Revealed Comparative Advantage at the Task Level: A Global Value Chain Perspective

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Abstract

Production increasingly fragments across borders. What tasks do different countries perform in these global value chains (GVCs)? In this paper we present a new measure of revealed comparative advantage (RCA) based on tasks in GVCs. Traditionally RCA analysis is based on gross exports values of products yielding surprising results such as stagnating patterns across Europe (Di Mauro and Forster, 2008), In the same vein, Rodrik (2006) argues that 'China has ended up with an export basket that is significantly more sophisticated than what would be normally expected for a country at its income level'.

Our alternative measure is based on what type of activities workers perform in the GVC of a particular product. A distinction is made between pre-production activities (such as R&D and design), production activities (manufacturing and basic services) and post-production activities (such as marketing and after-sales services). Based on a set of 560 manufactures GVCs we determine for each country the value added by workers involved in each of these tasks following Timmer et al. (2014). To this end we combine the WIOD database with new information from labour force surveys on the number of workers involved in particular occupations, and their wages. We map these occupations into the pre-production, production, or post-production activities. (The Appendix provides more detail on method and sources)

Our new RCA measures based on tasks in global value chains suggest that mature economies are indeed specializing in pre-production and post-production stages, while emerging markets specialise in production activities. Within Europe clear specialisation patterns are discovered. For example, the Netherlands specializes in post-production activities whereas Sweden and Finland specializes relatively more in the pre-production stage.

References

di Mauro, F. and K. Forster (2008), "Globalisation and the competitiveness of the euro area", ECB Occasional Paper No. 97.

Rodrik, D. (2006), "What's so Special about China's Exports? NBER working paper #11947.

Timmer, Marcel P., Bart Los, Robert Stehrer and Gaaitzen J. de Vries (2013) "Fragmentation, Incomes and Jobs. An Analysis of European Competitiveness". *Economic Policy*, 28(76), 613-661

Appendix. Measuring business functions in Global Value Chains: Method and Sources

In this section we first give an overview of the method that is used to measure global value chains. Next, we discuss the main data sources used.

Measuring global value chains and production stages

To measure GVC incomes we follow the approach outlined in Johnson and Noguera (2012), which in turn revived an older literature on input-output accounting with multiple regions going back to Isard (1951) and in particular work by Miller (1966).[1] By tracing the value added at the various stages of production in an international input-output model, we are able to provide an ex-post accounting of the value of final demand. We introduce our accounting framework drawing on the exposition in Johnson and Noguera (2012) and then generalize their approach to analyse the value added by specific occupations, organized by business functions.

We assume that there are S sectors, F occupations and N countries. Although we will apply annual data in our empirical analysis, time subscripts are left out in the following discussion for ease of exposition. Each country-sector produces one good, such that there are SN products. We use the term country-sector to denote a sector in a country, such as the French chemicals sector or the German transport equipment sector. Output in each country-sector is produced using domestic production factors and intermediate inputs, which may be sourced domestically or from foreign suppliers. Output may be used to satisfy final demand (either at home or abroad) or used as intermediate input in production (either at home or abroad as well). Final demand consists of household and government consumption and investment. To track the shipments of intermediate and final goods within and across countries, it is necessary to define source and destination country-sectors. For a particular product, we define i as the source country, j as the destination country, s as the source sector and t as the destination sector. By definition, the quantity of a product produced in a particular country-sector must equal the quantities of this product used domestically and abroad, since product market clearing is assumed (changes in inventories are considered as part of investment demand). The product market clearing condition can be written as

$$y_i(s) = \sum_j f_{ij}(s) + \sum_j \sum_t m_{ij}(s,t) \qquad (1)$$

where $y_i(s)$ is the value of output in sector s of country i, $f_{ij}(s)$ the value of goods shipped from this sector for final use in any country j, and $m_{ij}(s,t)$ the value of goods shipped from this sector for intermediate use by sector t in country j. Note that the use of goods can be at home (in case $i = j$) or abroad ($i \neq j$).

Using matrix algebra, the market clearing conditions for each of the SN goods can be combined to form a compact global input-output system. Let **y** be the vector of production of

[1] See Miller and Blair (2009) for an introduction into input-output analysis.

dimension (SNx1), which is obtained by stacking output levels in each country-sector. Define **f** as the vector of dimension (SNx1) that is constructed by stacking world final demand for output from each country-sector $f_i(s)$. World final demand is the summation of demand from any country, such that $f_i(s) = \sum_j f_{ij}(s)$. We further define a global intermediate input coefficients matrix $\mathbf{A}$ of dimension (SNxSN). The elements $a_{ij}(s,t) = m_{ij}(s,t)/y_j(t)$ describe the output from sector *s* in country *i* used as intermediate input by sector *t* in country *j* as a share of output in the latter sector. The matrix **A** describes how the products of each country-sector are produced using a combination of various intermediate products, both domestic and foreign. Using this we can rewrite the stacked SN market clearing conditions from (1) in compact form as $\mathbf{y} = \mathbf{Ay} + \mathbf{f}$. Rearranging, we arrive at the fundamental input-output identity

$$\mathbf{y} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} \tag{2}$$

where $\mathbf{I}$ is an (SNxSN) identity matrix with ones on the diagonal and zeros elsewhere. $(\mathbf{I} - \mathbf{A})^{-1}$ is famously known as the Leontief inverse (Leontief, 1936). The element in row *m* and column *n* of this matrix gives the total production value of sector *m* needed for production of one unit of final output of product *n*. To see this, let $\mathbf{z}_n$ be a column vector with the *n*th element representing a euro of global consumption of goods from country-sector *n*, while all the remaining elements are zero. The production of $\mathbf{z}_n$ requires intermediate inputs given by $\mathbf{Az}_n$. In turn, the production of these intermediates requires the use of other intermediates given by $\mathbf{A}^2\mathbf{z}_n$, and so on. As a result the increase in output in each sector is given by the sum of all direct and indirect effects $\sum_{k=0}^{\infty} \mathbf{A}^k\mathbf{z}_n$. This geometric series converges to $(\mathbf{I} - \mathbf{A})^{-1}\mathbf{z}_n$.

Our aim is to attribute the value of final demand for a specific product to value added in country-sectors that directly and indirectly participate in the production process of the final good. Value added is defined in the standard way as gross output value (at basic prices) minus the cost of intermediate goods and services (at purchaser's prices). We define $p_i(s)$ as the value added per unit of gross output produced in sector *s* in country *i* and create the stacked SN-vector **p** containing these 'direct' value added coefficients. To take 'indirect' contributions into account, we derive the SN-vector of value added levels **v** as generated to produce a final demand vector **f** by pre-multiplying the gross outputs needed for production of this final demand by the direct value added coefficients vector **p**:

$$\mathbf{v} = \hat{\mathbf{p}}(\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} \tag{3}$$

in which a hat-symbol indicates a diagonal matrix with the elements of $\mathbf{p}$ on the diagonal.[2] We can now post-multiply $\widehat{\mathbf{p}}(\mathbf{I}-\mathbf{A})^{-1}$ with any vector of final demand levels to find out what value added levels should be attributed to this particular set of final demand levels.

These value added levels will depend on the structure of the global production process as described by the global intermediate inputs coefficients matrix **A,** and the vector of value-added coefficients in each country-sector $\mathbf{p}$. For example, both $\mathbf{p}$ and $\mathbf{A}$ will change when outsourcing takes place and value added generating activities which were originally performed within the sector are now embodied in intermediate inputs sourced from other country-sectors. $\mathbf{A}$ will change when for example an industry shifts sourcing its intermediates from one country to another.

The decomposition of the value of final demand outlined above can be generalized to analyse the value and quantities used of specific occupations in the production of a particular final good. In our empirical application we will study the changes in distribution of jobs in global production, both across countries and across different types of labour. To do so, we now define $p^L{}_i(s)$ as the direct labour input per unit of gross output produced in sector s in country i, for example the hours of technical professionals used in the Hungarian electronics sector to produce one euro of output. Analogous to the analysis of value added, the elements in $\mathbf{p}^{\mathrm{L}}$ do not account for labour embodied in intermediate inputs used. Using equation (3), we can derive all direct and indirect labour inputs needed for the production of a specific final product.

Data sources and mapping of occupations to business functions

Global value chains are estimated using the World Input-Output Tables. See Timmer et al. (2014) for an overview and Dietzenbacher et al. (2013) for a technical exposition.

We combine these tables with information on occupations. Two-digit occupational shares by detailed industry are derived from the EU labour force surveys for European countries, from the Occupational Employment Statistics (OES) surveys for the US and from the Japan Industry Productivity Database for Japan. This information is combined with wage data by occupation from the 2002 Structure and Earnings Survey for Europe, the OES for the US, and the historical statistics published by Japan's statistical office.

[2] If $\mathbf{v}$ is indeed to give the distribution of the value of final output as attributed to sectors in the value chain of product n, the elements of $\mathbf{v}$ should add up to the elements of $\mathbf{f}$. Intuitively, this should be true, since the Leontief inverse takes an infinite number of production rounds into account, as a consequence of which we model the production of a final good from scratch. The entire unit value of final demand must thus be attributed to country-sectors. We can show also mathematically that this is true. Let $\mathbf{e}$ an SN summation vector containing ones, and a prime denotes transposition, then using equation (3) the summation of all value added related to a unit final demand $(\mathbf{e}'\mathbf{v}_n)$ can be rewritten as $\mathbf{e}'\mathbf{v}_n = \mathbf{e}'\widehat{\mathbf{p}}(\mathbf{I}-\mathbf{A})^{-1}\mathbf{z}_n = \mathbf{p}'(\mathbf{I}-\mathbf{A})^{-1}\mathbf{z}_n$. By definition, value added is production costs minus expenditures for intermediate inputs such that $\mathbf{p}' = \mathbf{e}'(\mathbf{I}-\mathbf{A})$. Substituting gives $\mathbf{e}'\mathbf{v}_n = \mathbf{e}'(\mathbf{I}-\mathbf{A})(\mathbf{I}-\mathbf{A})^{-1}\mathbf{z}_n = \mathbf{e}'\mathbf{z}_n$. The value of final demand is thus attributed to value added generation in any of the SN country-sectors that could possibly play a role in the global value chain for product n.

Occupations in the ISCO88 classification are mapped to particular business functions. This mapping is described in table 1. We use the business functions distinguished by Sturgeon and Gereffi (2009). These business functions can be broadly grouped into three production stages: the pre-production, the production, and the post-production stage. The production and the post-production stage are split into low- and high-skilled activities.

We use the occupational shares by production stage in the vector **p** described above. This information is available for the period from 1995 to 2011.

Table 1. Mapping occupations to business functions

1. Pre-production	Business functions: Basic R&D, Design, Commercialization Occupations: Professionals
Production **2. Prod (low)** **3. Prod (high)**	Business functions: Manufacturing, standardized services Occupations (production-low skilled): Service workers and shop and market sales workers. Craft and related trades workers, Plant and machine operators and assemblers, Elementary occupations Occupations (production-high skilled): Technicians and associate professionals
Post-production **4. Post (low)** **5. Post (high)**	Business functions: Marketing, advertising and brand management, specialized logistics, after-sales services Occupations (post-production-low skilled): Clerks Occupations (post-production-high skilled): Legislators, senior officials and managers

Notes: Classification of occupations based on ISCO88. Authors' mapping. Business function definitions derived from Sturgeon and Gereffi (2009).

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