use the fragmented production process.

In a similar theoretical exercise, Deardorff (2001) examines the issue with both a graphical and a formal mathematical analysis within a Ricardian as well as HO setting. Depending on how and whether fragmentation changes the prices, a country could also specialize completely in the intermediate good and export it, with the other country specializing in the final good. Also, both countries would experience an increase in their output and export level. In more formal and general equilibrium analyses, where fragmentation is allowed to occur in any sector and direction, typically a variety of results can be generated and the outcomes are rather ambiguous (depending on certain conditions) than straightforward predictions. Although the results are not clear-cut, a typical scenario is that the countries engaging in international production sharing experience an expansion in output and exports (e.g. Baldwin and Robert-Nicoud, 2010; Markusen and Venables, 2007).

The results of the rather small empirical literature with regard to the impact of production sharing on exports suggest that there is such a positive effect. More specifically, Cieslik's (2009) findings indicate that together with other country-level determinants vertical production networks explain Poland's trade with its trading partners. For seven East Asian economies, Bonham et al. (2007) find that fragmentation has a particularly strong and statistically significant effect on a country's ICT exports. Srholec's (2007) study, which includes several East Asian, developing, and developed countries, also finds strong econometric evidence of a significant impact of production sharing on electronics exports. Finally, Kimura and Obashi (2008) examine this issue for China using regional data. It is found that the observed differences in export performance in electronics and machinery products across Chinese regions is partly explained by the cross-regional differences in the extent of participation in the East Asian production sharing networks.

## 3. Global Production Sharing Developments in China

Although there are various indicators in the literature that could be used as a measure of the extent of a country's global production sharing (e.g. Hummels et al., 2001 index, inward/outward FDI), those cannot provide the required information for our investigation. We examine the extent of China's involvement in global production networks at the industry level. The above-mentioned indicators do not reflect adequately and accurately the phenomenon of production sharing and do not provide industry-specific information. The Hummels et al. (2001) index indicates the import content of exports, and thus captures only a part of the whole fragmentation phenomenon (countries may be involved in production sharing, where the imported intermediate inputs are used to produce the final good which is only consumed domestically).

On the other hand, FDI within a country may not be related to production fragmentation at all, as it might be of the horizontal type. Since only vertical FDI is relevant, overall FDI flows do not indicate a country's extent of international production fragmentation. Even vertical FDI data, if available, reveal only the production sharing among countries undertaken by multinational enterprises. However, fragmentation occurs also to a large extent between independent firms (at arm's length transactions). Therefore, we rely on data from international input-output tables. In particular, we use the OECD's database on imports of intermediate goods and services – international input-output tables by ISIC[1] sector.

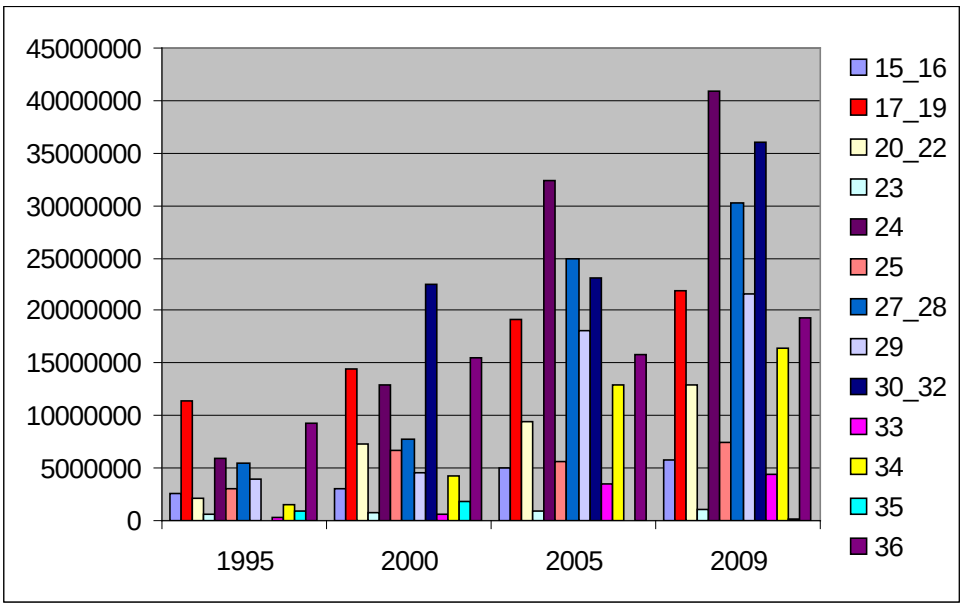
Figure 2 shows for each ISIC sector the development in the total world intermediate goods imports that are used in China's manufacturing industries over the 1995-2009 period. Those imported intermediate inputs originate from all the manufacturing sectors as an aggregate and from all the trade partners of China (world imports). Since the OECD database does not provide disaggregated information on each of the 22 ISIC manufacturing industries, we have a total of 13 sectors for our analysis, some of which have been grouped together.[2]

[1] Intermediate goods imports are presented in an input-output table format for two-digit sectors of the International Standard Industrial Classification, revision 3.

[2] Those 13 sectors are the following: (15_16) Food products, beverages, and tobacco; (17_19) Textiles, textile products, leather and footwear; (20_22) Wood, paper, products of wood, cork & paper, and printing & publishing; (23) Coke & refined petroleum products; (24) Chemicals and chemical & pharmaceutical products; (25) Rubber and plastic products; (27_28) Basic metals and fabricated metal products; (29) Machinery and equipment, n.e.c.; (30_32) Office and computing machinery, electrical machinery and apparatus, and radio, tv & communications equipment; (33) Medical, precision, and

Moreover, as the data are available for only 3 benchmarks years (1995, 2000, and 2005), we have used polynomial interpolation / extrapolation techniques to estimate and obtain the values for the in-between years and for the year 2009.

**Figure 2:**
**Total (Manufacturing) Intermediate Goods Imports Used in China's Manufacturing Industries by ISIC Sector, 1995-2009 (in thousands US dollars)**




***Source:*** Author's calculations based on data from the OECD's database on imports of intermediate goods and services (derived from the OECD international input-output tables)

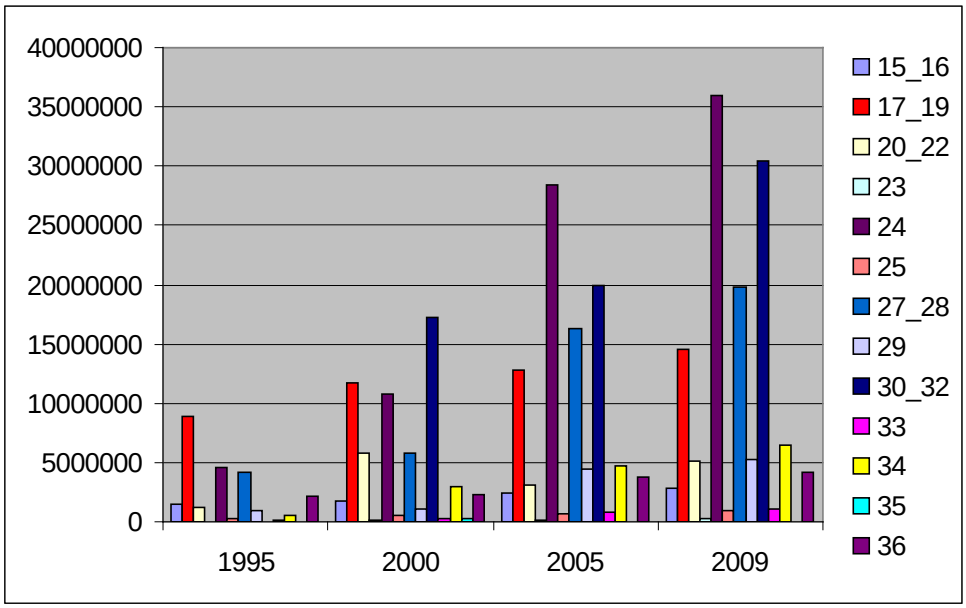
It is evident that there is a significant upward trend in the imported intermediate manufacturing inputs in almost every Chinese sector. Sector such as textile and clothing (17_19), electronics (30_32) and more recently chemicals (24) and metal products (27_28) exhibit the highest amounts (values) of intermediate goods imports. The motor vehicles sector (34) has also witnessed a tremendous growth in globally supplied intermediate manufactures between 1995 and 2009, which amounted to about 975%. The picture that emerges from those patterns is that China's international input-output linkages with the rest of the world have become substantially stronger in every manufacturing sector.

optical instruments; (34) Motor vehicles, trailers, and semi-trailers; (35) Other transport equipment; (36) Furniture and manufacturing n.e.c.

Although there is a strong indication that those developments may be attributed to global production fragmentation, we cannot infer from the above-observed patterns that this is really the case. The reason is that those international vertical linkages could to a large extent reflect general input-output relationships (where imported intermediates are comprised mostly of semi-processed raw materials and other industrial supplies which are not related to fragmentation).

Therefore, we additionally examine the developments in the intra-industry intermediate goods imports of China in each manufacturing sector. These imported inputs originate and are supplied from the same sector in which they are used as intermediate goods for the production of other (final) goods. These intermediates are much more likely to be related to and reflect more accurately global production sharing. This can also be understood and illustrated in terms of Figure 1, in which an initial vertically integrated production of a good within a firm is fragmented and produced in two or more different countries. Since all the fragments (intermediate production stages) that are produced in the different countries belong in the same sector, the imported intermediates are of the intra-industry type.

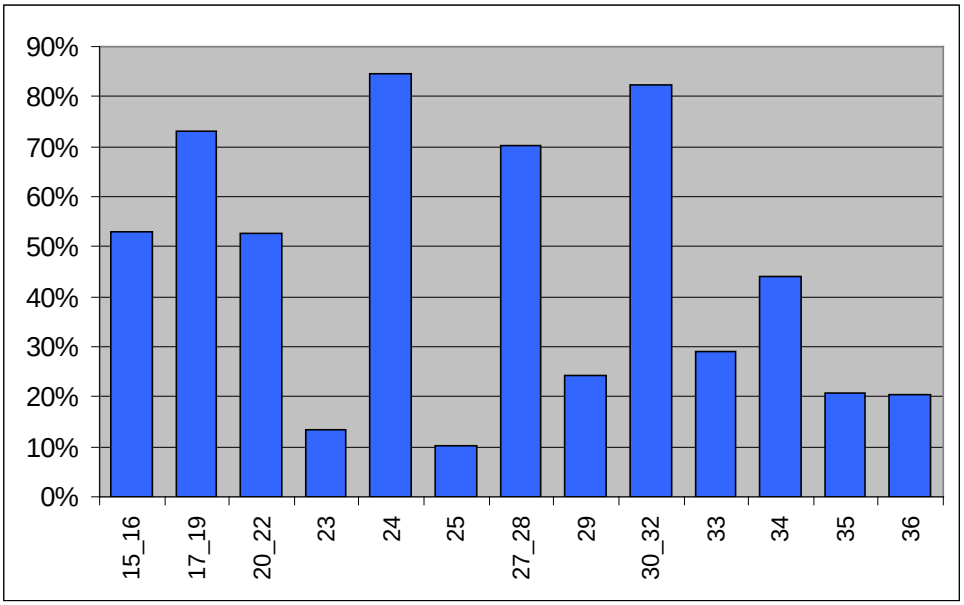
**Figure 3:**
**Intra-Industry Intermediate Goods Imports Used in China's Manufacturing Industries by ISIC Sector, 1995-2009 (in thousands US dollars)**




***Source:*** Same as in Figure 2.

From Figure 3, which depicts the patterns and trends in the intra-industry intermediate goods imports, it is apparent that China's global production sharing is mostly centered on four sectors (electronics, textiles and clothing, chemicals, and metal products). Those sectors also rank particularly high in Figure 2. This indicates that intermediate imports in general (that is, those originating from all manufacturing industries) have significance in those four Chinese manufacturing sectors.

**Figure 4:**
**Share of Intra-Industry Intermediate Goods Imports in Total Manufacturing Intermediate Goods Imports by ISIC Sector (period average)**




***Source:*** Same as in Figure 2.

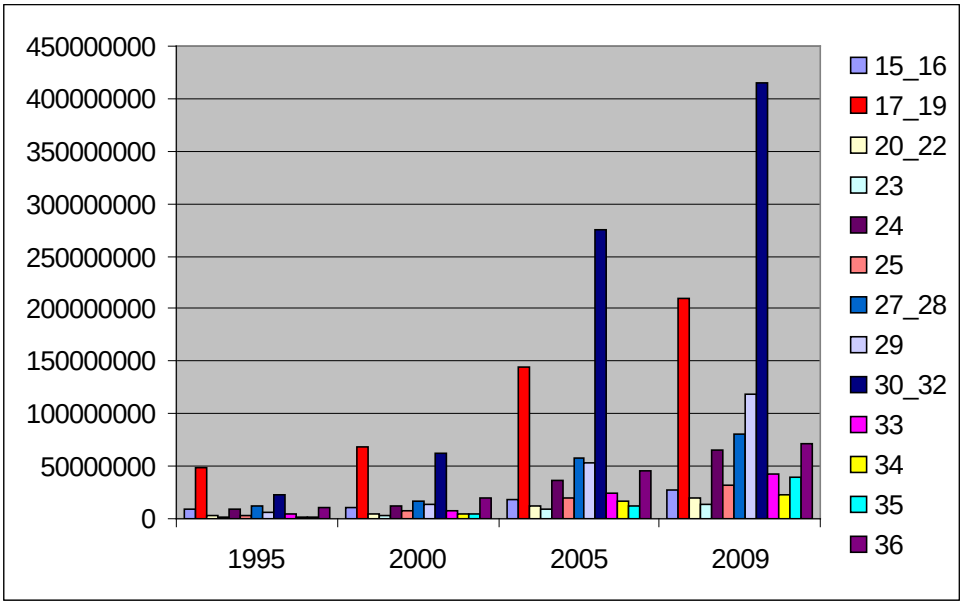
However, the intra-industry intermediate goods are the most important type of imports. This can be seen in Figure 4, which shows the share of intra-industry intermediate goods imports to total manufacturing intermediate goods imports. The above four sectors exhibit by far the highest shares, whilst food products (15_16), wood and paper products (20_22), and motor vehicles (34) show also significant shares. On the other hand, it has to be noted that production fragmentation is found in other manufacturing industries as well as. In addition, the extent of fragmentation shows an increasing trend in all sectors, indicating to some degree that China's production sharing is slowly extending to other activities.

## 4. Linking Fragmentation and Export Expansion

Having examined the developments with respect to production sharing, we next turn our attention to the trends and patterns of China's world exports of manufacturing goods. Those patterns are then cross-examined with our findings of section 3. The investigation aims at discerning whether there exists a relationship between the extent of global production sharing and export expansion at the sectoral level for the case of China.

We present the export data for the same 13 sectors of the previous analysis of the intermediate goods imports. Figure 5 shows China's export patterns and developments over the 1995-2009 period. Evidently, electronics and textiles & clothing stand out as the two most export-oriented sectors. Metal products and machinery equipment exhibit a high export value as well. This is also true to a lesser extent for chemicals. Between 1995 and 2009 there is a strong export growth in all sectors. In the electronics, transport equipment, and machinery equipment sectors this export expansion is enormous, achieving a growth of 1750%, 1850%, and 1810%, respectively.

**Figure 5:**
**China's Manufacturing Exports by ISIC Sector, 1995-2009 (in thousands US dollars)**

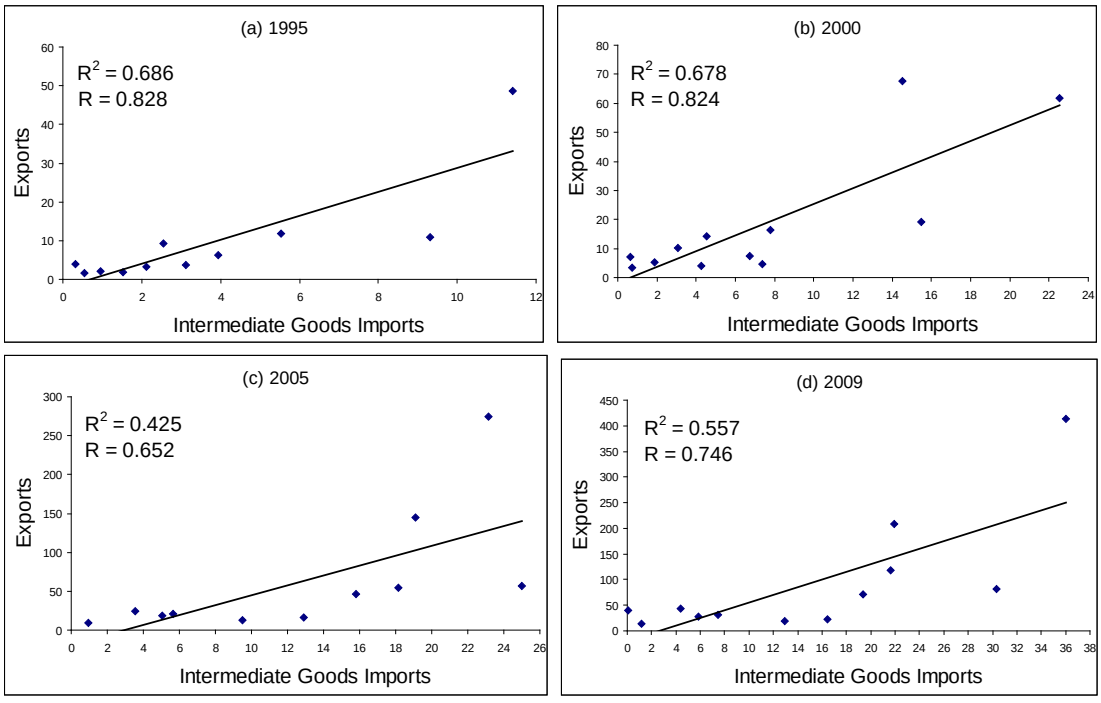



***Source:*** Author's calculations based on data from the UN COMTRADE database.

With the exception of chemicals, there is an indication that sectors that exhibit a high value of intermediate goods imports exhibit also a high export value. Furthermore, it appears that sectors that increase their imported intermediate inputs over time experience an increase in their exports over time. In order to shed more light on this issue, we conduct two sets of correlation and simple regression analyses for our variables of interest.

More specifically, the first analysis concerns the relationship between the total manufacturing intermediate goods imports and exports. The second analysis is for the intra-industry intermediate goods imports variable and exports. As it has already been mentioned, the intra-industry intermediate imports reflect more accurately and relate closer to global production sharing. Though the second analysis is more relevant to our investigation, we conduct both analyses so that we can compare the results. This analysis is performed for each year separately (1995, 2000, 2005, and 2009) as well as for the whole pooled sample. Figure 6, which presents the statistical results, confirms the observation made above by cross-examining the patterns and trends in China's intermediate goods imports and export expansion.

**Figure 6:**
**Correlation and Simple Regression Analysis:**
**Exports and Total Manufacturing Intermediate Goods Imports in China**



In particular, in each of the four years there is a high Pearson correlation coefficient (R) between these two variables. The coefficients are statistically significant at the 1% level, except for the year 2005 where the correlation is significant at the 5% level. It has to be noted that we have excluded the chemicals sector, as it has been determined as an outlier. The correlations with the inclusion of this sector are much lower, but still significant at either the 5% or 10% levels.

With exports as the dependent variable, a linear regression curve has been fitted to the data, as shown in the figure. Though the estimated parameters are not presented, it can be seen that the coefficient of determination ($R^2$) of the regression equation is about 0.68 for the years 1995 and 2000. Thus, the variation in exports is satisfactory explained by the variation in total manufacturing intermediate goods imports. For the other years, the explanatory strength of the regression is only moderate to low (especially for 2005).

**Figure 7:**
**Correlation and Simple Regression Analysis:**
**Exports and Intra-Industry Intermediate Goods Imports in China**

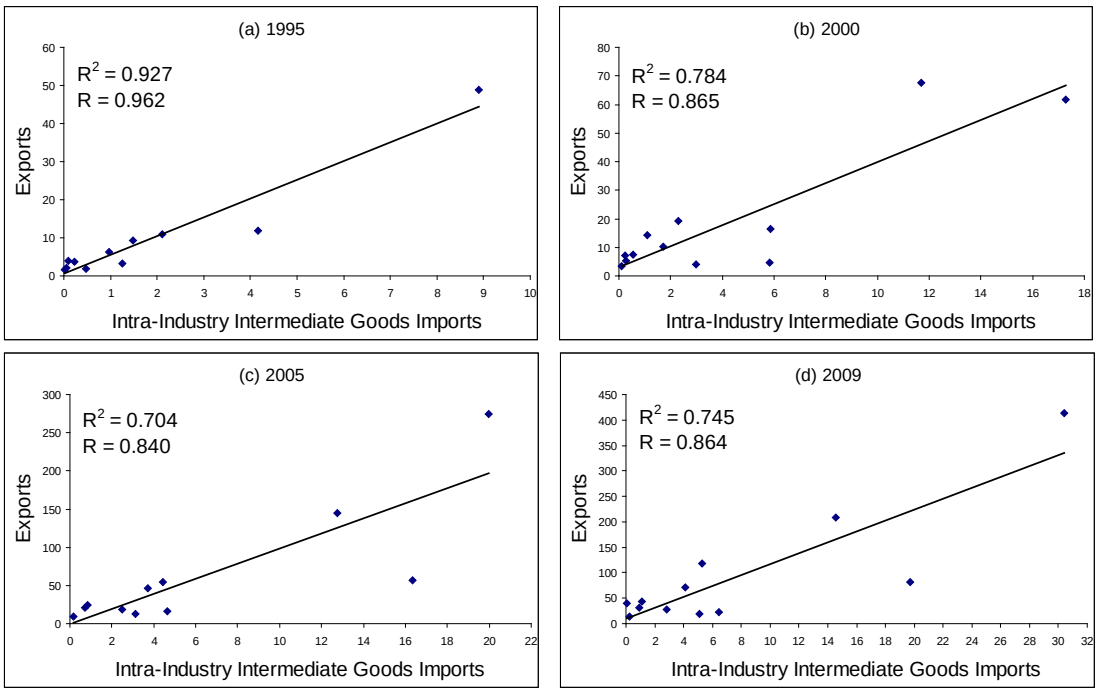
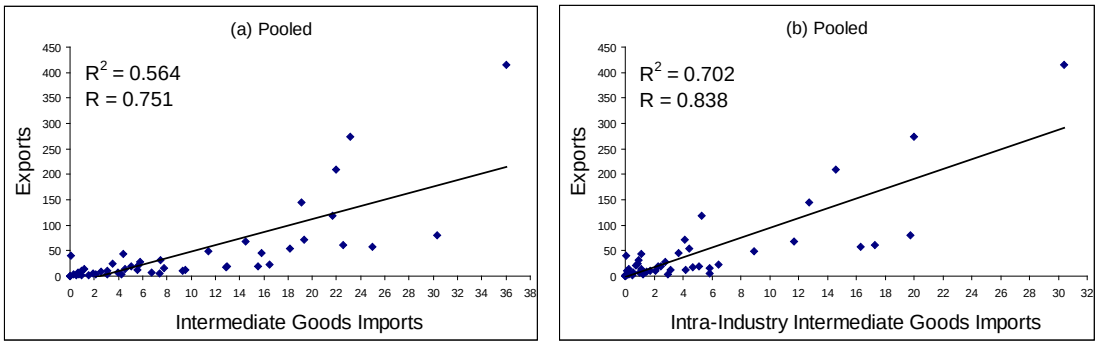



Figure 7 shows the statistical results for the intra-industry intermediate goods imports. It is evident that a very high correlation exists between those imports and the Chinese

manufacturing exports. Furthermore, all the correlation coefficients are highly significant at the 1% level. The coefficient of determination indicates that over 90% and about 80% of the cross-sectoral variance in China's export level can be explained by the cross-sectoral variability in the extent of global production sharing in the years 1995 and 2000, respectively.

For the remaining two years the model fit is slightly lower, but imported intermediate goods still explain a very large part of the observed variance in manufacturing exports. In addition to the above cross-sectional simple regression analyses, we have also estimated two pooled regressions, the results of which are shown in Figure 8. In those analyses the time variation is taken into account as well. The results are consistent with the previous findings.

**Figure 8:**
**Correlation and Simple Regression Analysis for Pooled Sample 1995-2009: Exports and Intermediate Goods Imports in China**




In summing up, according to the two sets of simple regression analyses, the impact of the intra-industry intermediate goods imports on the export level is much stronger and more statistically significant than the effect of imported intermediates from the manufacturing sector in general. Since the former type reflects more accurately the phenomenon of production sharing, our empirical results suggest that China's involvement in global production networks has a positive effect on China's world exports of manufacturing goods.

This finding is produced by a rather simple statistical analysis, where, for instance, the direction of the causality (or other factors affecting China's exports) has not been investigated. Due to lack of data (small number of time-series observations) we cannot conduct Granger causality tests. There is clearly a need for more data and a

more in depth analysis in the future. However, given that there are some theoretical expectations for such a causal link to exist (as discussed in Section 2) and that we have provided some empirical evidence pointing to that link, we may attribute China's impressive export expansion at least partly to the country's involvement in global production sharing.

## 5. Concluding Remarks

The paper has investigated and provided some empirical evidence on the relationship between a country's participation in global production networks and a country's export expansion. Our findings are based on the results of a cross-sectoral statistical analysis for China, a country which is increasingly involved in global production networks. We have found evidence of a positive impact of China's extent of production sharing on China's export performance. This suggests that the impressive export expansion in manufacturing goods that the country has witnessed over the last ten years can be attributed to the country's increasing integration into global production networks.

Interestingly, a related empirical literature suggests that developing countries engaging in global production sharing activities have witnessed a technological upgrade. More specifically, some South-East Asian economies and China have shifted away from simple assembly activities of components towards more skill-intensive stages (Amighini, 2005). In the case of China, the technological advancement that has been achieved in the electronics sector seems to have been particularly facilitated by the country's extensive participation in the global production sharing (Fan, 2008; Gaulier et al., 2007). Furthermore, a more general effect of international technological spillovers may occur to the domestic manufacturing industry from imports and production linkages with technologically advanced economies (Lopez-Pueyo et al., 2009).

In this broader view, global production networks seem to gain even more significance, as they might help a developing country's economy to come into contact with advanced technology. Thus, an important policy implication seems to be hinted by our results coupled with some of the literature's findings. A policy promoting a more extensive involvement in global production sharing may not only positively affect exports but also improve local productive and technological capacity in the long-run.

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