Decomposing net trade in value added and the patterns of trade in factors

Neil Foster[⋆], Robert Stehrer[⋆], and Gaaitzen de Vries[∗]

[⋆] The Vienna Institute for International
Economic Studies (wiiw)
Rahlgasse 3, A-1060 Vienna, Austria.

[∗] University of Groningen (RUG)
9700 AB Groningen, The Netherlands.

Corresponding author: Robert.Stehrer@wiiw.ac.at

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Abstract

Based on recent approaches to measuring the factor content of trade when intermediates are traded we decompose value added trade and its components (capital and labor, as well as their subcomponents ICT and Non-ICT capital and educational attainment categories) distinguishing between direct, indirect and re-imports and -exports of value added and trade in factors. This adds to the literature by simultaneously considering both exports and imports which allows one to focus on the patterns and dynamics of net value added trade and its components rather than vertical specialization patterns based on exports. As an extension we differentiate net value added trade flows resulting from trade in intermediate and final goods. The analysis can further be broken down to the industry level and to bilateral trade relations. Empirically we present results of an application of the proposed decomposition method based on the recently compiled World Input-Output Database (WIOD) covering 40 countries and 35 industries over the period 1995-2006. We show that direct value added exports and imports dominate but that the indirect part was increasing over time. This also holds for trade in factors with larger increases observed for high-educated labor for example . Patterns of trade in net value added closely resemble net trade flows but there are distinct patterns when looking at individual factors. For example, NAFTA countries are net exporters of high-educated labor mostly to EU-15 but have increasingly become net importers of low-educated labor from China.

Keywords: factor content of trade; trade integration; net value added trade; vertical specialization

JEL-classification: F1; F15; F19;

Contents

DECOMPOSING NET TRADE IN VALUE ADDED AND THE PATTERNS OF TRADE IN FACTORS

1 Introduction

Trade in value added has become an increasingly debated topic due to the rapid integration of production processes and the further inclusion of countries in this process. Though this process has been ongoing for quite some time there have been rapid integration processes in the world economy taking place over the last decade or so. In the 1990s this was the creation of the North American Free Trade Agreement (NAFTA) concerning the US, Canada and Mexico and the integration of formerly communist countries with Western EU countries which started after the transformational recession in these countries and led to the accession of some countries into the European Union in 2004. Further, large developing countries such as Brazil, Russia, India and China (and Indonesia and South Africa to a lesser extent) - termed the BRIC, BRIIC, or BRICS countries - became important players on world markets at least in particular industries. This implied an increase in overall trade flows in the world economy with increasing shares of imports and exports between these newly integrating countries and the developed world. This integration of trade flows in the world economy was further accompanied by increasing foreign direct investment activities. One particular feature of this integration process was also the integration of production structures in the sense that firms offshore activities to other countries to exploit cost advantages in particular stages of production. This integration of production processes has been theoretically analyzed under different headings including 'fragmentation', 'slicing up the value chain', 'outsourcing' and 'offshoring' or the 'great unbundling' and recent contributions emphasizing 'trade in tasks'.

From an empirical point of view there is still the challenge to properly measure this ongoing integration of production processes. The literature ranges from particular case studies for products like the Barbie doll (Tempest, 1996), the iPod (Linden et al., 2009; Varian, 2007), computers (Kraemer and Dedrick, 2002), or the Nokia N95 (Ali-Yrkkoö, 2010) or more complex products like cars (Baldwin, 2009) or airplanes (Grossman and Rossi-Hansberg, 2008), to studies of trade patterns in particular products such as 'parts and components' and overall trade in intermediates versus trade in final goods (Miroudot et al., 2009; Stehrer et al., 2011) and a number of studies focusing on the magnitude and changes of 'vertical specialization' patterns. In the European context the changes in the international structure of production are discussed from a multi-disciplinary point of view in Faust et al. (2004). This book also provides a

number of case studies at the level of industries (the automobile industry, the electronics industry, and the apparel industry). Other recent studies focus on measuring trade in value added between countries thus trying to measure how much of value added created in the production process in one country is exported thus 'netting out' the value already embodied in imported products and the extent of 'vertical specialization' or 'vertical integration' (Hummels et al., 2001; Daudin et al., 2009; Johnson and Noguera, 2009; Koopman et al., 2010), with an overview of these approaches provided by Meng and Yamano (2010); see also Meng et al. (2011) for a decomposition of vertical specialization measures. Related to these are papers on the measurement of trade in value added, examples including Escaith (2008); Maurer and Degain (2010); Timmer et al. (2011). Further there are a number of papers with a focus on the Asian production and trade network (recent examples include Meng and Inomata, 2009; Hiratsuka and Uchida, 2010; Yamano et al., 2010).

In the international trade literature this issue has to some extent been addressed over a number of years with work measuring the factor content of trade flows. The seminal contribution in this respect was that of Vanek (Vanek, 1968) and the so called Heckscher-Ohlin-Vanek model; for a recent overview see (Baldwin, 2008). In this model the perspective switches from that on trade in goods to trade in factors of production embodied in the goods traded. Empirically, this goes back even earlier to the important contribution of Leontief (Leontief, 1953) which triggered a number of subsequent studies focusing on the 'Leontief paradox'. Only recently have there been successful attempts to solve this 'paradox' by allowing for (Hicks neutral) technology differences across countries (Trefler, 1993). One particular concern in these contributions was to properly account for trade in intermediate products, an issue which has been the focus of some recent contributions including those of Davis and Weinstein (2001), Reimer (2006), and Trefler and Zhu (2010), though this issue was considered earlier by Deardorff (1982) and Staiger (1986).

The starting point of this paper are these recent papers accounting for intermediates trade and in particular the contribution of Trefler and Zhu (2010) where a Vanek-consistent measure of the factor content of trade is proposed. Based on this approach we introduce an alternative approach to decompose trade flows in value added and its components such as ICT and Non-ICT capital and labor differentiated by skills and relate these to recent approaches of measuring vertical specialization patterns (Hummels et al., 2001; Daudin et al., 2009; Johnson and Noguera, 2009; Koopman et al., 2010). Our approach can be aligned with the measures of vertical specialization proposed in these studies. We add to this literature by simultaneously looking at both exports and imports of value added thus focussing on net

trade in value added rather than exports of value added only. In our decomposition we can differentiate between direct and indirect exports and imports and re-imports. The data allow us to further break down the figures of (net) trade in value added in to the components of value added. We further differentiate net value added trade as embodied in intermediates and final goods trade. This latter aspect is an important one and we therefore we devote a section of the paper to present some stylized facts on the patterns of trade in intermediates. One should note that in this framework trade in raw materials is also counted as trade in intermediates which carries or embodies value added. In a sense the paper thus tries to link the literature on trade in value added and vertical specialization and on the factor content of trade by applying a decomposition approach.[1] The paper proceeds as follows. In Section 2 we summarize some important points regarding trade in intermediates. In Section 3 we introduce our method of decomposing trade in value added. In Section 4 we provide a short overview of the recently compiled WIOD database that we use and present selected results in Section 5. In Section 6 we discuss using revealed comparative advantage (RCA) measures of trade in factors as an appropriate way of describing patterns of trade in factors. Section 7 concludes and points towards further avenues of research.

2 Some stylized facts about trade in intermediates and final goods

Before presenting our approach and the results concerning the patterns of trade in value added and factors let us shortly summarize a few results on the relative importance and patterns of trade in intermediates which are the vehicle for international supply chains. We present only a short overview of some important stylized facts with respect to trade in intermediates as compared to trade in final products, however with an emphasis on the former category (see also Chen et al., 2005; Miroudot et al., 2009). This is based on detailed trade data as outlined below. A more detailed analysis for the EU countries can be found in Stehrer et al. (2010). The figures presented here are based on the data used for the construction of the WIOD database. We emphasize this as the notion of ”supply chains” - as often emphasized in case studies as mentioned above - is misleading when taking into account the fact that intermediate inputs (or components) are also themselves produced by various other inputs (intermediates and primary). Thus, though the notion of a supply chain might be relevant for particular products it does not properly account for the integrated nature of the whole production process (which might be better described as ”supply

[1] In future research this decomposition can be continued further as will be outlined in the conclusions.

loops" or the old notion of "roundaboutness" as discussed by Böhm-Bawerk (1888) for example.[2] In the literature other notions are also used such as 'modular production networks' (see e.g. Faust et al., 2004). For a discussion of supply chains and its conceptualizations see MacKechnie (2008) who proposes a discussion in terms of hierarchy, networks and markets. In essence, we point towards the fact that countries are both exporters and importers of intermediates even in narrowly defined industries which has to be taken into account when measuring trade in value added.

2.1 Specialization structures

When differentiating trade into end use categories it turns out that on average roughly 50 percent of trade is traded intermediates whereas the remaining part is either for final consumption or gross fixed capital formation. Here one has to note that the category 'intermediates' is rather broad including raw materials and agricultural goods, and in particular one has to mention that it is much broader than trade in parts and components which is often considered in the literature. Again these patterns are relatively stable over time as can be seen in Figure 1. More precisely, the shares of intermediate imports in total imports range from a little more than 43 percent in Cyprus and Russia to more than 70 percent in Bulgaria, India, Indonesia and Korea. Higher shares are mostly found for emerging and transition economies. These patterns are relatively stable over time as can be seen in Figure 2 which plots the shares in 1995 against the shares in 2006. As one can see most countries are close to the 45 degree line thus pointing towards relative constancy of these shares over time. The most significant shift occurred in Bulgaria which saw a decrease in this share from about 80 percent in 1995 to about 60 percent in 2006. With respect to exports we find an even broader range from about 20 percent in Cyprus to almost 90 percent in Russia. Other countries with relatively low shares of intermediate exports in total exports are Denmark, China and Ireland with around 40 percent. Intermediate exports play a dominant role in Australia, Brazil and the Slovak Republic. These patterns raise the question of whether one can find a specialization structure in terms of intermediates trade, i.e. whether some countries are specialized in the production of intermediates whereas others in the production and thus exports of final products. Typically one would argue that advanced countries produce complex intermediates which are then assembled in less developed countries, a pattern which is driven by relative factor endowments. However, this has to be seen more carefully as intermediates can also be simple products (in particular, raw materials) which go into the production process of more complex goods which would reverse the patterns above. To show this in detail

[2] One should note however that the focus in this contribution was different; see also (Samuelson, 1966) for a critical assessment.

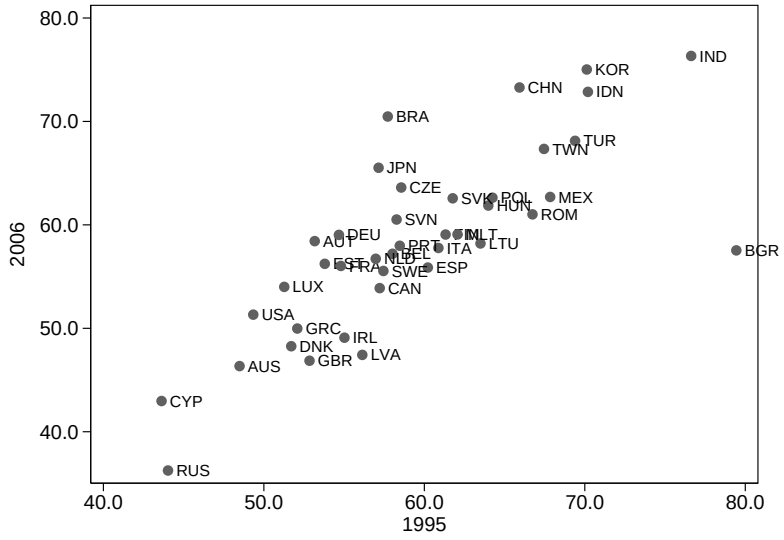

Figure 1: Share of intermediates in total imports, 1995 and 2006

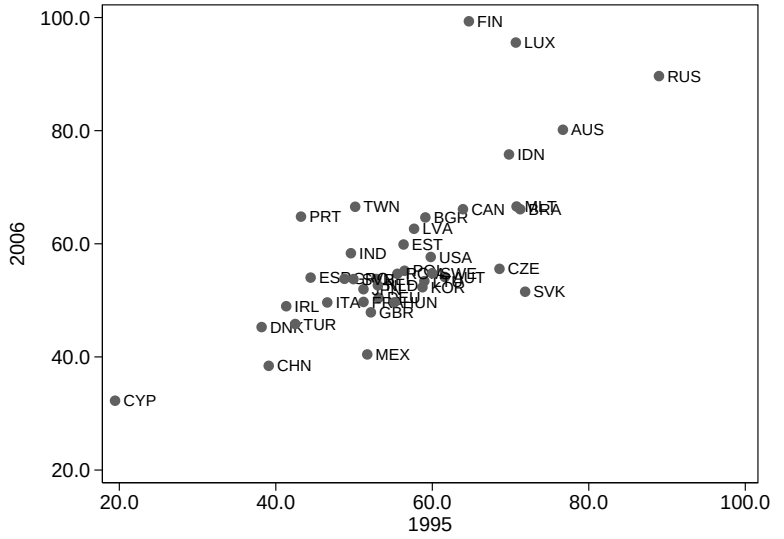

Figure 2: Share of intermediates in total exports, 1995 and 2006

we use a commonly used measure of revealed comparative advantages (RCA).[3] Results are presented in Figure 3 where a positive number would indicate that the country is specialized in intermediates In this

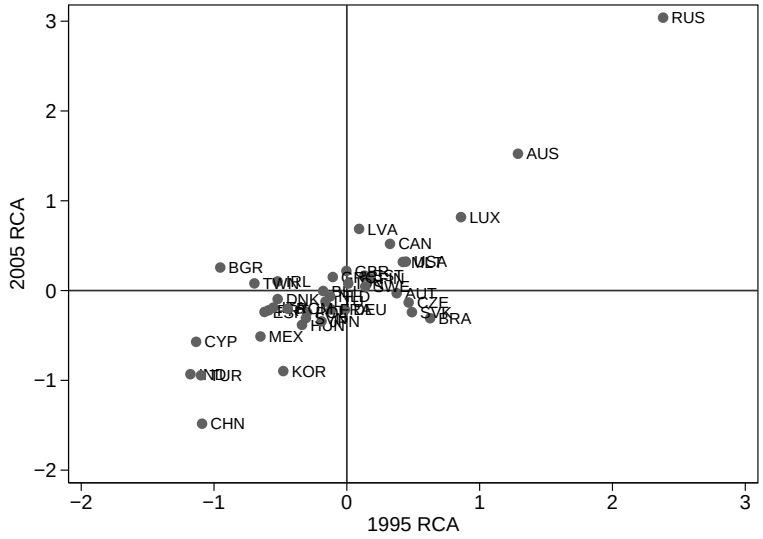

Figure 3: Specialization measure, 1995 and 2005

case, Russia turns out to be highly specialized in intermediates mostly due to exports of raw materials such as oil and gas. Similarly, Australia shows a comparative advantage in intermediates due to exports of agricultural products and mining products. On the other side of the spectrum China, India, Korea, and Turkey show negative numbers for both years indicating that these countries are larger importers of intermediates pointing towards the importance of processing trade. Again these patterns are relatively stable over time. Figure 4 shows the RCA measure for those countries within the range $(-1, 1)$ for both years considered. Countries in the first and third quadrant maintain their relative position, i.e. having a comparative advantage or disadvantage in intermediates trade respectively. Only a few countries shifted from a negative value to a slightly positive one, these countries being Greece, Bulgaria, Ireland and Taiwan. Some countries (Austria, Czech Republic, Slovak Republic and Brazil) shifted in the opposite direction.[4]

[3]The measure applied here is

$$\text{RCA}_k^r = \ln \frac{X_k^r / \sum_{j,j\neq k} X_j^r}{\sum_{p,p\neq c} X_j^p / \sum_{p,j;p\neq c,j\neq k} X_j^p} - \ln \frac{M_k^r / \sum_{j,j\neq k} M_j^r}{\sum_{p,p\neq c} M_j^p / \sum_{p,j;p\neq c,j\neq k} M_j^p}$$

where X denotes exports, M is imports, r denote country and k is for the category under consideration. See e.g. Vollrath (1991) for an overview of such measures. Results do not depend on the exact measure used.

[4]To study these patterns and their changes over time in more detail and to trace them back to potential explanatory factors such as endowment structures, industry patterns, technology, etc. is a matter for future research. Further one has to take into

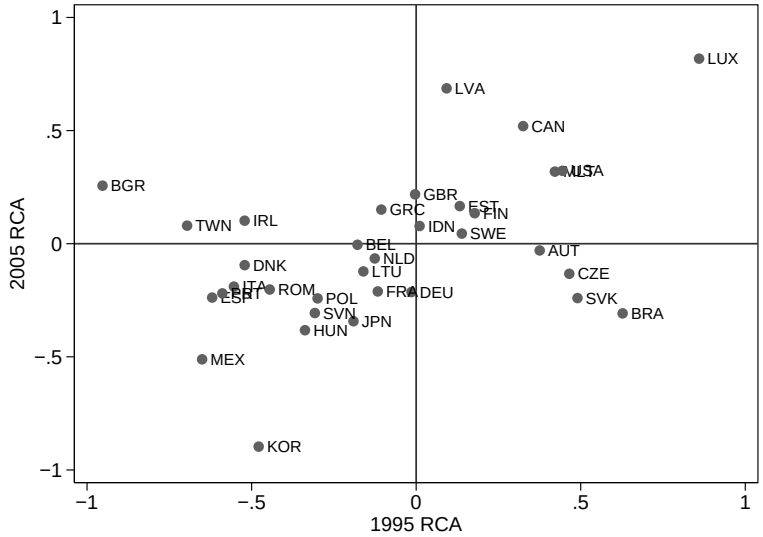

Figure 4: Specialization measure, 1995 and 2005, for selected countries

2.2 Industry specific patterns of intermediates trade

A further question is whether there are specific industries which are more likely to have a high share of imports or exports in intermediates which is likely the case for industries in need of raw materials for example or products with complex production structures. This would imply that a countries' exports and imports depends on its industrial specialization rather than its role as a producer of intermediates or final products. Figures 5 and 6 present box plots for 2006 for each industry NACE 1-37 for imports and exports, respectively. First, there seems to be a positive correlation across countries, i.e. there are particular industries which are more prone to intermediates trade than others irrespective of the country. However, there are some notable outliers (i.e. the countries outside the whiskers of the box plots which are labeled). These have to be studied in more detail and might reflect within industry patterns of specialization. At the lower end industries such as 16 (tobacco products), 18 (Wearing apparel), 05 (fish and fishing products), 15 (food products and beverages), and 19 (leather and leather products) show little trade in intermediates. Amongst the industries with the highest shares are mining industries, basic metals (27) and secondary raw materials (37) having shares of around 100 percent.[5]

account relative price movements over time (in particular for raw materials).

[5]To some extent these patterns reflect the correspondence applied between HS 6-digit codes and the end use categories applied to the data. One point of concern is that this classification applied (though we tried to improve on the commonly applied HS 6-digit to BEC correspondence) is still unsatisfactory. In particular, HS 6-digit product descriptions might provide too little information on the actual use of the product. Furthermore, here a more differentiated view of intermediates trade (like primary, processed, parts and components, etc.) would be necessary.

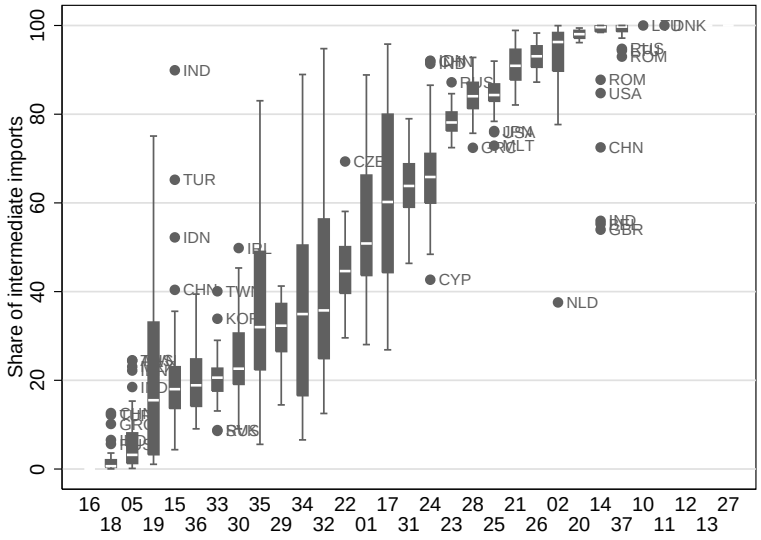

Figure 5: Share of intermediates imports in total imports by product category, 2006

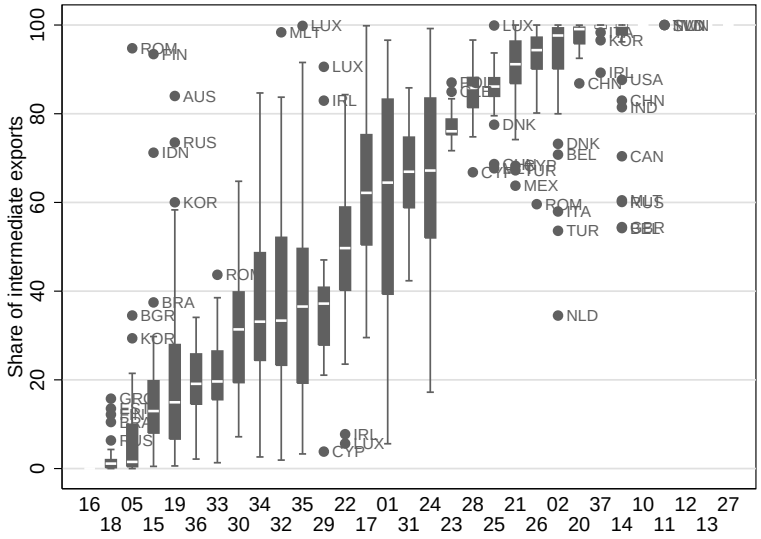

Figure 6: Share of intermediates exports in total exports by product category, 2006

2.3 Two-way trade in intermediates and final goods

Further, the rank correlation of exports and imports shares of intermediates is again very high. This points towards the fact that there might exist a lot of two-way trade also intermediates. To study this we use a measure of intra-industry trade, the 'generalised Grubel-Lloyd index but broken down by end use categories.[6] On average there are few differences with respect to two way trade between countries across end-use categories. The simple arithmetic mean over countries is 0.54 for consumption goods and about 0.5 for intermediates. The index for capital goods is even higher with an average of about 0.6, with a similar pattern found when looking at the median. As expected, the ratios tend to be lower for less developed economies. At the industry level the index tends to be even higher. Thus there is a substantial amount of two-way trade going on in all end use categories.

3 Patterns of net trade in value added and factors

In this section we introduce our approach to the decomposition of trade flows in value added exports and imports and consequently net trade. The same approach is also used to further to split up these flows into value added components, i.e. the value of labor and capital traded which can be further split up by various categories as outlined below. There is already a wide literature on the measurement of vertical specialization, value added chains and trade in value added (see e.g. Hummels et al., 2001; Johnson and Noguera, 2009; Daudin et al., 2009; Koopman et al., 2010; Timmer et al., 2011).

Often this literature focuses on measuring the vertical integration of production processes focusing on exports and thus leaving out the aspect that all countries are also important importers of intermediates and the existence of two-way trade in intermediates as outlined above.[7] On the other hand, the literature focusing on the effects of outsourcing on labor markets (employment and wages) and other variables like productivity often focus on the import side only. In this paper we therefore aim at including both sides of trade to measure the extent of exports, imports and net trade in value added and its relative importance across countries' trading patterns. The WIOD database (see below) further allows us to follow the respective trends over time and to further decompose value added flows into its components.

[6] This index is given by

$$\text{CGLI}_k^r = \frac{2\min\{X_k^r, M_k^r\}}{\sum_c X_k^c + \sum_c M_k^c - \left|\sum_c X_k^c - \sum_c M_k^c\right|}$$

This measure was proposed in Greenaway et al. (1994) and is based on Grubel and Lloyd (1975).

[7] The literature focuses on the 'import content of *exports*'; using supply-driven IO models allows one to also calculate the 'export content of imports' (see for example Meng and Yamano, 2010).

Another strand of literature which is related to the issue of trade in value added and vertical specialization focuses on trade in factors and is often motivated by the Heckscher-Ohlin-Vanek theorem with the further complication when trade in intermediates has to be accounted for (see Deardorff (1982) and Staiger (1986) for early contributions and Reimer (2006) and Trefler and Zhu (2010) for more recent ones). The approach suggested here is motivated by a recent paper on trade in factors, Trefler and Zhu (2010), which focuses on the correct (or 'Vanek consistent' way) of calculating the factor content of trade with trade in intermediates. We apply a similar method of calculating the factor content with two modifications. First, we apply this approach using value added shares in gross output and capital and labor income shares in gross output rather than physical input coefficients which most of the papers focusing on trade in factors is based. In essence, we therefore not only allow for cross-country and cross-industry differences in direct and indirect input coefficients but also for differences in factor rewards.[8] Second, we decompose the resulting measure into several categories which are outlined below in detail. In particular, this latter aspect links this paper to other approaches of measuring vertical integration and trade in value added.

The starting point for the analysis are indicators of the share of value added in gross output denoted by vector $\mathbf{v}$, the Leontief inverse of the global input-output matrix, $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$, and the flows of exports and imports of goods between countries denoted by $\mathbf{t}$. For simplicity we first discuss our approach for the case of three countries without an industry dimension. Further, we discuss net trade in value added from the viewpoint of country 1 without any loss in generality. In this special case the vector of value added coefficients becomes $\mathbf{v}' = (v^1, v^2, v^3)$, the Leontief-inverse is of dimension 3×3 and the trade vector is written as $\mathbf{t} = (x^{1*}, -x^{21}, -x^{31}$ where $x^{1*} = \sum_{p,p\neq 1} x^{1p}$ denotes exports of country 1 to all countries and x^{r1} denotes exports of country r to 1, i.e. imports of country 1. These imports are included in negative terms which results in net trade of value added for country 1, i.e. $t_V = \mathbf{v}'\mathbf{L}\mathbf{t}$. For the decomposition procedure however we need the individual entries of the matrix capturing exports and imports of country 1 which is achieved by a diagonalization of the value added coefficients and trade

[8] This can later be decomposed into the effects of changes in productivity, factor rewards and trade patterns by splitting ratios over gross output into factor rewards and physical input coefficients, i.e. to disentangle quantity and factor price effects.

vector which results in the following exposition:

$$\begin{aligned}
\mathbf{T}_V^1 &= \begin{pmatrix} v^1 & 0 & 0 \\ 0 & v^2 & 0 \\ 0 & 0 & v^3 \end{pmatrix} \begin{pmatrix} l^{11} & l^{12} & l^{13} \\ l^{21} & l^{22} & l^{23} \\ l^{31} & l^{32} & l^{33} \end{pmatrix} \begin{pmatrix} x^{1*} & 0 & 0 \\ 0 & -x^{21} & 0 \\ 0 & 0 & -x^{31} \end{pmatrix} \\
&= \begin{pmatrix} v^1 l^{11} & v^1 l^{12} & v^1 l^{13} \\ v^2 l^{21} & v^2 l^{22} & v^2 l^{23} \\ v^3 l^{31} & v^3 l^{32} & v^3 l^{33} \end{pmatrix} \begin{pmatrix} x^{1*} & 0 & 0 \\ 0 & -x^{21} & 0 \\ 0 & 0 & -x^{31} \end{pmatrix} \\
&= \begin{pmatrix} v^1 l^{11} x^{1*} & -v^1 l^{12} x^{21} & -v^1 l^{13} x^{31} \\ v^2 l^{21} x^{1*} & -v^2 l^{22} x^{21} & -v^2 l^{23} x^{31} \\ v^3 l^{31} x^{1*} & -v^3 l^{32} x^{21} & -v^3 l^{33} x^{31} \end{pmatrix}
\end{aligned}$$

The first matrix contains the value added coefficients of the three countries, the second matrix denotes the elements of the Leontief inverse from the global input-output matrix and the last matrix contains exports of country 1 and imports of country 1 from the other countries which are included as negative values. Summing up this matrix over rows and columns therefore gives a measure of net trade of value added for country 1. One should note however that this also includes indirect flows of value added and imports and it is therefore advisable to discuss the entries in these matrix separately. This will also document the decomposition of value added exports and imports in its various forms.

- *Exports:* The first column describes exports of country 1.
  - ∗ *Direct exports*: The first entry, $v^1 l^{11} x^{1*}$, denotes total direct value added exports of country 1 to the other countries.
  - ∗ *Indirect exports*: The production of these exports also requires inputs from other countries. For production of these inputs - used to produce exports of country 1 - value added in the other countries is created. This is captured by the remaining terms in the first column by partner country, i.e. $\sum_{p,p\neq 1} v^p l^{p1} x^{1*}$. Note, that this is added to value added exports of country 1, though value added is created in the other countries. We therefore name this part 'indirect exports'.
- *Imports*: The other columns capture the effects of the imports of country 1.
  - ∗ *Direct imports*: The exports of country 2 to country 1 create value added in the second

country; thus the second term in the second column captures the direct value added imports from country 2. Similarly, the third entry in the third column captures the direct value added imports from country 3. Thus, the remaining elements of the diagonal contain direct value added imports, $-\sum_{p\neq 1} v^p l^{pp} x^{p1}$.

- *Indirect imports*: These exports of country 2 to country 1 also require inputs from country 3. Thus the third entry in column 2 captures the value added imports of country 1 from country 3 which are embodied in imports from country 2. An analogous interpretation holds for the the second entry in column 2. Thus, the total amount of indirect imports is given by $-\sum_{p,q,p\neq q;p,q\neq 1} v^q l^{qp} x^{p1}$. These indirect imports do not appear in the 2-country case.
- *Re-Imports*: Exports of country 2 back to country 1 also require inputs from country 1. Therefore, the first entry in column 2 captures value added imports of country 1 embodied in imports from country 2; analogously for the third term in the first row. Total re-imports of value added are therefore $-\sum_{p\neq 1} v^1 l^{1p} x^{p1}$.

Analogous interpretations also hold for countries 2 and 3. To disentangle these five components of net value added trade for country 1 it is convenient to rewrite the sum of the equation in the following way:[9]

$$t_V^r = \underbrace{v^r l^{rr} x^{r*}}_{\text{Direct exports}} + \underbrace{\sum_{p,p\neq r} v^p l^{pr} x^{r*}}_{\text{Indirect exports}} - \underbrace{\sum_{p\neq r} v^p l^{pp} x^{pr}}_{\text{Direct imports}} - \underbrace{\sum_{p,q,p\neq q;p,q\neq r} v^q l^{qp} x^{pr}}_{\text{Re-imports}} - \underbrace{\sum_{r\neq p} v^r l^{rp} x^{pr}}_{\text{Indirect imports}} \tag{1}$$

There is a close relationship of this measure to others on vertical specialization already existing in the literature. Koopman et al. (2010) sorts out the measures as supposed by Hummels et al. (2001), Johnson and Noguera (2009) and Daudin et al. (2009) and provided an explicit derivation of the VS1 measure as supposed by Hummels et al. (2001). Relying on these results we can interpret the five terms in the above equation accordingly: The first term is country 1's domestic value added in direct exports, the second is the 'true' VS^1 measure capturing the import content of exports (see Hummels et al., 2001; Koopman et al., 2010), the third term are country 1's direct imports of value added or the other countries' direct exports of value added to country 1 (where each import of country 1 is valued with the trading partner's

[9] In matrix notation this could be written as

$$t_V^r = \underbrace{\boldsymbol{\iota}_1' \mathbf{T}_V^r \boldsymbol{\iota}_1}_{\text{Direct exports}} + \underbrace{\boldsymbol{\iota}_2' \mathbf{T}_V^r \boldsymbol{\iota}_1}_{\text{Indirect exports}} + \underbrace{\left(\text{tr}\, \mathbf{T}_V^r - \boldsymbol{\iota}_1' \mathbf{T}_V^r \boldsymbol{\iota}_1\right)}_{\text{Direct imports}} + \underbrace{\boldsymbol{\iota}_1' \mathbf{T}_V^r \boldsymbol{\iota}_2}_{\text{Re-imports}} + \underbrace{\left(\boldsymbol{\iota}' \mathbf{T}_V^r \boldsymbol{\iota} - \text{tr}\, \mathbf{T}_V^r - \boldsymbol{\iota}_2' \mathbf{T}_V^r \boldsymbol{\iota}_1 - \boldsymbol{\iota}_1' \mathbf{T}_V^r \boldsymbol{\iota}_2\right)}_{\text{Indirect imports}}$$

where $\boldsymbol{\iota}_1' = (1 \quad 0 \quad \cdots \quad 0)$ and $\boldsymbol{\iota}_2' = (0 \quad 1 \quad \cdots \quad 1)$ denote summation vectors.

value added coefficients), the fourth term is the VS1^{*1} measure capturing the re-imported value added of exports (see Daudin et al., 2009; Koopman et al., 2010) and the last term are country 1's indirect value added imports through third countries which is therefore the sum of VS1^{p} measures (see Hummels et al., 2001) where this was derived as value added exports through third countries (see also Koopman et al., 2010, where this was derived explitely).

Extending the above framework to many sectors requires only some slight changes in the dimensionality of the matrices involved. Let N denote the number of countries and G the number of industries.

$$\mathbf{T}_V^r = \hat{\mathbf{v}}'\mathbf{L}\hat{\mathbf{t}}^r$$

$\mathbf{v}$ is now a $NG \times 1$ matrix, the Leontief inverse $\mathbf{L}$ is of dimension $NG \times NG$ and $\mathbf{t}^r$ is of dimension $NG \times 1$; with sector specific information on exports (to all countries) and sector specific information of imports from individual countries. Calculations can then be performed in exactly the same way as indicated above with additionally summing up over industries.[10] To derive country specific results one first has to add up block-wise. Thus the algebra has to be rewritten in the following way with $\mathbf{R} = \mathbf{I} \otimes \boldsymbol{\iota}$ and $\mathbf{S} = \mathbf{R}'$ denoting summation matrices where $\mathbf{I}$ is the identity matrix of dimension $N \times N$ and $\boldsymbol{\iota}$ denoting a vector of ones of dimension $G \times 1$; $\otimes$ denotes the Kronecker symbol. Matrix $\mathbf{R}$ is therefore of dimension $NG \times N$. Pre- and post-multiplying the industry specific matrix $\mathbf{T}_V^r$ which is of dimension $NG \times NG$ by $\mathbf{S}$ and $\mathbf{R}$ respectively, results in a matrix of dimension $N \times N$ which has the same interpretation as above (having however incorporated industry-specific interrelations).

Instead of multiplying with the vector of value added coefficients one can instead use some other components of value added. The data set at hand allows us to distinguish first between labor and capital income. The former can be split into three categories by educational attainment levels according to ISCED classification (high, medium, and low educational attainment) and the latter into ICT and Non-ICT capital. This means that we can differentiate trade in value added into trade in capital and labor and the respective categories.[11] Finally, we can also split trade (i.e. exports and imports of goods and services) into end-use categories; in this paper we differentiate between trade of goods and services as intermediates and as final products.

Following this approach, i.e. considering both direct and indirect exports and imports (including re-imports) has an important consequence with respect to the magnitudes of trade in value added as

[10] This will further allow us to provide industry or industry-group specific results.

[11] In future research bilateral relations and country as well as sector specific results can be considered.

compared to gross trade in goods and services and therefore requires a careful interpretation of the results. Taking into account all five components of trade total imports and exports of value added equal total gross imports and exports and consequently net trade in value added equals net trade from gross exports and imports. This can easily be seen from the following algebra. The vector of value added $\mathbf{V}$ can be expressed in the following way from which value added coefficients can easily be derived.

$$\begin{aligned}
\mathbf{V} &= \mathbf{q} - \hat{\mathbf{q}}\mathbf{A}'\boldsymbol{\iota} \\
\hat{\mathbf{q}}^{-1}\mathbf{V} &= \hat{\mathbf{q}}^{-1}\mathbf{q} - \hat{\mathbf{q}}^{-1}\hat{\mathbf{q}}\mathbf{A}'\boldsymbol{\iota} \\
\mathbf{v} &= \boldsymbol{\iota} - \mathbf{A}'\boldsymbol{\iota} \\
\mathbf{v}' &= \boldsymbol{\iota}' - \boldsymbol{\iota}'\mathbf{A} \\
&= \boldsymbol{\iota}'\big(\mathbf{I} - \mathbf{A}\big)
\end{aligned}$$

Inserting into our equation for measuring net trade in value added we get

$$t_V^{\text{net}} = \mathbf{v}'\big(\mathbf{I} - \mathbf{A}\big)^{-1}\mathbf{t} = \boldsymbol{\iota}'\big(\mathbf{I} - \mathbf{A}\big)\big(\mathbf{I} - \mathbf{A}\big)^{-1}\mathbf{t} = \boldsymbol{\iota}'\mathbf{t} = t^{\text{net}}$$

i.e. net trade in value added equals net trade in goods and services. Similarly one can show (by using trade vectors consisting of the export cell or the import cells) that the ratio of value added exports (imports) to gross exports (imports) equals one. The reason for this result is that in this framework all goods (intermediates and final goods) are produced by capital and labor as the only two primary factors which capture all the value added; no other primary factors like raw materials are counted for.

Therefore, this approach of measuring net trade in value added is consistent with measures of net trade in gross terms, incorporates other measures as suggested in the recent literature and allows for a decomposition of value added trade along various dimensions which we document in subsequent sections.[12]

[12]Thus one has carefully to consider the results that a country's trade deficit in value added might be lower than in terms of gross trade. This might be the case in a bilateral relationship though it is not true when taking trade with all countries into account.

4 The world input-output database (WIOD): short description

The data used for the analysis is taken from 'The World Input-Output Database' (WIOD) as available in January 2011.[13] In this section we provide a short description of the data to be used and how these have been constructed; more detailed information can be obtained from papers mentioned below. The WIOD data are the outcome of an effort undertaken to bring together information from national accounts statistics, supply and use tables, trade in goods and services data and corresponding data on factors of production (ICT and Non-ICT capital, labor by educational attainment categories) for 40 countries over the period 1995-2006. A detailed description of datasources can be found in Erumban et al. (2010) on national accounts data and the supply and use tables, Francois and Pindyuk (2010) on services trade and Pöschl and Stehrer (2010) on goods trade.

National accounts data have been collected for all countries over the period 1995-2006 which served as benchmark values. Existing supply and use tables have then been adjusted to these national accounts data with some of the tables being estimated for years for which these were not available. Some countries only provide input-output tables which have been transformed back into supply and use tables. Through this process all tables have been standardized over years and across countries with respect to product and industry codings. These tables contain information on supply and use of 59 products in 35 industries together with the information on final use and value added. Accompanying this information corresponding trade data were collected at the same level of disaggregation at the product level. With respect to goods trade which are taken from UN COMTRADE data at the HS 6-digit level this is rather straightforward as there exists a correspondence from HS-6 to the product level in the supply and use tables (CPA). However services trade is only available from balance-of-payment statistics providing information on a detailed basis only in BoP categories. Using a rough correspondence these were merged to the product level data provided in the supply and use tables. Additionally, the trade data are split up into use categories fitting the needs of supply and use tables, i.e. intermediates, consumption and gross fixed capital formation. Goods trade has been split up by applying a categorization of products into intermediates, final consumer goods and gross fixed capital goods. The correspondence used for this was created by beginning with the usually used BEC classification (provided by UN) but adapting the classification to the specific needs (see Pöschl and Stehrer, 2010). In particular, the correspondence between HS6-digit and BEC categories has been revised and in a number of cases we use weights for particular products to distinguish between intermediates and the other categories. For services trade, however, there is no such

[13] See www.wiod.org.

information available. Therefore, we used data from existing input-output and supply and use data and applied average shares across countries. Relying on these underlying data we started from the import vector provided in the supply tables. Import values for each country and product are split up first into the three use categories. Second, within each use category a proportionality assumption is applied to split up the imports for each use category across the relevant dimensions. For example, imports of intermediates are split across using industries according to the shares resulting from the original use table. Similarly, imports for final consumption are split up into final demand categories. Investment are allocated only to gross fixed capital formation (i.e. not considering changes in inventories and valuables). This resulted in an import use table for each country. Finally each cell of the import use table was again split up by country of origin resulting in 39+1 (including the rest of world) import use tables for each country. Merging these tables together provides a full set of inter-country supply and use tables. Finally, an international input-output table was constructed by applying the transformations of model D as described in the Eurostat manual (Eurostat, 2008). This results in a world input-output database for 40 countries and 35 industries, i.e. the intermediates demand block is of dimension 1400×1400, plus the additional rows on value added and columns on final demand categories. The rest of the world is not explicitly modeled in this case but appears only in the import columns (imports from rest of the world by product) and export column (exports to rest of the world). In the application below an assumption on the structure of input coefficients is necessary which will be outlined below.

Corresponding data at the industry level allow splitting up value added into capital and labor income. Furthermore, capital income can be split up into ICT and Non-ICT income, and labor income into income of low, medium and high educated workers. These additional data for the factor incomes corresponds in construction to the method applied in the EU KLEMS database (Timmer et al., 2007) and efforts undertaken in the World KLEMS project.[14] In the results section we present figures for two groups of countries, EU-15 and EU-12 plus Turkey, and 13 individual countries which might be grouped into NAFTA (Canada, USA and Mexico), Asian countries (Japan, Korea and Taiwan), and the BRIICs (Brazil, Russia, India, Indonesia and China) to which we also add Australia. One should note however that all calculations are performed at the level of individual countries and industries thus taking account of all information available. Finally, the database also includes imports from rest of the world and exports to rest of the world.[15] To take account of trade with these countries one would have to construct such an

[14] Some of these data are still preliminary and will be replaced later by improved information. Furthermore, for a number of countries and factors we had to impute values from other countries which again is a source of a potential imprecision.

[15] In the construction process of the WIOD intercountry tables exports to rest of the world also serves as a balancing item.

entity. For the purpose of this paper we can do this by adding additional blocks (rows and columns) in the coefficient matrix. In this paper we present results when assuming that this rest of the world has the same structure as Brazil. Qualitatively the results do not depend on this assumption.

5 Net trade in value added - Selected results

In this section we present selected results on the patterns of value added by applying equation (3). For this we proceed in a series of steps: First, we present the magnitudes of exports and imports of value added comparing them to trade in goods and services and the net trade of value added for the 40 countries. Trade in value added is then differentiated by factors. Finally, we consider the trade in factors embodied in intermediates and final goods and services trade. For this we report results for the years 1995, 2000 and 2005.

5.1 Net trade in value added

Table 1 reports the figures for exports and imports of goods and services in value added terms in billions of US dollars. As we have shown above exports and imports correspond to the measure of value added trade and therefore net trade also equals net value added trade. First, for all countries the magnitude of exports and imports increased quite strongly, particularly for countries in the EU-12 where figures are three times higher in 2005 compared to 1995 and in China where the flows increased by a factor of five. The last three columns present net trade figures where a negative sign implies that this country is a net importer and a positive sign that it is a net exporter. One can clearly see the rising trade deficit of the US which amounted to about 700 billion US dollars in 2005 and the trade surplus of China. Net trade for the European countries has been or has slipped into the negative for all years and country groups. The EU-15 in particular turned a trade surplus of around 65 billion US dollars into a trade deficit of similar magnitude. The Asian countries, Japan, Korea and Taiwan, and the other countries all show a trade surplus at least in 2005 with the only exception being Australia.

Table 2 provides the shares according to our decomposition into direct and indirect exports and import flows and re-imports. As countries become more and more integrated in to international production processes one would expect that the share of indirect exports (i.e. country A's exports of value added imported from other countries for producing its export good) would be rising over time. Further, smaller countries would be expected to show higher values. In fact, this share was rising for almost all countries

Table 1 Trade in goods and services and trade in value added, in bn US-$

	(Value added) Exports			(Value added) Imports			Net trade		
Reporter	1995	2000	2005	1995	2000	2005	1995	2000	2005
EU-15	2241.7	2486.0	4070.3	-2177.0	-2541.6	-4137.8	64.8	-55.6	-67.4
EU-12	173.2	225.3	499.9	-176.0	-241.8	-521.0	-2.9	-16.4	-21.1
TUR	26.9	38.7	78.9	-37.0	-57.2	-113.3	-10.1	-18.5	-34.4
CAN	210.2	315.1	408.2	-193.6	-277.8	-372.3	16.6	37.3	35.9
USA	717.5	958.6	1149.1	-833.5	-1324.5	-1829.7	-116.0	-365.9	-680.6
MEX	78.3	166.9	214.0	-70.5	-174.0	-217.4	7.8	-7.1	-3.4
JPN	480.9	512.7	652.5	-389.8	-426.6	-565.1	91.0	86.1	87.4
KOR	134.5	175.3	277.0	-128.1	-148.9	-236.6	6.4	26.4	40.4
TWN	126.5	161.4	218.2	-117.7	-148.0	-194.0	8.8	13.4	24.2
AUS	71.0	88.3	145.9	-69.9	-83.2	-148.6	1.1	5.0	-2.7
BRA	51.2	59.0	123.5	-58.7	-64.5	-87.1	-7.5	-5.5	36.4
CHN	168.0	279.6	836.6	-128.2	-216.5	-612.2	39.8	63.0	224.5
IDN	53.2	62.1	96.4	-51.7	-47.4	-78.3	1.5	14.7	18.2
IND	38.9	62.0	144.1	-34.6	-51.1	-135.2	4.3	11.0	8.9
RUS	82.1	103.9	237.3	-58.7	-47.0	-119.5	23.4	56.9	117.8
ZROW	600.4	970.0	1594.1	-729.6	-814.7	-1377.8	-129.2	155.3	216.2

Source: WIOD database, Version January 2011; author's calculations

as reported in Table 2, the only exceptions being Canada, Australia and Indonesia. There have been particularly strong increases for EU-12, Turkey and Taiwan. For China the share increased from 12.4 to 16.8 percent and for Japan from 5.8 to 10 percent. Less strong increases are found for other developed countries including the US (8.1 to 10.3) and the EU-15 (19.5 to 22.5) for example. In magnitudes, the shares are particularly high for Taiwan (40 percent) and the EU-12 (33 percent). We also would expect that the share of indirect imports of value added would rise as the imports from other countries increasingly embody value added from third countries. Again this is what actually happened for all countries with the exception of Indonesia for which it was however more or less stable. The strongest increase from 10.5 to 15.3 took place in Mexico. Generally, however the changes are less strong compared to indirect exports. Finally, the shares of re-imports are fairly small but are increasing in most cases over time. Only the US shows significant magnitudes which results from trade with Mexico.

The trade figures can be split into trade in final goods (consumption and investment goods) and intermediates. When focusing on final goods trade only one circumvents the problem with 'double-counting' but one misses the fact that trade in intermediates also carries value added (or rewards of primary factors capital and labor). In our approach we can split trade by these use categories easily and

Table 2 Decomposition of total trade (in %)

	Indirect exports			Re-Imports			Indirect imports		
Reporter	1995	2000	2005	1995	2000	2005	1995	2000	2005
EU-15	19.5	22.1	22.5	1.7	1.7	1.9	14.9	17.2	18.3
EU-12	23.2	30.1	32.9	0.3	0.3	0.4	16.4	19.4	20.8
TUR	9.6	13.6	16.0	0.1	0.1	0.2	14.8	18.6	18.5
CAN	24.0	25.5	21.7	1.2	1.8	2.0	9.9	10.3	12.3
USA	8.1	8.5	10.3	6.5	8.4	6.0	9.1	9.8	11.6
MEX	22.4	27.1	24.3	0.4	0.6	0.7	10.5	11.6	15.3
JPN	5.8	7.2	10.0	1.8	1.9	1.9	9.3	10.6	11.3
KOR	18.3	19.7	21.5	0.4	0.6	0.9	9.8	10.0	12.0
TWN	31.2	34.2	40.7	0.2	0.5	0.7	10.1	11.2	13.4
AUS	8.3	7.4	7.0	0.3	0.4	0.6	11.4	12.1	13.8
BRA	4.3	6.8	6.8	0.1	0.1	0.2	10.8	12.7	13.7
CHN	12.4	12.0	16.8	0.6	1.2	2.4	13.0	14.6	15.3
IDN	13.3	12.0	10.5	0.2	0.3	0.4	11.8	10.3	11.6
IND	4.8	4.7	6.7	0.1	0.1	0.2	10.8	11.0	12.2
RUS	4.8	5.9	5.0	0.8	0.8	1.1	12.9	15.1	16.9
ZROW	5.3	7.1	7.1	0.1	0.1	0.1	13.1	11.8	12.3

Source: WIOD database, Version January 2011; author's calculations

thus take account of the relative importance of these with respect to trade in value added. One should note that exports, imports and net trade sum up to the total trade figures as shown in Table 1 and that (net) trade by use categories in value added terms again equals (net) trade in gross terms. Let us highlight some important aspects from the results in Table 3. Most countries are net exporters of final goods, the most important exceptions being the US and Australia as well as the rest of world which is a major importer of final goods. Most of these countries tend to be net importers of intermediates, now also including the US and China though not Japan and Taiwan. The most important net exporters are Australia, Russia and the rest of the world (mainly driven by raw materials trade including oil). However, there are also some interesting patterns and changes over time. In most cases the value of intermediates exports and imports are quite close to each other. However, there are interesting exceptions to this: For example, US exports in intermediates are much higher than US exports in final goods. Similarly, US imports of intermediates are (in absolute terms) also higher but have been growing even faster than US exports. As a consequence, US net trade in final goods is similar to that in intermediates, but the latter has been growing by a factor of around ten while the former has grown by a factor of only around four. Thus it is not the case that the huge US trade deficit was mainly caused by the fact that it imported more and

Table 3 Trade in goods and services and trade in value added by use category, in bn US-$

	(Value added) Exports			(Value added) Imports			Net trade		
Reporter	1995	2000	2005	1995	2000	2005	1995	2000	2005
				Final goods trade					
EU-15	1056.5	1203.9	1952.1	-891.2	-1048.2	-1704.5	165.3	155.7	247.5
EU-12	89.0	114.4	240.9	-68.4	-89.2	-181.6	20.6	25.2	59.3
TUR	15.9	22.4	42.7	-12.8	-21.3	-37.0	3.1	1.1	5.7
CAN	87.8	123.0	149.5	-85.2	-119.7	-167.1	2.6	3.3	-17.6
USA	276.3	377.5	446.8	-361.9	-597.3	-753.6	-85.6	-219.7	-306.8
MEX	39.7	95.7	107.8	-19.7	-51.4	-67.9	20.0	44.3	39.9
JPN	217.4	247.3	293.5	-155.9	-168.3	-212.3	61.5	79.0	81.3
KOR	60.8	84.1	112.5	-41.3	-34.9	-56.0	19.5	49.2	56.5
TWN	67.5	79.2	74.9	-40.7	-53.2	-56.6	26.7	26.0	18.3
AUS	22.6	27.4	34.1	-27.4	-39.6	-74.3	-4.8	-12.1	-40.2
BRA	21.6	23.4	46.5	-24.2	-22.3	-26.3	-2.6	1.1	20.2
CHN	114.5	180.3	461.3	-35.2	-54.5	-120.7	79.3	125.9	340.5
IDN	23.3	28.4	32.4	-18.9	-17.5	-21.1	4.5	10.9	11.3
IND	21.9	33.8	88.9	-8.8	-10.3	-41.9	13.1	23.5	47.0
RUS	23.0	37.4	65.3	-34.1	-22.4	-65.9	-11.1	15.0	-0.6
ZROW	208.1	296.1	456.7	-520.3	-624.3	-1019.1	-312.2	-328.2	-562.4
				Intermediate goods trade					
EU-15	1185.2	1282.1	2118.3	-1285.8	-1493.4	-2433.2	-100.5	-211.3	-315.0
EU-12	84.1	110.9	259.0	-107.6	-152.6	-339.4	-23.5	-41.7	-80.4
TUR	11.0	16.3	36.2	-24.2	-35.9	-76.3	-13.2	-19.6	-40.1
CAN	122.4	192.1	258.6	-108.3	-158.1	-205.2	14.1	33.9	53.5
USA	441.2	581.1	702.3	-471.6	-727.3	-1076.1	-30.5	-146.2	-373.8
MEX	38.6	71.2	106.2	-50.8	-122.6	-149.5	-12.2	-51.4	-43.4
JPN	263.5	265.4	358.9	-234.0	-258.3	-352.8	29.5	7.2	6.1
KOR	73.7	91.2	164.5	-86.9	-114.0	-180.6	-13.2	-22.8	-16.1
TWN	59.0	82.2	143.2	-77.0	-94.8	-137.4	-17.9	-12.7	5.9
AUS	48.4	60.9	111.8	-42.5	-43.7	-74.3	6.0	17.2	37.5
BRA	29.6	35.7	76.9	-34.5	-42.2	-60.8	-4.9	-6.5	16.2
CHN	53.5	99.2	375.3	-93.0	-162.1	-491.4	-39.6	-62.8	-116.1
IDN	29.8	33.6	64.0	-32.8	-29.9	-57.2	-3.0	3.8	6.8
IND	17.0	28.3	55.2	-25.8	-40.8	-93.3	-8.8	-12.5	-38.1
RUS	59.1	66.5	172.0	-24.6	-24.6	-53.6	34.5	41.9	118.4
ZROW	392.3	673.9	1137.4	-209.3	-190.4	-358.7	183.0	483.5	778.6

Source: WIOD database, Version January 2011; author's calculations

more final goods (which more or less doubled) but mainly due the fact that its imports of intermediates have been growing relatively fast (by a factor of 2.5). On the other hand, China shows much lower exports in intermediates as compared to final goods but with a strong increase between 2000 and 2006. China's imports of intermediates are (again in absolute terms) higher than its imports in final goods and the former have been growing faster than the latter. China therefore shows a trade deficit in intermediates and a huge surplus in final goods. This can be compared to the US which is running a trade deficit of similar magnitudes in both categories. Note however, that this description so far would be also seen from usual statistics in gross trade (as outlined above). Table 4 therefore again shows the decomposition into the categories, more exactly the shares of indirect exports, re-imports and indirect imports. First, the shares by use category are not too different for the individual countries though there are some notable exceptions such as India. The shares of indirect imports however tend to be lower for the more advanced countries. The reason for this is that these countries' shares in direct imports of intermediates are high because of imports of raw materials (also from the rest of the world). Importantly however, in most cases these shares are increasing over time both for final and intermediates goods trade. The latter in particular implies that the production of intermediates goods trade has also become more integrated over time.

5.2 Net trade in factors

Trade in value added is itself composed of trade in capital and labor. From a theoretical perspective the HOV results suggest that countries being abundant with labor (capital) would be net exporters of labor (capital) services at least in productivity adjusted terms. As in this paper we focus on trade in value terms (rather than in physical units) this picture becomes distorted as we allow for differences in factor rewards (i.e. no factor-price equalization). However, the picture is already distorted when allowing for trade in intermediates or 'trade in tasks' (see Baldwin and Robert-Nicoud, 2011).

5.2.1 Trade in capital and labor

Table 5 presents the results when using capital and labor coefficients instead of value added coefficients. As the former two sum up to the latter trade flows in capital and labor must also sum up to flows in value added terms. A number of countries are both net exporters of labor and capital (including China, India, Indonesia, Russia, Japan, Korea and Taiwan). Conversely, the US and Turkey have been net importers of both labor and capital over the whole period. There are also a few countries where the signs are different. The EU-15, for example, was a net exporter of labor but a net importer of capital. And the EU-12,

Table 4 Decomposition of trade by use category (in %)

	Indirect exports			Re-Imports			Indirect imports		
Reporter	1995	2000	2005	1995	2000	2005	1995	2000	2005
				Final goods trade					
EU-15	19.9	22.5	22.9	1.9	1.8	2.0	16.1	19.1	20.4
EU-12	23.2	30.6	32.5	0.3	0.3	0.4	17.9	20.8	22.5
TUR	9.8	13.7	16.0	0.1	0.1	0.2	17.1	23.1	23.3
CAN	29.2	32.0	27.4	1.2	1.7	1.9	10.7	11.3	13.6
USA	9.1	9.0	11.3	7.5	9.1	6.5	10.5	11.4	13.7
MEX	24.8	30.1	27.6	0.4	0.6	0.6	10.6	11.9	15.8
JPN	5.7	7.1	9.4	2.0	2.3	2.3	10.5	12.2	13.3
KOR	17.6	19.8	21.4	0.5	0.7	0.9	10.4	10.8	12.8
TWN	29.7	32.4	36.3	0.2	0.5	0.7	9.9	10.9	13.7
AUS	8.3	8.1	8.9	0.3	0.4	0.5	11.6	12.8	15.1
BRA	4.0	7.4	7.0	0.2	0.1	0.2	11.4	13.5	14.9
CHN	13.1	12.6	16.5	0.5	1.2	2.5	14.3	15.4	16.0
IDN	16.2	15.7	14.2	0.1	0.3	0.3	12.9	10.9	12.9
IND	4.5	4.5	7.0	0.1	0.1	0.2	11.6	13.6	14.2
RUS	4.1	4.9	5.9	0.6	0.7	1.0	13.5	16.0	16.8
ZROW	5.4	8.4	7.8	0.1	0.1	0.1	13.6	13.3	13.4
				Intermediate goods trade					
EU-15	19.0	21.7	22.2	1.6	1.5	1.9	14.1	15.8	16.8
EU-12	23.2	29.5	33.2	0.4	0.4	0.4	15.5	18.5	19.8
TUR	9.4	13.5	16.0	0.1	0.1	0.2	13.6	15.9	16.1
CAN	20.4	21.4	18.4	1.3	1.9	2.1	9.2	9.5	11.2
USA	7.6	8.1	9.7	5.7	7.8	5.6	8.0	8.4	10.2
MEX	19.9	23.0	20.9	0.4	0.7	0.7	10.5	11.5	15.1
JPN	6.0	7.3	10.5	1.6	1.6	1.6	8.5	9.6	10.2
KOR	18.9	19.6	21.6	0.4	0.6	0.9	9.5	9.7	11.8
TWN	33.0	35.9	43.0	0.2	0.5	0.7	10.1	11.3	13.3
AUS	8.4	7.1	6.4	0.3	0.4	0.6	11.3	11.4	12.6
BRA	4.5	6.4	6.6	0.1	0.1	0.2	10.3	12.3	13.2
CHN	11.0	11.0	17.1	0.6	1.2	2.4	12.6	14.3	15.1
IDN	11.0	8.9	8.5	0.2	0.3	0.5	11.3	10.0	11.2
IND	5.2	4.9	6.2	0.1	0.1	0.2	10.5	10.4	11.3
RUS	5.1	6.4	4.7	1.0	0.9	1.3	12.1	14.2	17.0
ZROW	5.3	6.6	6.9	0.1	0.0	0.1	11.8	7.1	9.4

Source: WIOD database, Version January 2011; author's calculations

Canada, Mexico (in the latter years) and Australia have been net exporters of capital and net importers of labor. Some countries, like Brazil, show a mixed pattern. Table 5 again includes direct and indirect

Table 5 Net trade in capital and labor (total trade), in bn US-$

	Net exports capital			Net exports labor		
Reporter	1995	2000	2005	1995	2000	2005
EU-15	-35.41	-77.64	-187.21	100.16	22.06	119.77
EU-12	4.29	3.09	6.69	-7.16	-19.53	-27.77
TUR	-3.09	-7.93	-13.00	-6.97	-10.61	-21.38
CAN	18.72	43.31	43.04	-2.08	-6.06	-7.15
USA	-64.47	-197.24	-367.60	-51.55	-168.64	-313.04
MEX	4.88	0.85	11.96	2.94	-7.96	-15.40
JPN	39.24	44.15	40.04	51.78	41.99	47.31
KOR	-4.54	10.33	6.91	10.94	16.05	33.49
TWN	8.51	9.80	15.18	0.31	3.55	8.99
AUS	3.53	7.28	11.53	-2.39	-2.24	-14.27
BRA	-3.85	-4.86	7.91	-3.61	-0.60	28.45
CHN	11.47	11.90	103.45	28.31	51.12	121.02
IDN	0.42	3.63	8.24	1.07	11.04	9.91
IND	0.78	0.50	3.85	3.54	10.45	5.07
RUS	14.30	26.97	76.05	9.10	29.95	41.74
ZROW	5.20	125.85	232.97	-134.38	29.44	-16.73

Source: WIOD database, Version January 2011; author's calculations

exports and imports. We therefore present in Table 6 the shares of indirect exports and imports (we leave out the share of re-imports as this is rather small). In magnitude these are quite close to the ones for total trade and also the patterns across countries are quite similar. Again, the share of indirect exports tend to be larger than the share of indirect imports. There is however no clear evidence of whether these shares are higher or lower for capital or labor across countries.

5.2.2 Trade in ICT and Non-ICT capital

Now we move on to split up capital into ICT and Non-ICT capital[16] and later on also labor into its subcomponents. Table 7 presents the results for the two capital categories. First, one has to note that trade in ICT capital has a much lower share than trade in Non-ICT capital. Again, in most cases surplus countries are net exporters of both types of capital. However, some interesting changes over time can be observed. The EU-15 is a net importer of ICT capital, though the trade deficit diminishes whereas the

[16]The ICT share in capital income was imputed for some countries and thus results are preliminary.

Table 6 Decomposition of trade in factors (total trade), in %

	Capital						Labor					
	Indirect exports			Indirect imports			Indirect exports			Indirect imports		
Reporter	1995	2000	2005	1995	2000	2005	1995	2000	2005	1995	2000	2005
EU-15	20.9	23.3	25.0	16.9	18.8	20.5	18.7	21.5	21.1	16.6	18.8	20.0
EU-12	21.4	26.9	30.5	17.3	20.4	22.1	24.3	32.1	34.7	16.5	19.3	20.6
TUR	9.2	13.9	14.6	15.3	17.9	18.2	9.8	13.5	17.1	14.7	19.2	19.0
CAN	20.4	20.0	18.9	11.8	13.5	15.4	26.6	29.9	24.1	10.7	11.4	13.5
USA	9.0	10.5	12.5	14.6	16.8	16.9	7.7	7.5	9.1	16.2	19.0	18.2
MEX	20.2	24.6	20.4	11.7	14.0	17.4	23.7	28.5	27.6	10.5	11.4	15.0
JPN	5.8	7.1	10.6	10.8	12.1	12.6	5.8	7.3	9.5	11.2	12.7	13.7
KOR	21.8	18.5	23.1	10.2	10.1	12.7	16.7	20.5	20.4	10.1	10.8	13.1
TWN	30.1	32.7	40.1	10.7	11.8	14.4	32.1	35.2	41.2	10.1	11.5	13.9
AUS	7.4	6.4	6.0	11.4	12.5	15.1	9.1	8.3	7.9	11.8	12.4	13.9
BRA	4.6	7.3	8.0	10.7	12.1	13.0	4.1	6.6	6.0	11.0	13.3	14.7
CHN	13.2	13.4	16.4	14.1	15.3	17.9	12.0	11.2	17.0	13.4	16.1	17.5
IDN	13.8	13.0	10.5	11.9	10.4	11.4	13.0	11.5	10.4	12.1	10.8	12.6
IND	4.9	4.8	6.0	10.3	10.0	11.9	4.7	4.6	7.3	11.3	11.9	12.8
RUS	3.9	5.2	3.9	14.3	16.6	20.0	5.4	6.4	6.2	13.3	15.4	16.9
ZROW	5.0	6.3	7.1	14.5	12.1	14.2	5.6	7.8	7.1	12.5	11.8	11.4

Source: WIOD database, Version January 2011; author's calculations

Table 7 Net trade in ICT and Non-ICT capital (total trade), in bn US-$

	ICT capital			Non-ICT capital		
Reporter	1995	2000	2005	1995	2000	2005
EU-15	-16.24	-3.73	-6.27	-19.16	-73.90	-180.94
EU-12	1.65	-0.31	-0.19	2.64	3.40	6.88
TUR	0.20	-0.78	-1.18	-3.29	-7.15	-11.81
CAN	-0.94	-0.12	-1.04	19.67	43.43	44.08
USA	2.76	5.62	-3.21	-67.22	-202.86	-364.39
MEX	2.19	-2.07	-1.18	2.69	2.92	13.14
JPN	-0.30	6.34	4.84	39.54	37.81	35.20
KOR	-2.41	0.14	1.33	-2.13	10.19	5.57
TWN	-0.21	0.38	1.04	8.72	9.42	14.14
AUS	-0.83	-0.57	-0.80	4.36	7.85	12.33
BRA	0.30	-0.79	1.30	-4.14	-4.06	6.61
CHN	4.44	0.72	10.14	7.03	11.18	93.31
IDN	1.34	0.10	0.14	-0.91	3.53	8.09
IND	0.78	0.66	2.60	-0.00	-0.15	1.25
RUS	4.08	2.53	6.21	10.22	24.43	69.83
ZROW	3.20	-8.12	-13.73	2.01	133.97	246.71

Source: WIOD database, Version January 2011; author's calculations

US which has been a net exporter of ICT capital becomes a net importer in 2005 which is similarly also the case for Canada and Mexico. The Asian countries (Japan, Korea and Taiwan) are however improving their position and becoming net exporters of ICT capital. Finally, China is also improving its position in this category.

In the case of Non-ICT capital there seems a tendency for each country (group) to maintain its position. Only a few countries succeeded in becoming net exporters of Non-ICT capital (Korea, Brazil, Indonesia, and India). The other countries did not switch their position as either net exporters or net-importers with the tendency that the trade deficit/surplus increased in each case.

5.2.3 Trade in labor by educational attainment categories

Finally, we present in Table 8 the results when splitting up trade flows in labor terms into the components high-educated and medium andlow educated combined. The first interesting point here is that the EU-15

Table 8 Net trade in labour by educational catgories, in bn US-$

	High educated			Medium + low educated		
Reporter	1995	2000	2005	1995	2000	2005
EU-15	-45.98	-55.58	-72.04	146.14	77.64	191.81
EU-12	-3.05	-7.51	-10.76	-4.11	-12.02	-17.01
TUR	-1.97	-3.90	-6.85	-5.00	-6.71	-14.53
CAN	-10.09	-16.01	-22.90	8.01	9.94	15.75
USA	73.17	86.94	53.09	-124.72	-255.58	-366.13
MEX	-4.92	-17.52	-15.00	7.86	9.56	-0.40
JPN	22.67	29.06	37.59	29.12	12.93	9.72
KOR	9.72	16.29	35.92	1.21	-0.24	-2.43
TWN	1.11	2.26	6.14	-0.80	1.29	2.84
AUS	-2.01	-1.81	-7.39	-0.38	-0.44	-6.88
BRA	-1.76	-3.48	4.18	-1.86	2.87	24.27
CHN	-3.96	-7.61	0.42	32.26	58.72	120.60
IDN	-1.85	-1.08	-0.20	2.92	12.11	10.11
IND	-0.78	-0.74	0.39	4.32	11.19	4.68
RUS	0.25	2.87	10.64	8.85	27.08	31.10
ZROW	-30.56	-22.19	-13.23	-103.82	51.63	-3.50

Source: WIOD database, Version January 2011; author's calculations

is a net importer of high-educated labor (and increasingly so) whereas the US is maintaining its position in being a net exporter of high-educated labor though again with the trade surplus declining over time.

The Asian countries (Japan, Korea and Taiwan) are net exporters of high-educated labor with increasing trade surpluses. Finally, China which has been a net importer of high-educated labor became a net exporter in 2005 (with a very small trade surplus however). Nonetheless, China is also maintaining its position as being an important net exporter of low-educated labor where it had a huge trade surplus. Most of the other emerging economies also show large trade surpluses in medium and low-educated labor. With respect to the advanced countries, the US is - as expected - a huge net importer of medium and low-educated labor, whereas the EU-15 are net exporters of this category and also show a rising trade surplus.

6 Revealed comparative advantages in factor trade

In this section we consider the possibility of using common measures of revealed comparative advantages to describe actual patterns of trade in factors (in value terms). For this we report the Ballassa index (Ballassa, 1965) on exports (both differentiated by our measure of direct and indirect exports) in logs (the first term in the equation below) and an index which subtracts a similar term for imports:

$$\text{RCA}_k^r = \ln \frac{X_k^r / \sum_{j,j\neq k} X_j^r}{\sum_{p,p\neq r} X_j^p / \sum_{p,j;p\neq r,j\neq k} X_j^p}$$

and

$$\text{RCA}_k^r = \ln \frac{X_k^r / \sum_{j,j\neq k} X_j^r}{\sum_{p,p\neq r} X_j^p / \sum_{p,j;p\neq r,j\neq k} X_j^p} - \ln \frac{M_k^r / \sum_{j,j\neq k} M_j^r}{\sum_{p,p\neq r} M_j^p / \sum_{p,j;p\neq r,j\neq k} M_j^p}$$

where X denotes exports, M is imports, r denote country and k is for the category under consideration (in this case the factor). See Vollrath (1991) for an overview of such measures. To our knowledge this is the first attempt to apply RCA measures to the factor content of trade.

The figures below present these measures for 1995 (on the vertical axes) and 2005 on the horizontal axes. Points in the first (third) quadrant indicate that the countries had a comparative advantage (disadvantage) in both periods, points in the second (fourth) quadrant imply that a country had a comparative advantage (disadvantage) in the first year, and a comparative disadvantage (advantage) in the second year. Points lying on the diagonal mean that there has been no shift in the position of the particular country. Accordingly, countries moving up (down) improved (worsened) their position.

[DESCRIPTION OF RESULTS TO BE INCLUDED ...]

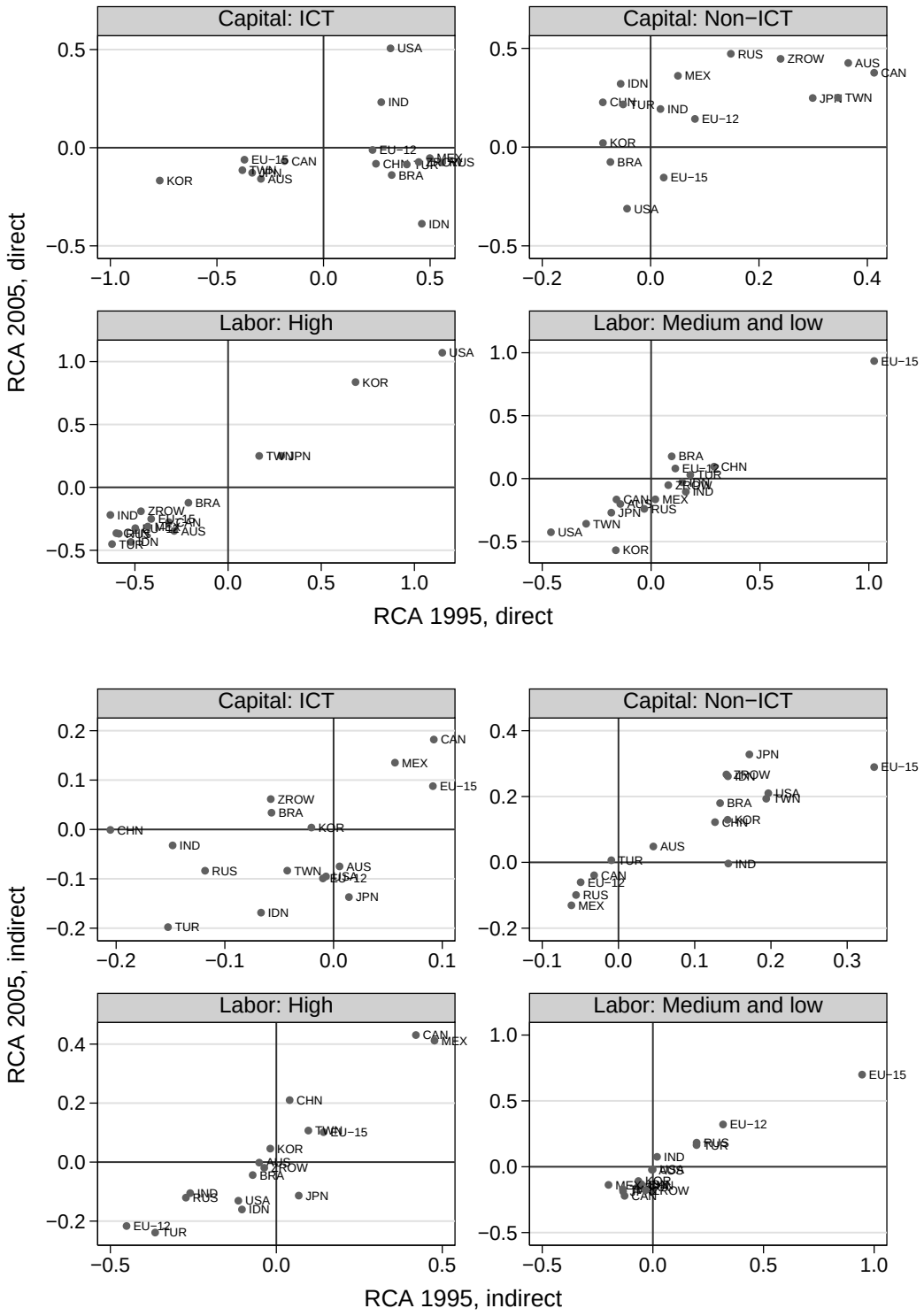

Figure 7: RCA1 (exports only)

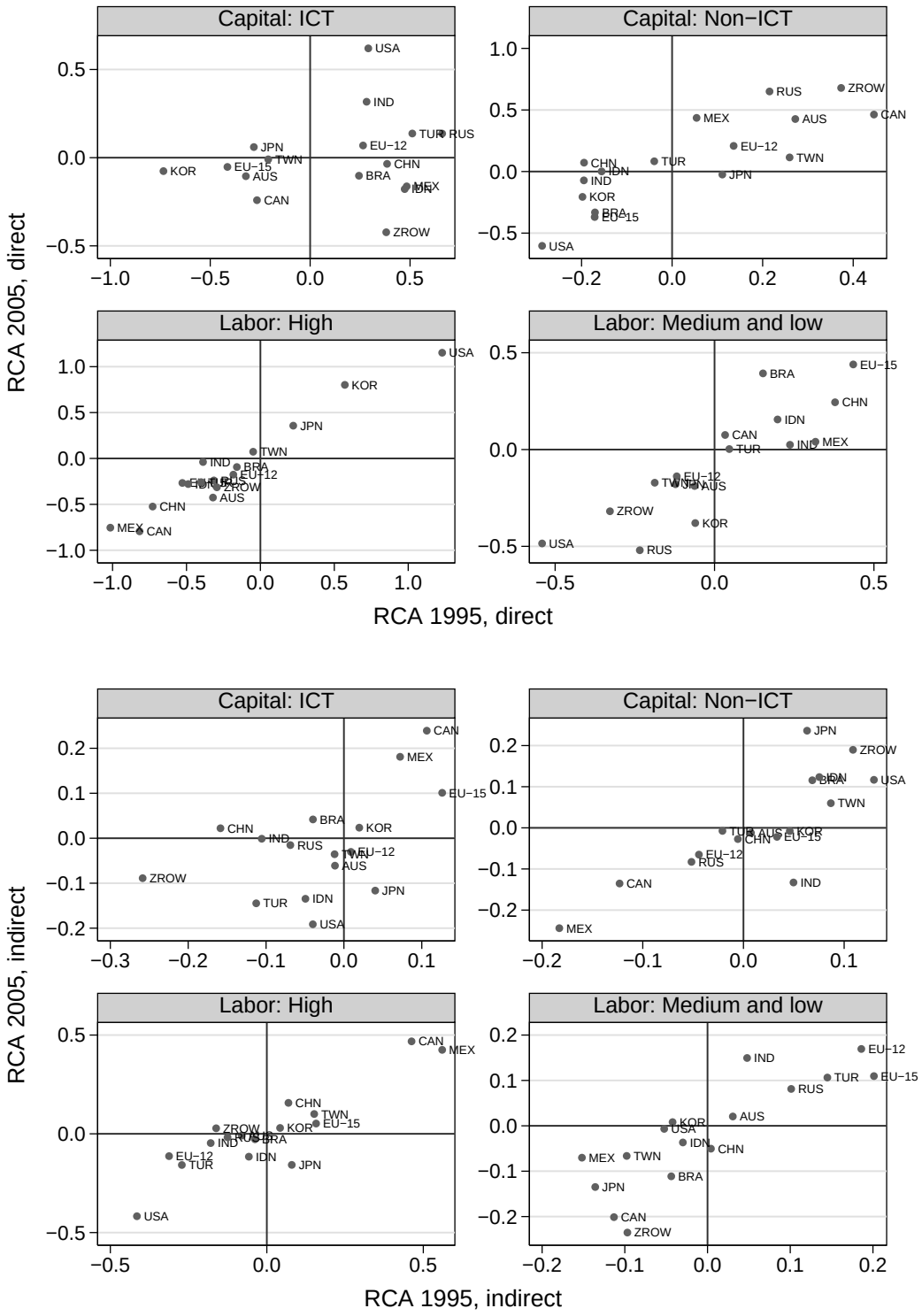

Figure 8: RCA2 measure (RCAX-RCAM)

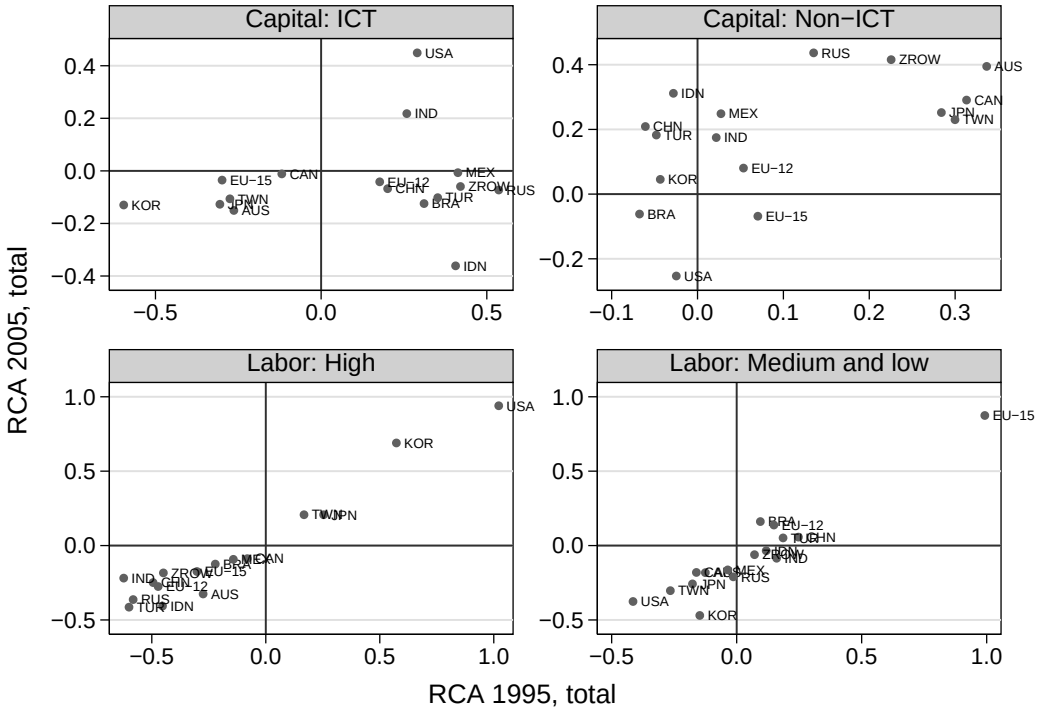

Figure 9: RCA1 (exports only) for direct + indirect exports

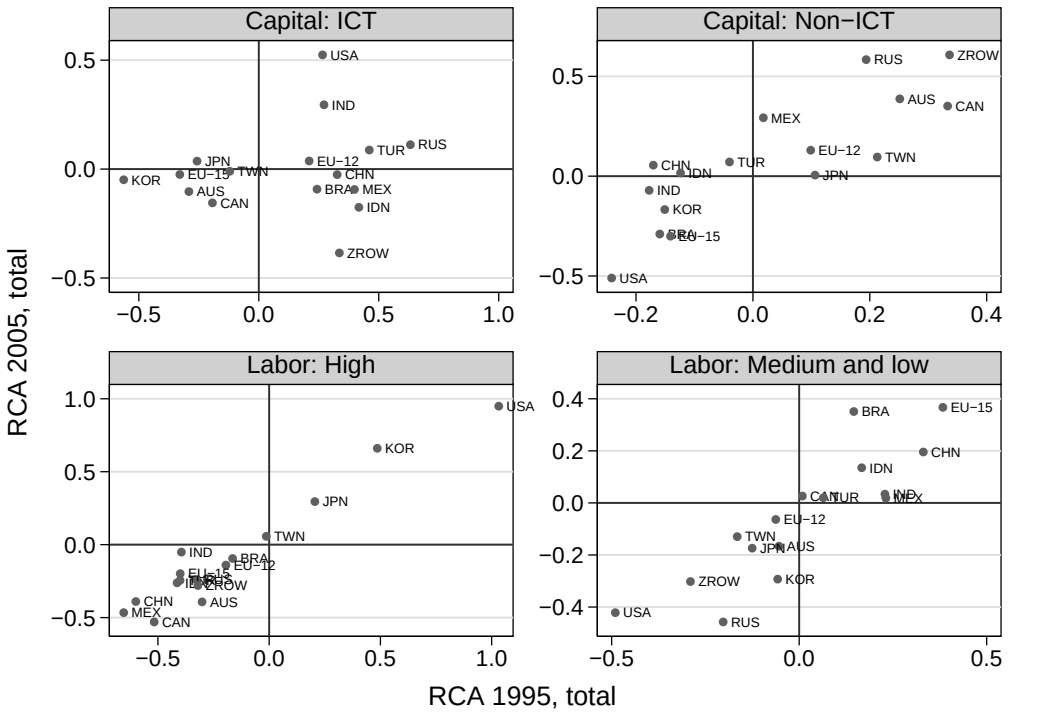

Figure 10: RCA2 measure (RCAX-RCAM) for direct + indirect trade

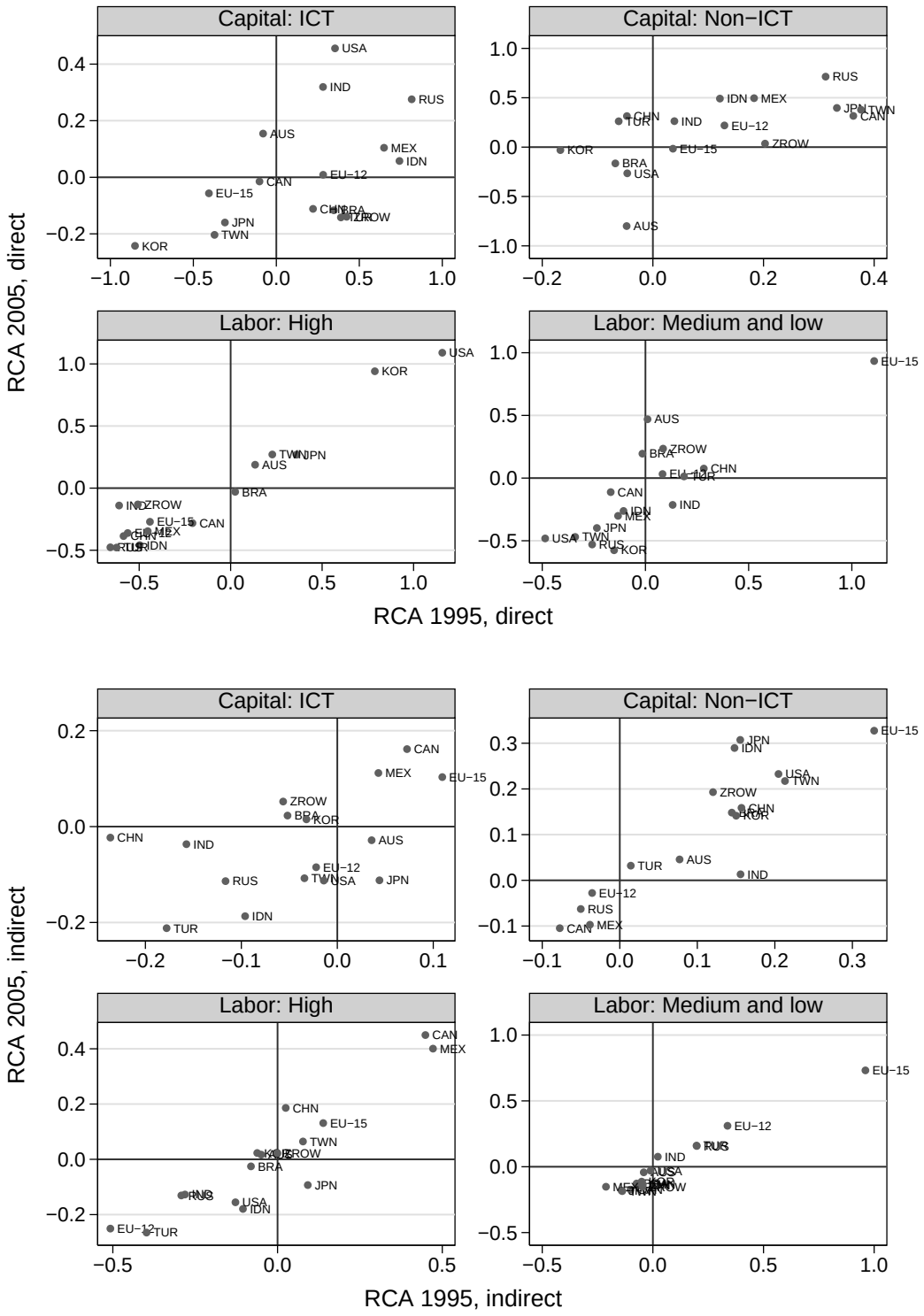

Figure 11: RCA1 measure (exports only) for final goods exports

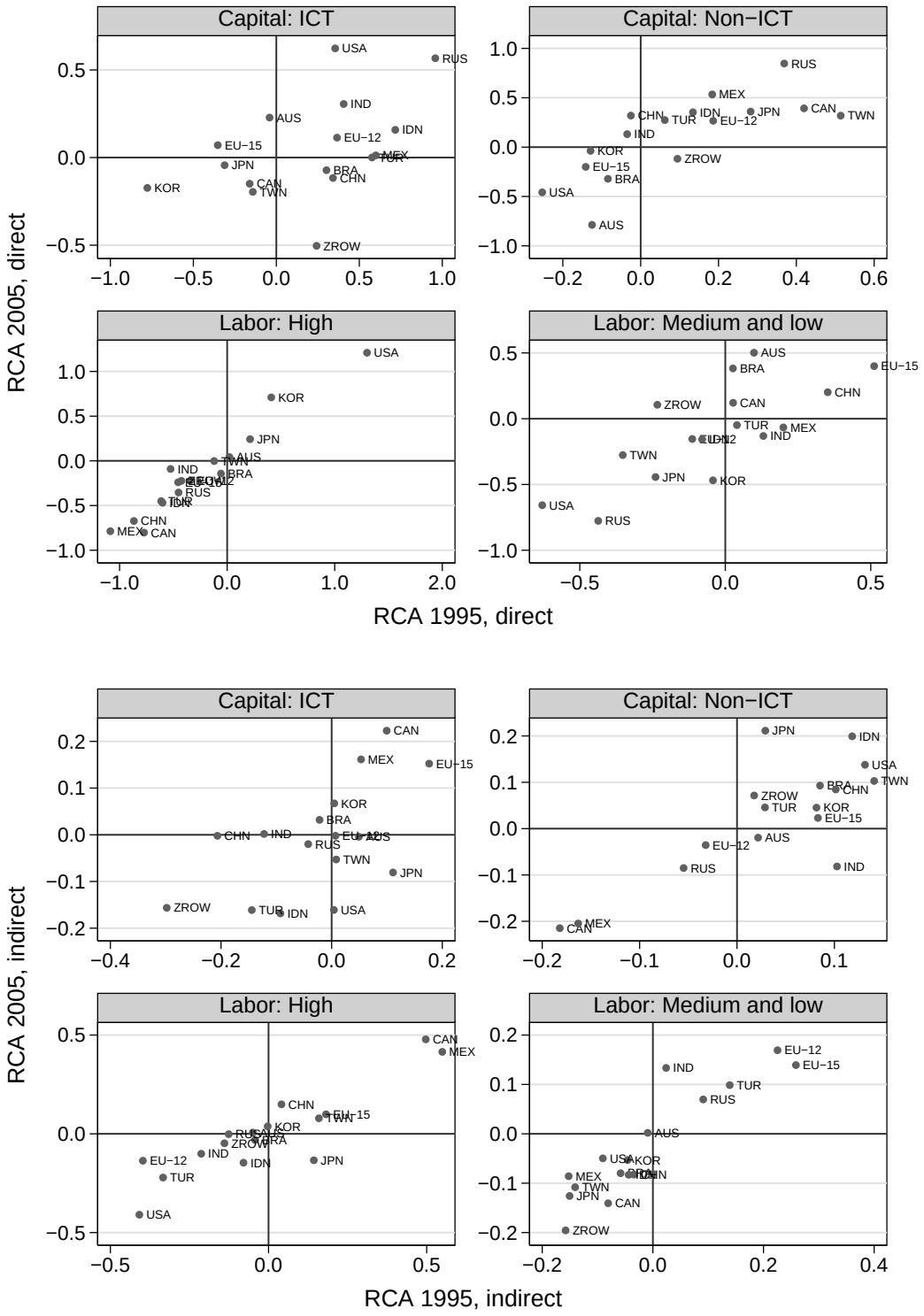

Figure 12: RCA2 measure (RCAX-RCAM) for final goods

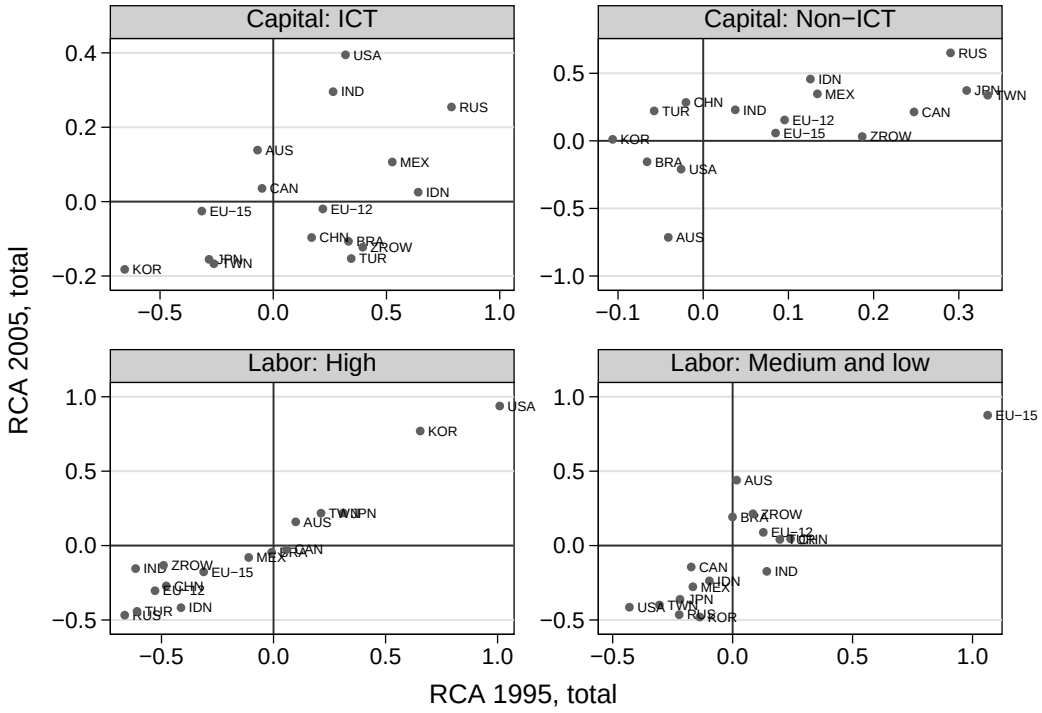

Figure 13: RCA1 measure (exports only) for final goods exports (direct + indirect)

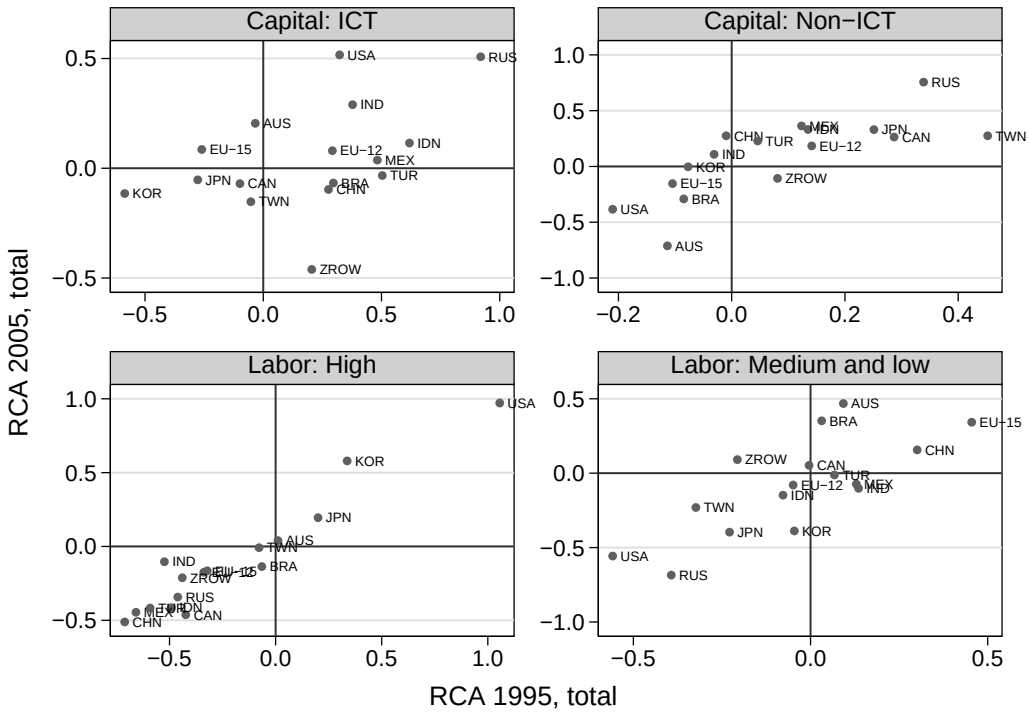

Figure 14: RCA2 (RCAX-RCAM) measure for final goods total trade (direct + indirect)

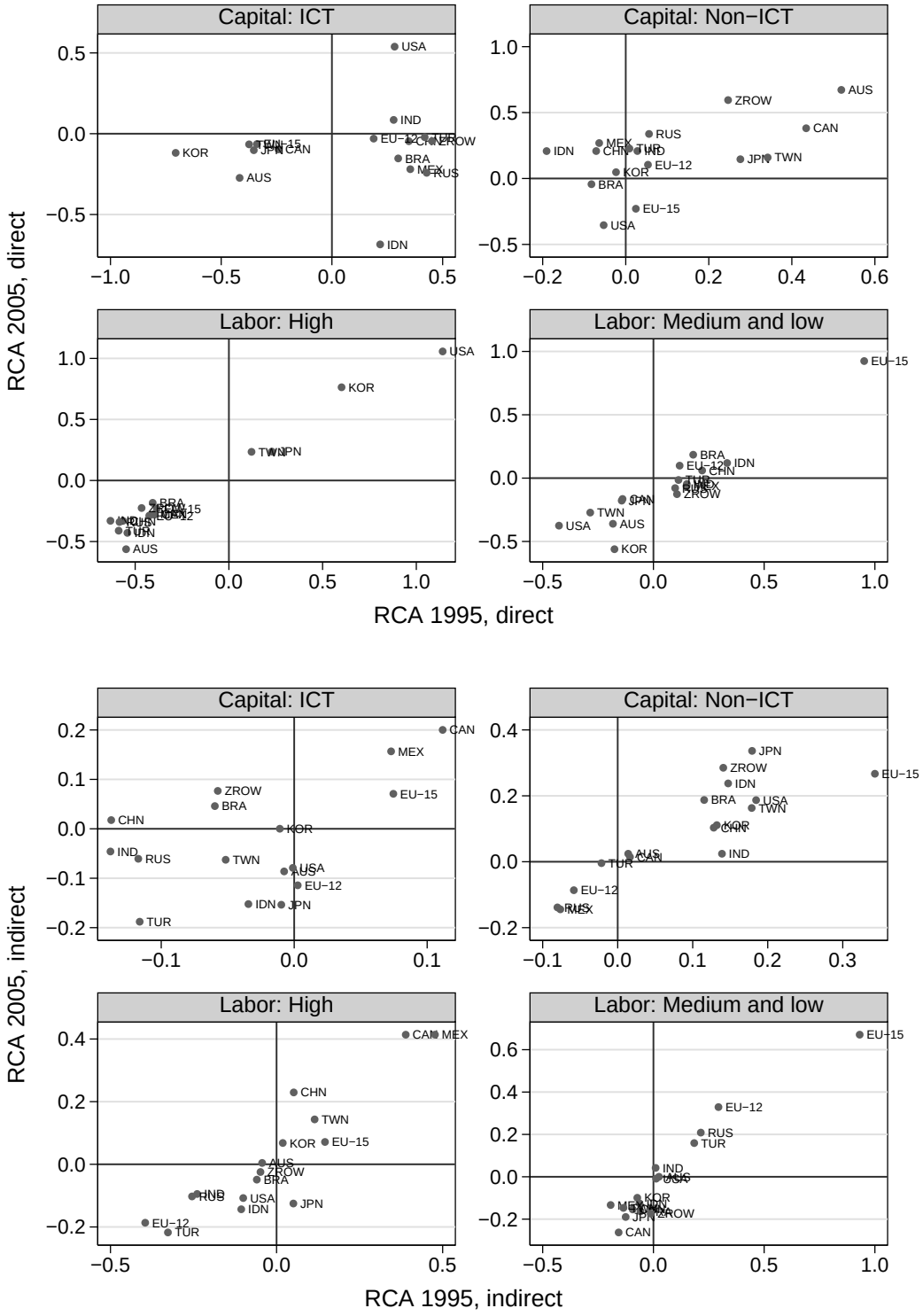

Figure 15: RCA1 measure (exports only) for intermediate goods exports

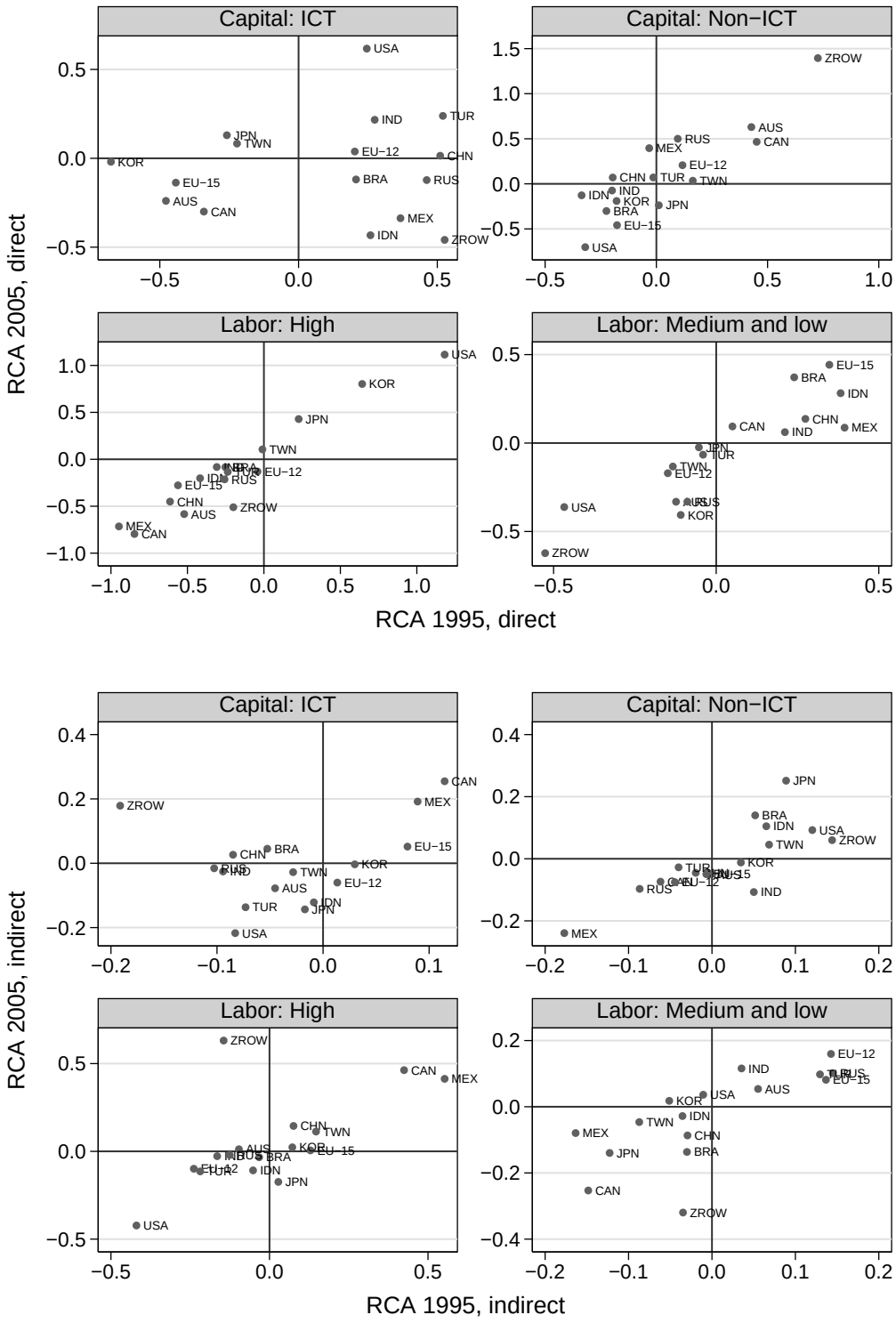

Figure 16: RCA2 measure (RCAX-RCAM) for intermediate goods trade

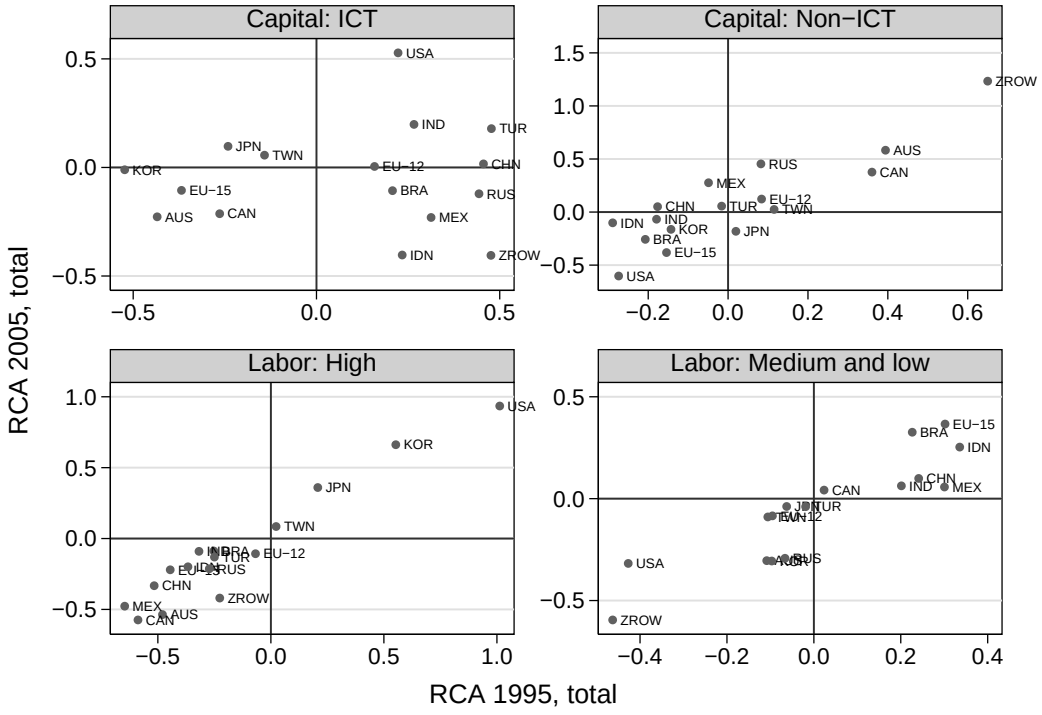

Figure 17: RCA1 measure (exports only) for intermediate goods exports (direct plus indirect)

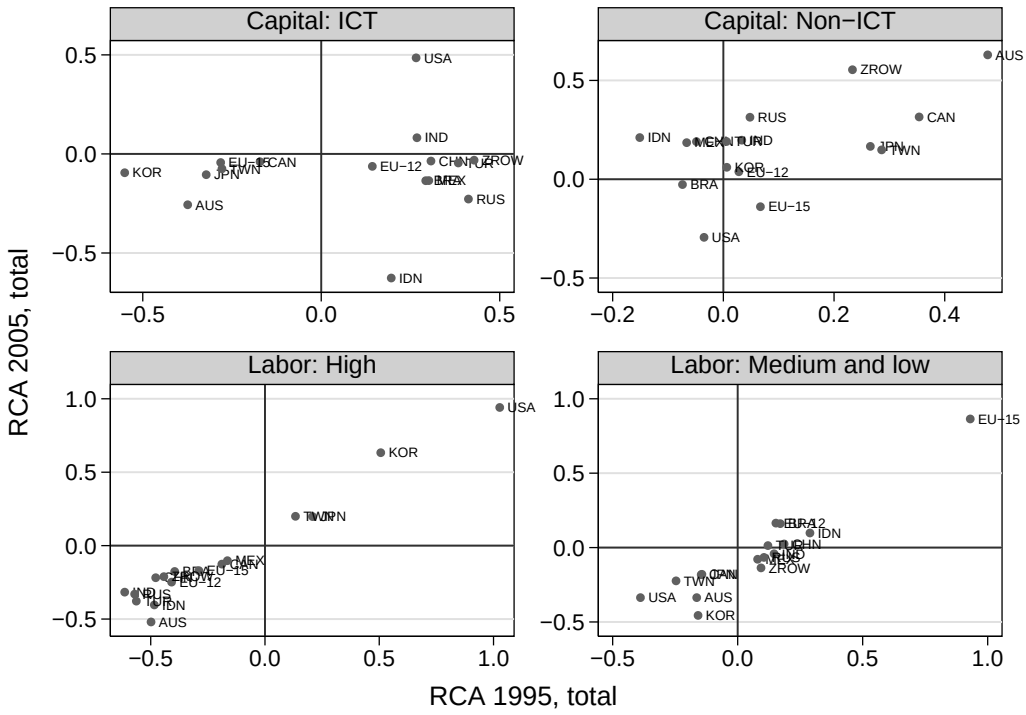

Figure 18: RCA2 measure (RCAX-RCAM) for intermediate goods total trade (direct plus indirect)

7 Conclusions

[... to be written ...]

A Appendix - Tables

Table 9 Net trade in capital and labor by use category, in bn US-$

	Net exports capital			Net exports labour		
Reporter	1995	2000	2005	1995	2000	2005
			Final goods trade			
EU-15	30.21	38.33	49.66	135.08	117.37	197.86
EU-12	10.44	13.29	31.63	10.18	11.95	27.68
TUR	1.53	0.34	4.28	1.59	0.74	1.43
CAN	5.60	12.68	1.48	-3.02	-9.35	-19.06
USA	-35.99	-91.53	-137.79	-49.57	-128.20	-169.05
MEX	9.05	17.89	24.09	10.99	26.39	15.84
JPN	29.02	44.33	50.40	32.48	34.65	30.88
KOR	4.36	19.05	20.76	15.19	30.13	35.73
TWN	14.40	13.13	11.39	12.34	12.89	6.92
AUS	-2.28	-5.48	-19.37	-2.57	-6.64	-20.83
BRA	-0.93	-0.30	5.17	-1.68	1.36	15.00
CHN	27.48	39.70	149.63	51.87	86.15	190.91
IDN	3.08	4.53	7.31	1.40	6.37	4.02
IND	4.86	8.08	22.69	8.23	15.38	24.36
RUS	-0.62	10.24	12.79	-10.48	4.74	-13.41
ZROW	-100.21	-124.29	-234.12	-212.01	-203.94	-328.28
			Intermediates trade			
EU-15	-65.61	-115.96	-236.87	-34.92	-95.31	-78.09
EU-12	-6.15	-10.21	-24.94	-17.34	-31.48	-55.45
TUR	-4.62	-8.27	-17.27	-8.56	-11.35	-22.81
CAN	13.13	30.63	41.56	0.94	3.29	11.91
USA	-28.48	-105.72	-229.81	-1.97	-40.44	-143.99
MEX	-4.17	-17.04	-12.13	-8.05	-34.35	-31.24
JPN	10.22	-0.18	-10.36	19.30	7.34	16.43
KOR	-8.90	-8.73	-13.86	-4.25	-14.08	-2.25
TWN	-5.89	-3.33	3.78	-12.03	-9.34	2.07
AUS	5.80	12.76	30.90	0.18	4.40	6.56
BRA	-2.92	-4.56	2.73	-1.93	-1.96	13.45
CHN	-16.00	-27.80	-46.18	-23.56	-35.04	-69.89
IDN	-2.66	-0.90	0.93	-0.33	4.67	5.89
IND	-4.08	-7.57	-18.85	-4.68	-4.93	-19.29
RUS	14.92	16.72	63.26	19.58	25.21	55.15
ZROW	105.41	250.14	467.09	77.63	233.38	311.55

Source: WIOD database, Version January 2011; author's calculations

Table 10 Net trade in ICT and Non-ICT capital by use category (bn US-$)

	ICT capital			Non-ICT capital		
Reporter	1995	2000	2005	1995	2000	2005
			Final goods			
EU-15	1.03	10.85	16.47	29.17	27.48	33.19
EU-12	2.19	1.69	3.63	8.26	11.60	28.00
TUR	0.54	-0.06	0.20	0.99	0.40	4.07
CAN	-0.26	-0.44	-1.51	5.85	13.12	2.99
USA	-0.09	-0.13	-3.17	-35.90	-91.39	-134.62
MEX	2.15	1.71	2.39	6.90	16.19	21.71
JPN	0.71	4.28	3.18	28.32	40.06	47.23
KOR	-0.29	1.81	2.17	4.65	17.25	18.59
TWN	0.95	1.09	0.42	13.45	12.04	10.97
AUS	-0.26	-0.59	-1.59	-2.01	-4.89	-17.77
BRA	0.22	-0.13	0.86	-1.14	-0.17	4.32
CHN	4.97	3.92	15.52	22.51	35.77	134.11
IDN	1.12	0.56	0.71	1.96	3.97	6.60
IND	0.99	1.04	3.83	3.87	7.04	18.86
RUS	0.84	1.14	1.58	-1.46	9.11	11.21
ZROW	-14.80	-26.72	-44.68	-85.41	-97.57	-189.44
			Intermediates			
EU-15	-17.28	-14.59	-22.74	-48.33	-101.38	-214.13
EU-12	-0.53	-2.00	-3.82	-5.62	-8.20	-21.12
TUR	-0.33	-0.72	-1.38	-4.28	-7.55	-15.89
CAN	-0.69	0.33	0.47	13.81	30.31	41.09
USA	2.85	5.75	-0.04	-31.33	-111.47	-229.77
MEX	0.04	-3.77	-3.56	-4.21	-13.27	-8.57
JPN	-1.01	2.06	1.67	11.23	-2.24	-12.02
KOR	-2.12	-1.67	-0.84	-6.78	-7.06	-13.02
TWN	-1.16	-0.71	0.62	-4.73	-2.62	3.17
AUS	-0.57	0.01	0.80	6.37	12.74	30.11
BRA	0.08	-0.66	0.44	-3.00	-3.90	2.29
CHN	-0.53	-3.20	-5.38	-15.47	-24.60	-40.79
IDN	0.22	-0.46	-0.57	-2.87	-0.44	1.50
IND	-0.21	-0.38	-1.23	-3.87	-7.19	-17.62
RUS	3.24	1.40	4.64	11.68	15.32	58.62
ZROW	18.00	18.60	30.94	87.42	231.54	436.14

Source: WIOD database, Version January 2011; author's calculations

Table 11 Net trade in labour by educational catgories by use category (bn US-$)

	High educated			Medium + low educated		
Reporter	1995	2000	2005	1995	2000	2005
			Final goods			
EU-15	-0.18	6.27	12.16	135.26	111.10	185.70
EU-12	-0.24	-0.21	3.82	10.42	12.16	23.86
TUR	-0.42	-1.29	-1.11	2.01	2.03	2.55
CAN	-4.16	-8.21	-13.81	1.14	-1.14	-5.25
USA	24.62	26.44	17.14	-74.20	-154.63	-186.19
MEX	0.62	1.16	1.55	10.36	25.23	14.29
JPN	12.88	17.40	20.40	19.61	17.26	10.48
KOR	6.09	13.28	21.44	9.10	16.86	14.29
TWN	3.53	4.20	3.36	8.81	8.69	3.55
AUS	-0.62	-1.85	-6.80	-1.95	-4.79	-14.04
BRA	-0.49	-1.08	2.59	-1.19	2.44	12.41
CHN	4.07	7.21	35.31	47.79	78.95	155.60
IDN	-0.50	-0.08	0.25	1.90	6.45	3.77
IND	0.56	1.27	6.00	7.67	14.11	18.36
RUS	-1.97	-0.07	-2.47	-8.51	4.81	-10.94
ZROW	-43.79	-64.43	-99.84	-168.22	-139.51	-228.44
			Intermediates			
EU-15	-17.28	-14.59	-22.74	-48.33	-101.38	-214.13
EU-12	-0.53	-2.00	-3.82	-5.62	-8.20	-21.12
TUR	-0.33	-0.72	-1.38	-4.28	-7.55	-15.89
CAN	-0.69	0.33	0.47	13.81	30.31	41.09
USA	2.85	5.75	-0.04	-31.33	-111.47	-229.77
MEX	0.04	-3.77	-3.56	-4.21	-13.27	-8.57
JPN	-1.01	2.06	1.67	11.23	-2.24	-12.02
KOR	-2.12	-1.67	-0.84	-6.78	-7.06	-13.02
TWN	-1.16	-0.71	0.62	-4.73	-2.62	3.17
AUS	-0.57	0.01	0.80	6.37	12.74	30.11
BRA	0.08	-0.66	0.44	-3.00	-3.90	2.29
CHN	-0.53	-3.20	-5.38	-15.47	-24.60	-40.79
IDN	0.22	-0.46	-0.57	-2.87	-0.44	1.50
IND	-0.21	-0.38	-1.23	-3.87	-7.19	-17.62
RUS	3.24	1.40	4.64	11.68	15.32	58.62
ZROW	18.00	18.60	30.94	87.42	231.54	436.14

Source: WIOD database, Version January 2011; author's calculations

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