Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development

14-Dec-2009

English - Or. English

STATISTICS DIRECTORATE

STD/SES/WPTGS(2009)16
Unclassified

Cancels & replaces the same document of 06 November 2009

Working Party on International Trade in Goods and Trade in Services Statistics

VERTICAL SPECIALISATION AND GLOBAL VALUE CHAINS

16-18 November 2009, OECD Headquarters, Paris

Topic 4.2 of Item 9 of the Agenda.

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JT03276164

English - Or. English

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EXECUTIVE SUMMARY

1. Advances in transportation and communication technology, together with the low barriers to trade, have contributed in the recent decades to the emergence of a new structure of production and international trade. In several industries, production processes have broken up into several stages or 'production tasks' that are no longer closely tightened in time and space. The reorganisation of production at the world level has implied that each task is now being performed in the location that offers the highest comparative advantage.

2. In this process, many tasks in manufacturing and business services have been either off-shored, through arm's length relationships, or kept inside the firm, by transferring one or several stages of the production process to foreign affiliates. To measure the fragmentation of world production at the global level, this study relies on the methodology of Hummels *et al.* (2001) to determine the amount of international trade that is due to global production chains. Vertical specialisation is measured by the foreign content of countries' exports, i.e. the share of imported inputs in domestic production that is later exported to other countries, either as a final product or as a good-in-process. These estimates (covering 29 OECD countries, four accession countries, and all enhanced engagement countries plus Argentina between 1995-2005) highlight a widespread increase in the degree of vertical specialisation as a share of countries' total exports in all OECD countries except Belgium, Canada and the United Kingdom. Vertical specialisation is higher in manufacturing, but some countries also exhibit high vertical specialisation in some service sectors. The extent of vertical specialisation differs significantly across countries and sectors.

3. The results in this paper constitute ongoing work. The concluding section lists possible areas for further work by the OECD Secretariat to improve the understanding of how vertical supply chains operate.

1. INTRODUCTION

4. The rises in trade flows and in the internationalisation of production are often referred to as the two most salient features of globalisation. Although the internationalisation of production does not necessarily lead to trade (as is the case when foreign direct investment replaces exports as a mean to supply foreign markets), a new structure of international production has emerged in the last decades of the twentieth century that is directly associated with increases in international trade flows.

5. The decrease in international communication costs and further decline in international trade barriers fuelled what Baldwin (2006) called the "second unbundling": the end of the need to perform most manufacturing stages close to each other. Production processes were broken down in several stages and each stage was assigned to the most cost-effective location, while 'service links' (transportation and communication activities) ensured the co-ordination among the several stages of integrated production processes (Jones and Kierzkowski, 2005).

6. This 'second unbundling' effectively weakened the importance of distance and borders and allowed the reorganisation of production processes at a global scale. A new type of specialisation pattern among countries has emerged, as several countries become involved in the production of a single good. In this process, each stage of production is geographically re-assigned according to countries' comparative advantage.

7. As regards trade, the fragmentation of production at the word level caused a rise in the volume and the value of trade flows as inputs cross borders several times along the international production chain before reaching final consumers. Moreover, the international redistribution of the production chain through the geographical relocation of productive activities has led to the emergence of a specific pattern of international trade. As a country specialises in a particular stage of the production of a good along a sequence of stages of production, it imports goods from another country, uses them as inputs in the production of its own good, which is then exported to the country specialised in the next stage of production. This sequence continues till the good reaches its final consumers. The term "vertical specialisation" is used widely in the literature to describe this kind of production process and the resulting trade pattern.[1] Vertical specialisation, or vertical trade, captures one feature of global production networks: the share of intermediate goods that is imported by a country and embodied in the goods that it exports.

8. This paper provides estimates of the degree of vertical specialisation, both at the country and industry levels, for 29 OECD countries (with the exception of Iceland), 4 accession countries (with the exception of Chile) and all the enhanced engagement countries plus Argentina. The estimates of vertical trade are computed using the OECD Input-Output Database, and consequently their availability depends crucially on the existence of country input-output tables. As a result, vertical specialisation values could only be computed for 3 years (1995, 2000 and 2005) and the country coverage varies across years. However, the countries in the dataset represent the bulk of international trade flows. For instance, for the

[1] The terms "vertical specialisation" and "vertical trade" have been used interchangeably in the literature as synonyms of international fragmentation of production, global production or value chains, trade in tasks and multistage production. The term "vertical specialisation" was first coined by Balassa (1967), although the current definition (described in section 2.1) differs slightly from Balassa's initial one.

year 2005, vertical specialisation values are calculated for 30 countries that, taken together, accounted for 75% of total world trade.

9. A number of conclusions can be drawn from the analysis:

- Country-level vertical specialisation as a share of total exports varies widely across countries.
- Small economies have the highest vertical specialisation shares.
- Country-level vertical specialisation grew between 1995 and 2005 in all countries, with the exception of Belgium, Canada and the United Kingdom.
- Most of the growth in vertical specialisation occurred between 1995 and 2000.
- There is a wide cross-sector variation in vertical specialisation within a country.
- There is a wide within-sector variation in vertical specialisation across countries.

10. The rest of the paper is organised as follows. Section 2 presents in detail the measure used to calculate the degree of vertical specialisation, and discusses the features of the global production chain that this measure is able to capture and its limitations. Section 3 describes the main findings at the country- and industry-levels.

2. VERTICAL SPECIALISATION: MEASURING THE FOREIGN CONTENT OF EXPORTS

1.1. Vertical specialisation: concept and measurement

11. The concept of "vertical specialisation" captures the sequential stages of production by measuring the share of imported intermediate inputs used by the economic agents within a country in the production of goods that are later exported to another country for final consumption or subsequent transformation along the production chain.

12. Hummels, Ishii and Yi (HIY, 2001) define the conditions that need to be met for vertical specialisation to occur:

- a good is produced in two or more sequential stages,
- at least two countries provide value-added during the production of the good, and
- at least one country must use imported inputs in its stage of the production sequence, and
- some of the resulting output must be exported.

13. The concept of vertical specialisation is closely related to the statistics of trade in intermediate goods. While the latter measures imports of intermediate goods that are used in countries' production, independently of the destination of the goods produced, *i.e.*, domestic consumption or foreign markets, vertical specialisation is a narrower concept, as it focuses only on the share of intermediate goods that are embodied in exports. However, data on trade in intermediate goods typically rely on somewhat arbitrary classification of goods into intermediate and final goods. Instead, Input-Output tables bypass this problem as they track how each sector's output is used: either as input into other sectors' production or as final demand.

Box 1. The Input-Output Tables

Input-Output tables describe the sale and purchase relationships between producers and consumers within an economy. They can be produced by illustrating flows between the sales and purchases (final and intermediate) of *industry outputs* or by illustrating the sales and purchases (final and intermediate) of *product outputs*. The OECD Input-Output database is presented on the former basis. This partly reflects the collection mechanisms for many other data sources such as research and development (R&D) expenditure data, employment statistics, pollution data, energy consumption, which are in the main collected by enterprise or by establishment, and thus according to industry classifications.

The latest set of OECD Input-Output tables covers 29 OECD countries (currently all OECD member countries except Iceland) and 11 non-member countries (Argentina, Brazil, China, Chinese Taipei, Estonia, India, Indonesia, Israel, Russia, Slovenia and South Africa), for the years 1995, 2000 and 2005 or nearest year. Through the use of a standard industry classification based on ISIC Revision 3, comparisons can be made across countries. Tables for earlier years (before 1995) are al so available, in constant and current prices, covering 10 OECD countries (Australia, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, United Kingdom and United States) and (broadly) five year points from the early seventies through to the early nineties. These were

produced using an earlier system of national accounts (SNA68) and industrial classification system (ISIC Revision 2).

The database is a very useful tool for economic research and structural analysis at international level. It highlights inter-industrial relationships and covers not only manufacturing but also services. Further information for each country and the estimation methodology is available in Yamano and Ahmad (2006). For insights on how the Input-Output Tables can be used to measure globalisation see De Backer and Yamano (2007).

14. Formally, Vertical Specialisation (VS) is defined as the imported input content of exports, or the foreign value-added embodied in exports. The quantitative measure follows directly from this definition: for country *k* and sector *i*, VS is defined as

$$VS_{ki} = \left(\frac{imported\ intermediates}{gross\ output}\right).exports \qquad (1)$$

15. The first term of the equation is the share of imported inputs into gross output in sector *i*. Multiplying this share by the value of exports provides the monetary value for the imported input content of a country's exports in a given sector. This measure takes value zero if the country uses no imported inputs or if it does not export any of its output. For country *k*, the level of vertical specialisation is given by the sum of VS hares across all sectors *i*, $VS_k = \sum_i VS_{ki}$. To allow for cross-country and inter-temporal comparisons, VS shares are generally presented in terms of shares of total exports. The VS share of total exports at the sector and country level are then given by, respectively:

$$VS_{ki}\ share\ of\ total\ exports \equiv \frac{VS_{ki}}{Xk} \qquad (2)$$

$$VS\ share\ of\ total\ exports \equiv \frac{VS_k}{Xk} = \frac{\sum_i VS_{ki}}{\sum_i X_{ki}} = \sum_i \left[\left(\frac{X_{ki}}{X_k}\right).\left(\frac{VS_{ki}}{X_{ki}}\right)\right]. \qquad (3)$$

One important feature of the I-O tables is that they allow calculating the value of imported inputs used *indirectly* in the production of an exported good. Indirectly imported inputs refers to all foreign inputs that are used to produce domestic inputs that are later incorporated in the production of another domestic good, part of which is exported. Using the I-O tables, the VS share of total exports for country *k* is given by:

$$VS\ share\ of\ total\ exports \equiv \frac{VS_k}{X_k} = uA^M[I - A^D]^{-1}X/X_k, \qquad (4)$$

16. where *u* is a 1 × *n* vector of 1's, $\boldsymbol{A}^{\mathrm{M}}$ is the *n* × *n* imported coefficient matrix, $\boldsymbol{I}$ is the identity matrix, $\boldsymbol{A}^{\mathrm{D}}$ is the *n* × *n* domestic coefficient matrix, $\boldsymbol{X}$ is an *n* × *1* vector of exports, X_k is total country exports and *n* is the number of sectors. The term $[I - A^D]^{-1}$ allows capturing the imported inputs content

at the different stages of the domestic production, before these imported inputs become embodied in the good that is exported.

17. Vertical specialisation figures have previously been calculated for 10 OECD countries by HIY for several years between 1970 and 1990 using the OECD Input-Output Database.[2] The authors find that for, the entire 14 countries that constitute their sample, the vertical specialisation share of exports grew by about 30% between 1970 and 1990, and that this growth accounted for about 30% of the growth of the overall export to GDP ratio. More recently, Chen *et al.* (2005) extend the figures calculated by HIY to the years 1995-1998 (depending on the country), but restrain their analysis to 10 OECD countries only.

18. Vertical specialisation has been analysed in many theoretical models. These models typically focus on the conditions under which it may emerge and its impact on factor prices, production, trade patterns and welfare. For instance, Venables (1999) shows that fragmentation of production becomes possible only when transport costs are lowered. Yi (2003) analyses the effect of global tariffs reductions on trade flows, demonstrating that vertical trade grows by more than trade in final goods, due to the multiplicative reduction in production costs when the production of final goods occurs in different stages across countries. Hanson *et al.* (2005) corroborate Yi's (2003) findings: using firm-level data on U.S. multinationals, the authors find that a 1% fall in trade costs leads to a 2-4% increase in the quantity of imported intermediate inputs for further processing by foreign affiliates. Miroudot and Ragoussis (2009) estimate extended gravity equations based on the knowledge-capital model to analyse the determinants of vertical trade over the period 1995-2005, for the countries that comprise this current study. The results of their analysis reveal that vertical trade reacts to the same determinants as total bilateral exports. More specifically, country-level vertical trade appears to be slightly more sensitive than total exports to increases in distance-related costs, while transport costs seem to affect both types of exports in a similar manner. Their sector level analysis shows significant differences in distance-related costs across industries.

19. Burstein *et al.* (2008) investigate the relationship between business cycles and trade in vertically integrated goods. Using data on trade flows between US multinationals and their foreign affiliates, as well as on trade flows between the United States and Mexico through maquiladoras, the authors find that business cycles are more synchronised between pairs of countries with a high share of international trade in inputs used in the production of vertically integrated goods than between countries whose trade is dominated by inputs used in the production of horizontally differentiated goods. The model used by these authors does not consider some additional channels that could further strengthen the link between vertically integrated production networks and the synchronisation of business cycles. For instance, countries engaging in the same vertical production chain may specialise in similar sectors, making them more prone to experience common shocks. Additionally, if vertical production chains occur inside multinational firms, technological shocks are more easily spread across countries.

20. Escaith and Gonguet (2009) study the role of global production networks as transmission channels of financial shocks, in the form of credit constraints. The authors construct a supply-driven indicator and compute the indirect demand-impacts for China, Japan, Malaysia, Thailand and the United States (using international input-output tables computed for 2000 and estimated for 2006). Their results reveal that the real effect of a financial shock propagates between countries when these are linked via a global production chain, albeit at different degrees across countries and sectors. The impact of the shock depends on countries' degree of openness and the size of the originating sector with respect to the rest of the economy. In the period analysed, Japan is shown to be the largest exporter of potential supply shocks, and Malaysia and Thailand to be the most vulnerable, given their high degree of vertical integration in the manufacturing sector. While the propensity of shocks originating in China spreading to the other four

[2] The authors also provide vertical specialisation estimates for Ireland, Korea, Chinese Taipei and Mexico but the data source for these countries is not the OECD Input-Output Database.

economies increased between 2000 and 2006 (due to the increased intensity of its international linkages), China's insulation from external shocks was constant, as the country increasingly relied on domestic suppliers as input sources.

21. Indeed, the consensus is that vertical specialisation plays a crucial role in shaping the current structure of trade flows. For instance, Yi (2009) raises the possibility that vertical specialisation acted as a transmission mechanism of domestic shocks and that it has contributed to the sharp and synchronised decline in trade between end-2008 and spring-2009. Tanaka (2009) argues that vertical specialisation implies higher trade values and volumes due to the pure statistical effect (since trade flows are recorded in gross value, and components of a final good are recorded in trade statistics each time they cross the border along the production chain). Given that GDP is recorded as a sum of value-added, a lower drop in world GDP could be consistent with a much sharper decline in trade flows. Kowalski and Miroudot (2009) also agree that vertical specialisation has contributed to spread of the crisis and to the synchronised drop in trade flows across countries, while arguing that this factor alone cannot account for the magnitude of the trade collapse.

22. Freund (2009) investigates the impacts of past recessions on trade flows, focusing on the periods of global slowdown in GDP growth and global demand in 1975, 1982, 1991 and 2001. The paper presents estimates of the elasticity of global trade volumes to income and shows that its value has increased from under 2% in the 1960s to over 3.5% in the 2000s. The author suggests that this increase may be due to the fragmentation of production, if the incentives to offshore part of the production chain increase with demand. This effect will be magnified by a pure statistical effect: while GDP is measured in terms of value added, international trade flows are measured in gross values; this implies that an increase in the world GDP that raises the incentives to offshore will lead to much higher increases in trade flows. Among the possible explanations of this higher income elasticity of trade volumes are protectionist policies; the fact that manufactured goods (despite their lower share in GDP) constitute a larger share of trade flows compared to services which implies that trade in goods will be hit harder by an economic crisis, as producers switch to domestic suppliers due to lower trust in international transactions and financing. This statistical effect partly explains why the decline in trade is larger than the decline in GDP and is magnified by global production chains, as inputs cross borders several times, embodied in sequential stages of production.

23. Bénassy-Quéré *et al*. (2009) argue that while the value of world trade is a multiple of world production when production is vertically and internationally fragmented, reduction in the world trade are proportional to reductions in the world trade if certain conditions are observed.[3] In particular, when trade flows are deflated using sector-specific trade prices (rather than through world GDP deflator), and when world GDP is calculated by summing up country values at current exchange rates (instead of using purchasing power parities), GDP and trade flows drop in 2009 by similar amounts.

2.2. Shortcomings of existing measures of vertical specialisation

24. Ideally, the computation of VS would require data on the production process and the direction of the trade flow for every stage of the production of each good that is traded. Since this information is seldom available, computation of vertical specialisation has typically relied on the information contained in the Input-Output tables, as they provide all the data needed to calculate the measure: imported inputs, gross output and exports. Additionally, the OECD Input-Output Database has the advantage of providing a consistent set of information that facilitates comparison of data across sectors, countries as well as over time.

[3] This result is obtained if imported inputs remain a fixed proportion of output, exported final products remain a fixed proportion of foreign income and relative prices are held constant.

25. However, the level of sector aggregation in the input-output tables can lead to biases in the computation of the "true" level of country and sector vertical specialisation. At the sector level, whenever there is a positive (negative) correlation between exports and the imported inputs to gross output ratio, the calculated VS values will be downward (upward) biased.

26. The measure of vertical specialisation has another shortcoming which does not concern measurement issues *per se*, but rather is directly linked to the concept itself. Indeed, by definition, vertical specialisation does not capture a country's involvement in global production chains if the country specialises in the first stage of the vertical chain, *i.e.* if the country exports goods that are used as inputs in subsequent stages of the production of an exported good in another country. This stage of the international supply chain is labelled in the literature as "VS1" and can be expressed as:

$$VS1_K = \sum_{j=1}^{J} \left[exported\ intermediates\ to\ country\ j * \frac{exports\ \ of\ country\ \ j}{gross\ \ output\ \ of\ country\ \ j} \right]. \qquad (5)$$

27. VS1 is more difficult to measure than the subsequent stages of the vertical chain, as calculation requires not only matching trade data to the input-output tables, but also having access to the input-output tables of all the trading partners of country K. In an earlier version of their paper, HYI provide some rough estimates of country-level VS1 for 9 OECD countries, finding that VS1 as a share of the country's exports ranged from 1% to 8% between 1970 and 1990. The U.S., Germany, and the Netherlands are the countries with the highest VS1 shares, while Australia and Canada are those with the lowest shares.[4]

28. Finally, it should be noticed that while measures of vertical specialisation capture the importance of global production chains in international trade, it does not allow identifying the "actors" that shape international value chains. In other terms, because it is computed at the sectoral level, the concept of vertical integration does not allow distinguishing between the share of vertical trade that is conducted inside a multinational firm and the share that takes place through arm's length relationships.

[4] VS1 values were computed using only top export destinations and under the assumption that importing countries use inputs in their production processes with the same intensity (i.e. independently of the country they originate from). The authors also present more detailed calculations for the U.S. trade with Canada and Mexico and find that in 1997 the U.S. VS1 share of exports was about 8.2%. The earlier version of HIY's paper can be downloaded at: http://www.newyorkfed.org/research/staff_reports/sr72.pdf.

3. RESULTS

3.1. Country-level vertical specialisation

29. Table 1 in the Annex lists the level of vertical specialisation as a share of a country's total exports for the years of 1995, 2000, and 2005.[5] The first thing to notice is that the degree of vertical specialisation has increased between 1995 and 2005, although at a slower pace in the early 2000s. Figure 1 displays vertical specialisation shares for the countries with values above 40%. These countries are small economies, most of them with a significant presence of multinationals: the Central and Eastern European Countries (Czech Republic, Estonia, Hungary, Slovak Republic and Slovenia) together with Ireland, Luxembourg, Korea and Israel.[6] The value of vertical specialisation in these countries lies very close to or above 50% in 2000 and 2005, well above the average (across countries) values of 30% in 2000 and 33%, in 2005.[7]

30. On the other end of the spectrum, Australia, Japan and the United States are the OECD member countries with the lowest degree of vertical specialisation. This result is in line with previous findings (Hummels *et al.,* 1998; HIY). Due to the size of their economies or geographical location, these countries are generally more able to keep production of every stage of a good within their borders, relying less on foreign inputs for domestic production. Another possible explanation relates to the stage of the global vertical production chain in which countries are involved in. If a country engages mainly in the first stage of the vertical production process, exporting inputs that are either assembled elsewhere or part of the production process occurring in another country, its degree of vertical specialisation (as measured in this paper) will be low. Indeed, this measure only captures the degree of foreign content embodied in domestic exports while excluding the exports of raw materials and the inputs of those countries that specialise in the first stage of the international production chain. Outside the OECD area, Russia, Argentina, Brazil, India and South Africa also exhibit low values of vertical specialisation, which lie below 15%.

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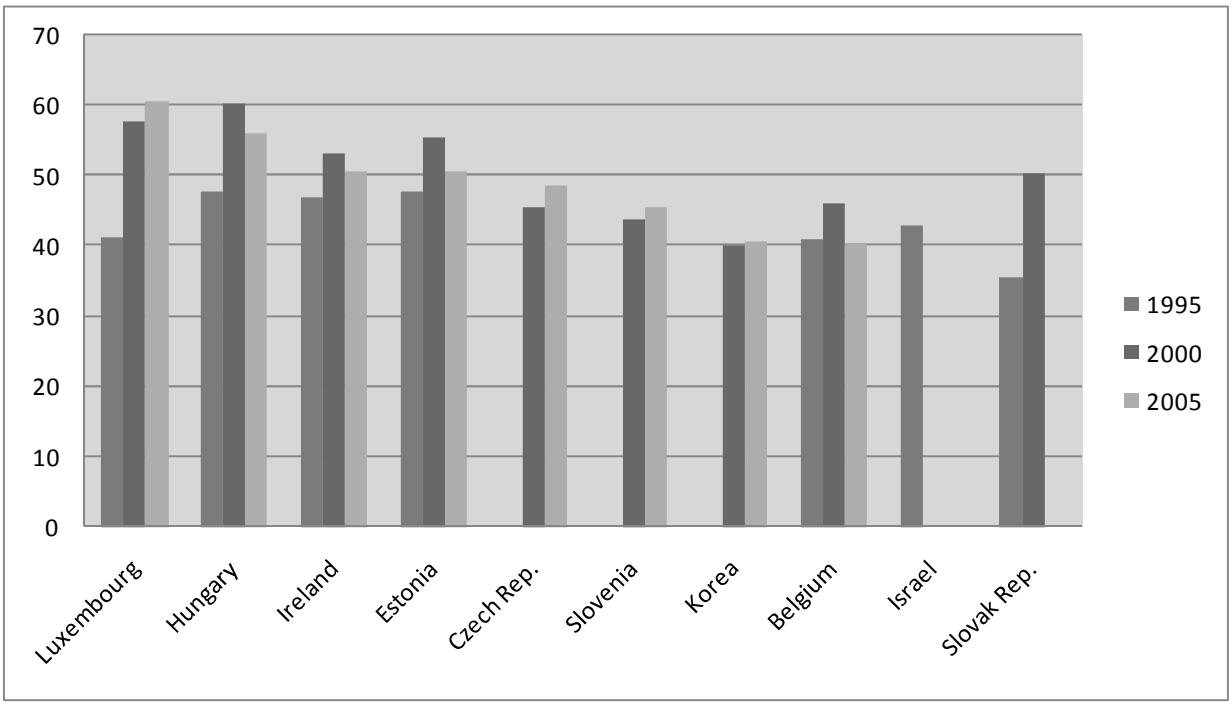
5 For some countries, the Input-Output tables were computed for nearby years. See Table 42 in the Annex for information regarding the exact years for the countries covered in the OECD Input-Output tables.

6 Data for Israel is only available for 1995.

7 These values were obtained by taking a simple average of the index of vertical specialisation across countries for each available year. Averages do not change by much if a standardised sample is used. If the sample is restricted to the countries for which the index is available in all 3 periods, averages are around 320% in both 2000 and 2005. If the values for 1995 are excluded, and the sample limited to those countries for which the index is available for both 2000 and 2005, mean values are 30% and 33%, respectively.

Figure 1. Countries with the highest degree of vertical integration shares of countries' exports, values in %



31. In the period under analysis, the importance of vertical specialisation has grown in all countries with the exception of the United Kingdom, Belgium and Canada. In the United Kingdom, vertical specialisation declined by 17% between 1995 and 2005, whereas in both Belgium and Canada values dropped by around 12%.

32. By contrast, Japan, Greece, China, Poland and Luxembourg experienced higher vertical specialisation between the mid-1990s and the mid-2000s (Table 1), with increases above 70% for the first four countries. However, the magnitude of the increase in the degree of vertical integration can be explained by the low initial values in these countries.

33. As for the countries that are considered as destinations of offshoring and export processing activities, only Mexico has a degree of vertical specialisation above the sample average in 2005. India is one of the countries with the lowest values of vertical specialisation, ranging between 10% in 1995 and 13% in 2005. Conversely, China records a low value of vertical specialisation in 1995 (16%), but rising rapidly in subsequent years (to a value of 28% in 2005).

34. As mentioned in Section 2, the sector aggregation used in the computation of the Input-Output Tables can lead to bias in the measurement of vertical specialisation. HIY provide evidence of the aggregation bias by calculating VS shares of exports using several levels of sectoral aggregation in the input-output table of Korea in 1995. They find that more disaggregated sectoral data leads to higher estimates of the degree of vertical integration. This suggests that the use of more aggregated data may lead to downward bias in the calculation of the degree of vertical integration. However, the magnitude of the bias is small: the VS share increases only by 1.6 percentage points when the number of sectors used in its computation increases from 28 to 168 sectors. Since the I-O tables are typically not available at different

levels of disaggregation, it is difficult to ascertain with accuracy the direction of the bias for other countries.

Table 1: Largest changes in the degree of vertical specialisation by country, 1995-2005

Top 5 increases:				
Country	**1995**	**2000**	**2005**	**% increase**
Japan	9.44	10.76	16.97	79.66
Greece	15.75	28.30	28.11	78.45
China	16.39	22.04	28.25	72.42
Poland	16.80	25.00	28.73	71.05
Luxembourg	41.36	57.75	60.54	46.38
Negative growth rates:				
Country	**1995**	**2000**	**2005**	**% decrease**
UK	22.52	20.52	18.69	-16.98
Canada	31.48	30.84	27.25	-13.45
Belgium	41.01	46.16	40.42	-1.44

35. More generally, the sector aggregation in the I-O tables is likely to lead to biases in measuring the true level of vertical specialisation whenever there is a correlation between the sector VS shares and sector level export output ratios. VS shares will be underestimated if this correlation is positive (*i.e.* the sectors with higher VS shares are also the ones that are more export intensive) and overestimated in case the correlation is negative. These correlations are positive and significant (at 5% significance level) for 29 out of the 40 countries that comprise the OECD dataset.[8] Moreover, they are particularly high for those countries with high VS shares, or for which processing exports accounts for large percentages in total trade (such as Hungary, Mexico and Slovenia).

36. Another approach to assess the existence and the direction of the aggregation bias is to compare, for each country-year pair, the ratio of the country-level imported inputs to country-level gross output, on one side, with the aggregated VS share value obtained by adding up the sector VS values, on the other. For all the countries in the dataset, the VS shares are higher than the country-level imported inputs to output ratios, albeit with large differences across countries. These results suggest that the estimated VS shares are likely to be underestimated and may be interpreted as providing a lower bound for the share of vertical specialisation in countries' trade flows.[9]

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8 The correlations between sector level exports and imported input to gross output ratios were computed for each country, first aggregating all the years for which I-O tables are available and subsequently for each country-year. The countries for which the correlation is not significant are Argentina, Australia, India, Indonesia, Japan, Norway, Russia, South Africa and Turkey.

9 Recent research suggests that the level of vertical specialisation is underestimated in countries with high shares of export processing trade, that is, countries for which the import input share embodied in processing exports is likely to be higher than the one embodied in traditional exports. Koopman *et al.* (2008) developed an algorithm that generates two sets of input-output coefficients, one for processing exports and another for non-processing exports, by combining trade data with the input-output tables. Dean *et al* (2008) compare the VS estimates obtained by applying the HIY method with the ones obtained applying the method proposed by Koopman *et al.* to Chinese trade. They find that nearly always the latter method provides higher VS shares. Nevertheless, both methods identify a very similar list of sectors with high levels of vertical specialisation. Chen *et al.* (2009), based on a similar methodology, find that non-processing exports in China had a higher effects on domestic value added and employment than processing

37. Finally, it is worth stressing that the measure of vertical specialisation presented in this paper does not capture the participation of a country in the international supply chains when the country specialises in the exports of goods that are used as inputs into another country's production of exports goods. Hence, it may well be the case that a country registers lows vertical specialisation shares although it is involved in global production networks. In an earlier version of their paper, the authors presented more detailed calculations for the U.S. trade with Canada and Mexico and find that in 1997 the U.S. VS1 share of exports was about 8.2%.

3.2. Sector-level vertical specialisation

38. Tables 2 to 41 in the Annex list the sector vertical specialisation shares for each country in the dataset. Three facts clearly stand out from the analysis.

First, manufacturing VS levels are typically higher than the ones found for services. The only sector outside manufacturing appearing in the top 12 positions of sectors with higher VS shares is water transport, but with very high shares (above 60%) for Denmark, Korea and Israel.

Second, within each sector, VS shares vary widely across countries. For instance, in the 'finance and insurance' sector in 2000 and 2005, the VS share reached almost 70% in Luxembourg, but amounted to less than 5% in Brazil, India and Argentina.

Third, there is also a wide dispersion in sector-level VS shares within a country, both in services as well in manufacturing. For instance, in Ireland, VS shares in manufacturing in 2005ranged from 27% in 'non-metallic mineral products' to 80% in 'office, accounting and computing machinery'.

39. Figure 2 depicts the sectors with the highest average VS shares in the period 1995-2005. While 'coke, refined petroleum products and nuclear fuel' and 'iron & steel' occupied the top two positions in 1995, none of the sectors is present in the list of the 5 most vertically specialised sectors in 2000 and 2005. In 2005, the top 3 sectors with the highest VS shares are, in decreasing order, 'office, accounting and computing machinery', 'motor vehicles' and 'electrical machinery'. As for the 'radio, TV and communication equipment' sector, it ranked in the top third position in 1995, but was no longer part of the five most vertically specialised sectors either in 2000 or in 2005.

40. In all six sectors with the highest degree of vertical integration, average vertical specialisation shares increased between 1995 and 2005, with the largest increase in the 'office, accounting and computing machinery' and 'iron & steel' sectors. Conversely, the degree of vertical integration was stabile in the 'radio, TV and communication equipment' and in the 'coke, refined petroleum and nuclear fuel' sectors. The representativeness of the countries with the highest sector VS shares is fairly stable throughout the period 1995-2005; all countries increase or maintain their level of vertical integration, with the exceptions of Ireland in the 'electrical machinery' and 'iron & steel sectors', Finland in the 'office, accounting and computing machinery' sector, and Hungary in the 'iron & steel' sector.

41. Figure 2 also highlights large cross-country dispersion in VS shares. The degree of dispersion decreased in all sectors, with the exception of the 'iron & steel' sector, where it remained fairly stable between 1995 and 2005. The decrease in the cross country dispersion of vertical integration is mainly due to the increase of VS shares recorded in the countries with the lowest values.

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exports in all sectors between in 1995 and 2002; they further report that traditional manufacturing sectors such as textiles have higher domestic content shares than sectors such as machinery or electric and telecommunication equipment.

Table 2. Largest Variations in Vertical Specialisation in Country-Industry Pairs

Top 5 increases:				
Country	**Sector**	**1995**	**2000**	**2005**
India	Building and repairing of ships and boats	8.85	15.91	46.03
India	Office, accounting and computing machinery	6.48	18.26	27.90
Greece	Building and repairing of ships and boats	10.94	17.81	27.27
Japan	Radio, TV and communication equipment	8.66	11.64	21.50
India	Wood and products of wood and cork	3.51	6.78	8.60
Top 5 decreases:				
Country	**Sector**	**1995**	**2000**	**2005**
Indonesia	Medical, precision and optical instruments	57.8	26.79	27.12
Greece	Medical, precision and optical instruments	32.47	29.58	18.84
Indonesia	Non-ferrous metals	22.93	19.46	13.39
Greece	Radio, TV and communication equipment	32.72	26.97	19.18
Indonesia	Manufacturing n.e.c.	31.60	21.51	18.89

42. Figure 3 presents the country-industry pairs with the highest levels of vertical specialisation for each year in the dataset. The graphs show clearly the persistence over time of the country-industry pairs that exhibit the highest VS shares. In all years, 'radio, TV and communication equipment' in Estonia registers the highest VS share, followed by 'office, accounting and computing machinery' in Hungary in 1995 and 2000, which is surpassed by Czech Republic in 2005. The figures show a dominance of specific countries and sectors with the highest VS shares. These countries are typically the Eastern European Countries (Estonia, Hungary, Czech Republic and Slovak Republic) and Ireland. The sectors with the highest VS shares are found in manufacturing: 'radio, TV and communication equipment', 'office, accounting and computing machinery' and 'motor vehicles'.

43. Table 2 lists the country-industry pairs with the largest variations in their VS shares between 1995 and 2005.[10] The largest increases are recorded in the manufacturing sector, in countries with low initial VS values. As for the sectors with the highest average VS shares, the 'office, accounting and computing machinery' sector registered the largest percent increase in India. The highest increase in the VS shares of the 'radio, TV and communication equipment' sector occurred in Japan, while its largest decrease took place in Greece. Also worth of notice is the increased importance of 'building and repairing of ships' in India, with a VS share of 46% in 2005. The largest decreases occurred in the 'medical, precision and optical instruments' sector in Indonesia and Greece: both countries account for the largest 5 drops in sector VS shares.

[10] The countries for which the Input-Output tables were not available in 1995 and 2005 were excluded from the analysis.

4. CONCLUSION AND NEXT STEPS

44. The current crisis has brought renewed interest in vertical specialisation as a factor contributing to the sharp decline in trade flows and to the transmission of domestic shocks. This paper reviews the main findings from this literature and presents estimates of the size of vertical specialisation. The proposed measure attempts to capture the sequential stages of production by measuring the share of imported intermediate inputs used within a country to produce goods and services that are later exported to another country either for final consumption or for subsequent transformation along the production chain

45. The estimates presented in this paper constitute work in progress. In order to capture structural changes in global production chains, future work will aim to calculate vertical specialisation measures for the years prior to 1995, for all OECD countries which have Input-Output tables prior to that date. This extension will contribute to identify long-term changes in countries' engagement in global production networks, as well as the sectors that have become more vertical specialised over time, but it will require reducing the sector disaggregation from 48 to 35 sectors. Further work in the OECD Statistics Directorate will also analyse how the sharp changes in oil prices have affected vertical specialisation. Work could also be undertaken to better understand the drivers of vertical specialisation over time and across countries (*i.e.* to explain how much of the variation in VS shares is due to changes in sectoral VS shares and how much is due to changes in the sector's contribution to a country's overall exports).

46. Other parts of the OECD Secretariat are undertaking work on global vertical chains. The 2008 meeting of the OECD Working Party on Industry Analysis (WPIA) discussed the methodologies underlying the content and characteristics of published bilateral trade data, identifying issues that will need to be addressed in the future (e.g. the presence of re-exports, and their implications for analyses linking country I-O tables with bilateral trade for the purposes of multi-regional input-output analyses). The OECD Directorate on Science and Technology also launched a project to compute Input-Output tables for Europe as a single region, in cooperation with IDE-JETRO.[11]

47. Other organisations are engaged in better understanding global value chains. The EC is funding a three-year project to construct a World Input-Output Database. The OECD is involved in this project, which is led by a team from the University of Groningen in the Netherlands; in particular, the OECD will host a two-day meeting in early-December where Consortium members join experts to discuss data issues and determine best practices concerning I-O data, trade data, multi-regional tables and various satellite accounts – social, economic and environmental. Finally, the World Trade Organisation is considering developing indicators of trade flows in terms of value added (i.e. to take into account the import content of exports), so as to overcome some of the limits of "gross" trade statistics.

[11] Further information on this project and others regarding the OECD Input-Output Tables can be found in Yamano and Webb (2009).

Figure 2. Sectors with Highest Average Vertical Specialisation Shares (%): 1995-2005

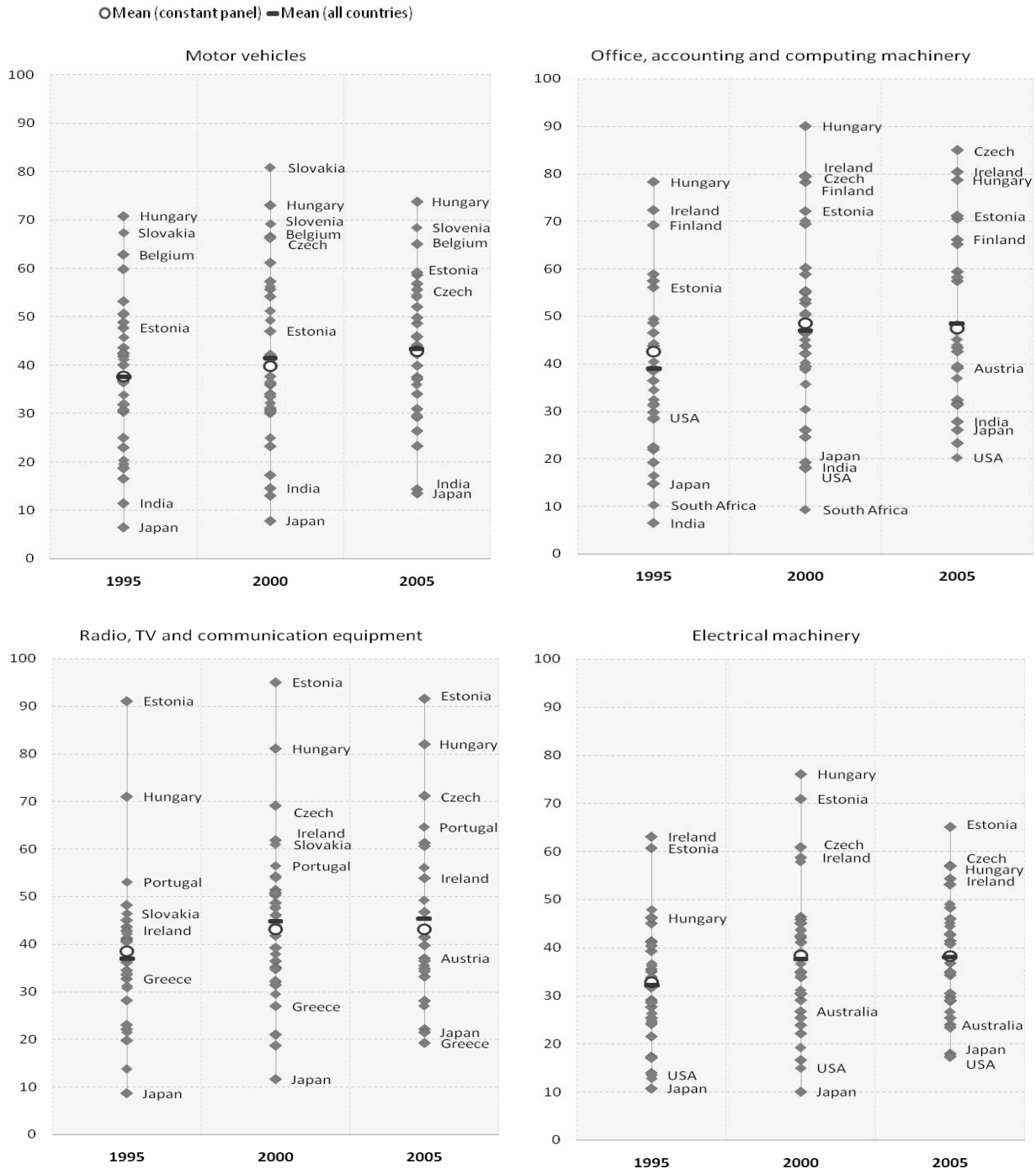


Figure 2. Sectors with Highest Average Vertical Specialisation Shares (%): 1995-2005 (cont.)

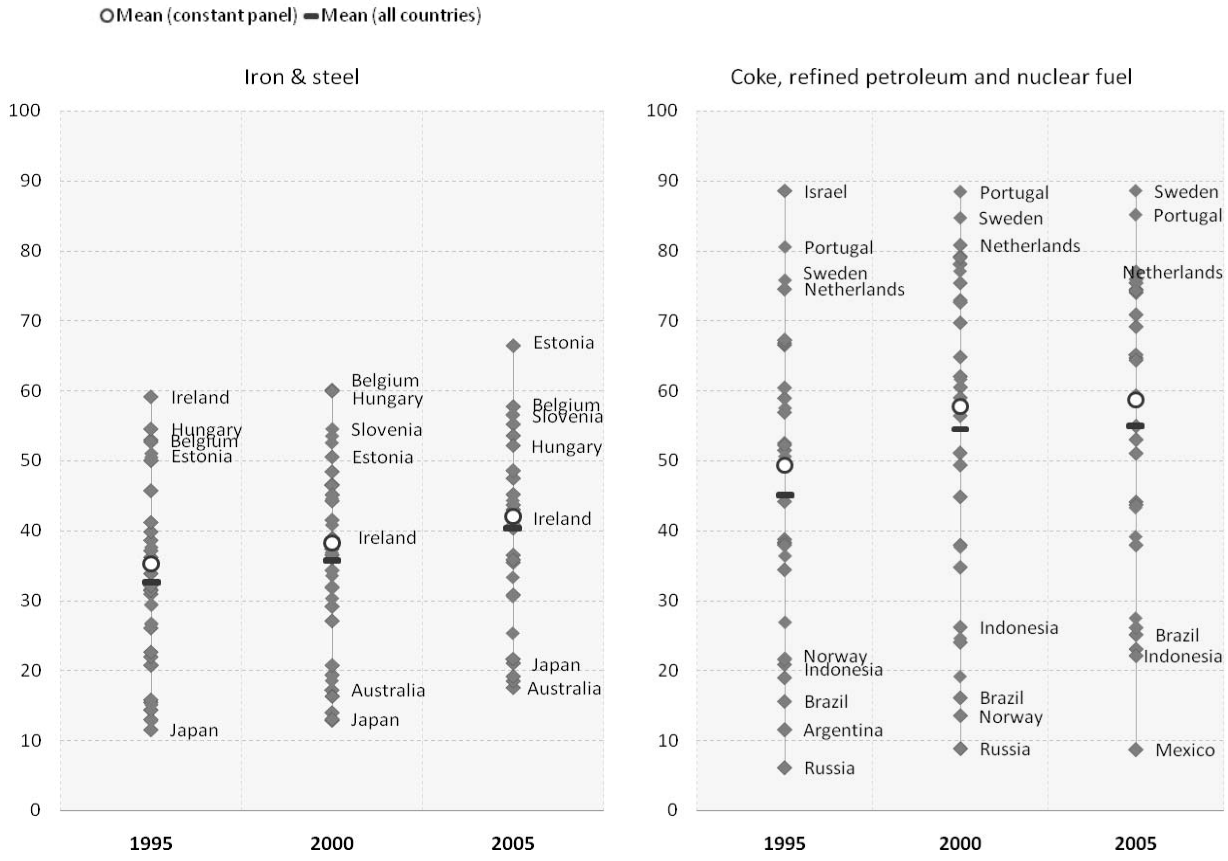
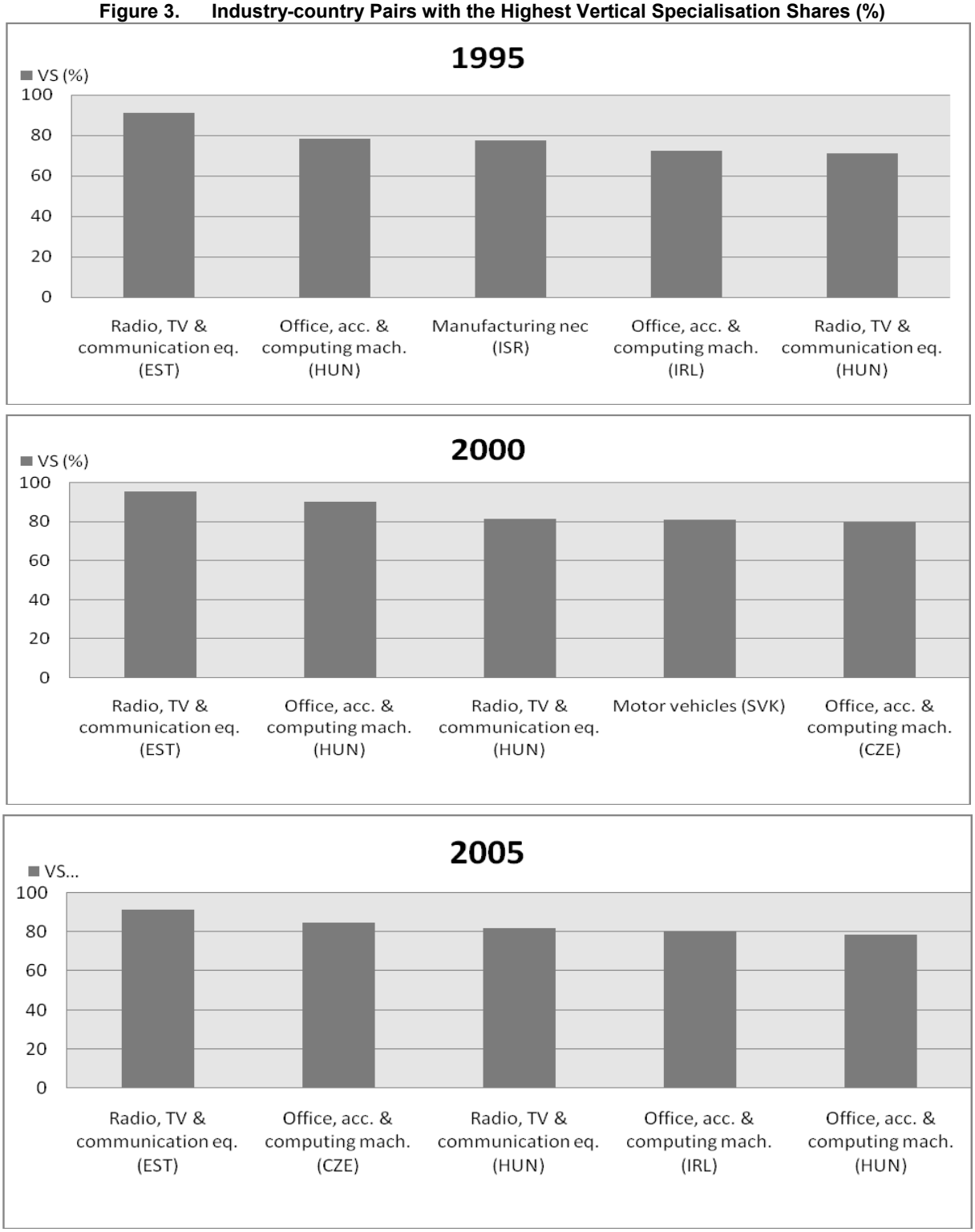


Figure 3. Industry-country Pairs with the Highest Vertical Specialisation Shares (%)



REFERENCES

Bénassy-Quéré, A., Decreux, Y., Fontagné, L. and Khoudour-Casteras, D. (2009), "Economic Crisis and Global Supply Chains ", *CEPII Working Paper*, n. 2009-15.

Balassa, B. (1967), *Trade Liberalization among Industrial Countries*, McGraw-Hill, New York.

Baldwin, R. (2006), "Globalisation: the great unbundling(s)", in *Globalisation Challenges for Europe*, Secretariat of the Economic Council, Finnish Prime Minister's Office, Helsinki.

Burstein, A., Kurz, C. and Tesar, L. (2008), "Trade, Production Sharing and the International Transmission of Business Cycles", *Journal of Monetary Economics*, 55, pp. 775-795.

Chen, X., Cheng, L., Fund, K.C, Lau, L. Sung, Y.W., Yang, C., Pei, J. and Tang, Z. (2009), "Domestic Value Added and Employment Generated by Chinese Exports: a Quantitative Estimation", *Santa Cruz Institute for International Economics*, WP 09-07.

Chen, H., Kondratowicz, M. and Yi, K-M. (2005), "Vertical Specialisation and Three Fact about U.S. International Trade", *North American Journal of Economics and Finance*, 16, pp. 35-59.

De Backer, K. and Yamano, N. (2007), "The Measurement of Globalisation Using International Input-Output Tables", *STI Working Paper* 2007/8, DSTI/DOC(2007)8.

Dean, J., Fung. K.C. and Wang, Z. (2008), "How Vertically Specialised is Chinese Trade?", *BOFIT Discussion Papers*, 31/2008, Bank of Finland.

Escaith, H. and Gonguet, F. (2009), "International Trade and Real Transmission Channels of Financial Shocks in Globalized Production Networks", *Staff Working Paper*, ERSD-2009-06, WTO, Economic Research and Statistics Division.

Freund, C. (2009), "The Trade Response to Global Crisis: historical evidence", *World Bank Working Paper*, n. 5015

Guo, Webb and Yamano, N. (2009), "Towards Harmonised Bilateral Trade Data for Inter-Country Input-Output Analyses: Statistical Issues", *STI Working Paper*, 2009/4.

Hanson, G., Mataloni, R. J., and Slaughter, M. (2005), "Vertical Production Networks in Multinational Firms", *The Review of Economics and Statistics*, 97:4, pp. 664-678

Hummels, D., Ishii, J. and Yi K-M (2001), "The Nature and Growth of Vertical Specialization in World Trade", *Journal of International economics*, 54, pp. 75–96.

Hummels, D., Rapoport, D. and Yi, K-M. (1998), "Vertical Specialisation and the Changing Nature of World Trade", *FRBNY Economic Policy Review*, June, pp. 79-99.

Jones, R. and Kierzkowski, H. (2005), "International Fragmentation and the New Economic Geography", *North American Journal of Economics and Finance*, 16, pp. 1-10.

Koopman, R., Wang, Z. and Wei, S-J. (2008), "How Much of Chinese Exports is Really Made in China? Assessing Domestic Value-Added when Processing Trade is Pervasive", *NBER Working Paper*, n. 14109, National Bureau of Economic Research.

Kowalski, P. and Miroudot, S. (2009), "Explaining the 2008-2009 Trade Collapse: trade multipliers, the role of trade composition and vertical specialisation", in Trade and Economic Effects of Responses to the Economic Crisis – preliminary results, OECD TAD/TC(2009)2.

Miroudot, S. and Ragoussis, A. (2008), "Vertical Trade, Trade Costs and FDI", *OECD Trade Policy Working Paper*, no. 89, TAD/TC/WP(2008)23/FINAL.

Tanaka, K. (2009), "Trade Collapse and Vertical Foreign Direct Investment", VoxEU.org, May 7.

Venables, A. (1999), "Fragmentation and Multinational Production", *European Economic Review*, 4 (4/6), pp. 935-945.

Yamano, N. and Webb, C. (2009), "OECD Input-Output Tables and Related Analytical Work", OECD DSTI/EAS/IND/WPIA(2009)10.

Yamano, N. and Ahmad, N. (2006), "The OECD Input-Output Database: 2006 Edition", *OECD Science, Technology and Industry Working Papers*, 2006/8.

Yi, K-M. (2009), "The Collapse of Global Trade: the role of vertical specialization", in Baldwin, R. and Evenett, S. (eds.), *The Collapse of Global Trade, Murky Protectionism, and the Crisis: Recommendations for the G20,* E-book, VoxEU.org Publication, London, downloadable at: http://www.voxeu.org/reports/Murky_Protectionism.pdf.

Yi, K-M. (2003), "Can Vertical Specialisation Explain the Growth of World Trade?", *Journal of Political Economy*, vol. 111(3), pp. 52-102.