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Labour Income and Employment embodied in Internationally Fragmented Production Chains

Patrick Tomberger

The vertical fragmentation of the production chains of final goods causes new challenges for governments with respect to employment policies. But data on this fragmentation processes remains limited. This paper contributes to the literature with the construction of a database on labour value added and employment embodied in the production of final goods and exports, accounting for globally fragmented supply chains. It is based on Global Trade Analysis Project (GTAP) input-output data and covers 25 sectors and up to 64 countries for the years 1997, 2001, 2004, 2007 and 2011 and extends comparable databases with respect to the coverage of developing countries.

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Abstract

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1 Introduction

During the past three decades production processes have become increasingly complex. Before all tasks of the production of a final good took place within one firm. Advances in communication technology and decreasing trade costs allows firms to allocate tasks to those countries where it can processed at lowest costs. This "second unbundling of globalisation" (Baldwin, 2006 and 2014) has led to an increasing branch in the literature that tries to break up the value of a final good to the value added contributed by all the sectors and countries involved in its production (see Johnson and Noguera, 2012a; Johnson and Noguera, 2012b; Koopman et al., 2014; Timmer et al. 2014 and 2015; Los et al., 2015, Cali et al., 2016 and Francois et al., 2016). This process is driven by a complex interplay of relative prices of labour and capital and elasticities between these factors in different countries and sectors (see Timmer et al., 2014). For workers this means that competition moves from labour aggregates between countries to competition for tasks within firms itself (see Baldwin, 2006).

This poses new challenges for governments with respect to employment policies, especially in developing economies. In areas such as industrial, labour market and trade policies governments have to take the relative position of their country in these global value chains into account. The competition for tasks makes it much more difficult for governments to anticipate in which sectors and which skill type of employment will profit from globalisation (see Baldwin, 2006). Despite recent improvements in the development of datasets on international fragmentation of production (see citations above) those databases remain sketchy especially with respect to developing countries. In this respect this paper contributes to the literature in two ways.

First, we construct a dataset on the contribution of skilled and unskilled labour value added to final products and exports produced in 25 sectors in up to 64 countries. The main source for this dataset is input-output data from the Global Trade Analysis Project (GTAP) for the years 1997, 2001, 2004, 2007 and 2011. Compared to similar approaches, such as presented in Timmer et al. (2015), this database will cover a larger number of developing economies and also includes a number of least developed countries. Compared to the work of Johnson and Noguera (2012) our database has the advantage of a larger time dimension.

Secondly we create a database on skilled and unskilled employment that contributed to the production of final goods and exports within these sectors and countries. Bots datasets allow us to assess the value added and employment content contributed by all countries and sectors along the the supply chain of final goods and exports that leave the factory in a given country and sector. The skill break in our data also allows us to assess how the fragmentation of production has affected demand for skilled and unskilled labour. We will demonstrate potential applications of our dataset by a descriptive analysis on vertical fragmentation of the manufacturing sectors in the countries of our dataset on a global scale between 1997 and 2011. We then assess whether demand for skilled or unskilled labour has increased during this time period. In this we follow closely recent research by Timmer et al. (2014).

This article is structured as follows. In Section 2 we will discuss the construction the dataset in detail. Also the assumptions that had to be taken in constructing the dataset and paths of further improvement are discussed in this section. We will show a descriptive analysis on the fragmentation of manufacturing production for the countries in our dataset in Section 3. A special focus will be given on the partner countries of the r4d project "Employment Effects of Different Development Policy Instruments" located at the Word Trade Institute, University of Bern[1]. Those countries are Bangladesh, Ethiopia, Ghana, Madagascar, Vietnam and South Africa. Section 4 finally concludes and offers paths for further research.

2 Constructing a MRIO for labour embodied in trade

The construction of the database on labour value added and jobs embodied in international trade required three steps. First, data on value added and number of jobs per gross output was calculated for the countries in the database. We calculated this data for two skill levels of labour (skilled and unskilled). Secondly, we constructed multi-region input-output tables for various years and the corresponding Leontief-inverse matrices. Finally, we created the data for global value chains (GVCs) of labour value added and jobs based on these Leontief-inverse matrices.

The primary data source for this database were the databases of the Global Trade Analysis Project (GTAP) benchmarked to several years. It contains not only the input-output data required to calculate the Leontief-inverse matrices but also supplied us with data on labour value added, skill splits for skilled and unskilled labour per sector, as well as gross output per sector. The releases of the database we used are benchmarked to the years 1997 (GTAP 5), 2001 (GTAP 6), 2004, 2007 and 2011 (GTAP 9).

These datasets contain 57 sectors, but due to lack of employment data we have to restrict our GVC data to 25 sectors. Depending on the release, the database provides IO data for up to 140 economies, but we restrict our database to those countries present in GTAP 5 to ensure consistency of the data between the years. We will now discuss each of the

[1] See www.r4d-employment.com.

three steps in detail, beginning with the construction of the data on labour value added and employment per sector for skilled and unskilled labour.

2.1 Labour Value Added and Jobs per Gross Output

We source the data on value added and gross output per sector from the GTAP database. For labour value added embodied in global value chains the GTAP database itself is the only limiting factor. Unfortunately neither data on employment per sector nor wage data, which would allow us to calculate implied employment, is available in the database. So we had to rely on data from third sources. First, we sourced employment data from the WIOD database (see Erumban et al., 2012 and Timmer et al., 2015 for a documentation of the WIOD database) and matched it with GTAP sectors, which resulted in 25 sectors. This covered employment data for most of the high income countries in our dataset. For the remaining countries, mainly developing ones, we relied on ILO data from the ILOSTAT database (see Cali et al., 2016 for a similar attempt). Finally, the r4d partner countries South Africa and Vietnam provided us with national employment data for their countries. Matching ILO and Vietnamese data with GTAP resulted in employment data in 11 sectors without a skill split. Finally, for the remaining countries not covered by these sources, we went back to the ILO data and interpolated missing sectors and years, expanded the ILO data to 25 sectors and split it into skilled and unskilled employment.

For the latter two steps information from WIOD and GTAP data was used. We then calculated skilled and unskilled value added and employment per gross output as input for the Leontief-inverse matrices. As a side product we expanded the database constructed by Cali et al. (2016) with respect to covered countries, sectors and skill levels[2]. We will now discuss each of these steps in detail.

The WIOD database contains yearly data on persons engaged for 40 countries (mainly OECD plus China, India, Russia, Indonesia, Mexico and Brazil) and 35 sectors for period 1995 – 2011. Data for high-, medium- and low-skilled employment based on educational attainment levels[3] is available (see Erumban et al., 2012). We matched this data with GTAP, which uses a occupational definition of skill levels, see Appendix Table A.4. Using ILO (2012) correspondence tables we matched skill levels of GTAP and WIOD and end up with data on jobs of skilled and unskilled employment for 25 sectors in the years 1997, 2001, 2004, 2007 and 2011. Unfortunately, the WIOD database does not include such data for any of the r4d partner countries. Also, the coverage of these countries in ILO

[2] Cali et al. (2016) used a single-region input-output approach (SRIO) in order to calculate employment embodied in exports. We refer to their paper for details on the methodology. This data is available upon request.

[3] See Appendix Table A.3 for the skill definition used in WIOD.

data is limited. In two cases, South Africa and Vietnam, we could fill this gap with data provided by the partners. The data from South Africa contains data on high- and low-skilled employment for 46 sectors which could be merged to the 25 sector data constructed so far[4]

Vietnam provided us with data on total employment in 21 sectors (ISIC classification) from Labour Force Surveys (LFS). It could be matched with GTAP to 11 sectors in the same way as for other countries where ILO data was available. For the remaining countries for which data on employment was neither available in WIOD nor provided by the partners, we went back to ILO data from ILOSTAT database. It contains employment for 21 (ISIC 4 classification) or 17 (ISIC 3 classification) sectors, depending on country and year. The sources of these data differs and we concentrated on employment data based on Labour Force Surveys to remain consistent. We then matched these 21/17 sectors with GTAP sectors, which resulted in 11 consistent sectors (see Tables A.6 and A.7 in the appendix).

We then processed the ILO data along three dimensions. First, for some countries not all 21/17 raw sectors were available in all years. In these cases we interpolated the missing data by using growth rates of real labour value added as proxy for employment growth[5]. The number of sectors and countries treated in this way is minor, however (see Table A.10 in the appendix).

Second, if ILO employment data was not available for a whole year, we interpolated the missing year using information from GTAP, ILO and the World Development Indicators (WDI) database. In particular, we used growth rates of total employment from the WDI to impute total employment of a country in missing years. From this data we imputed employment in agriculture, industry and services using employment shares, also obtained from WDI data. Next, we calculated the jobs per labour value added ratio for each sector for the years closest to the missing years. Assuming those shares stay relatively constant (a similar assumption was applied by Erumban et al. (2012) for many countries in WIOD) we then calculated implied jobs per sector in the missing years using value added data from GTAP. We then bring this implied employment in accordance with broad sector employment obtained from WDI data. For this we calculated the shares of the implied employment per sector with respect to the broad sectors. Then we distributed the broad sector employment from WDI data according to theses shares[6].

[4] The concordance table used for the matching is given in Table A.9 in the appendix. Besides formal employment the data from South Africa included also data on informal employment.

[5] We deflated the nominal labour value added per sector provided by GTAP with GDP deflators obtained from the World Development Indicators (WDI). If no GTAP data for this missing sector was available, we used real value added growth of the parent sector.

[6] See Table A.11 in the appendix for an overview of the countries and years treated in that way.

For some countries the ILO data offers only employment data for nine sectors (ISIC 2 definition). Matching with GTAP data resulted in only nine sectors[7]. In these (few) cases we used labour value added ratios from GTAP in order to expand this data to 11 sectors as a first step. Considering that only a minor number of countries/years were treated in this way, the procedure seems to be acceptable. In Table A.13 in the appendix we summarize which raw employment data was used for which country. In a final step we expanded the employment data of those countries where only ILO data was available to 25 sectors and split it into skilled and unskilled employment. Specifically, we split the manufacturing sector into 12 sub-sectors and the trade and communication sector into three transport sectors and one communication sector. We could have used the shares of labour value added in these sub-sectors obtained from GTAP to distribute employment of the parent sector. But this procedure would require identical wages in all sub-sectors.

Because this is an unrealistic assumption, we weighted GTAP value added by wages before we split up the sectors instead. For each country we used wage computed from the WIOD database of a comparable country and weighted the labour value added in the sub sectors. Employment of the parent sector was then distributed according to the shares of this weighted labour value added. A similar strategy was used to split the data into skilled and unskilled employment. We assumed that the wage premium of skilled labour is relatively similar among comparable countries. Therefore, for each country we calculated the wage premium of skilled labour of the same country in the WIOD database we used as a proxy for expanding the sectors. With this we weighted the skilled labour value added from the GTAP database and then distributed total employment in these countries into the two skill levels[8]. We admit that our assumptions are very strong and discuss their implications and possible improvements in our methodology below.

Finally, we combined the data on labour value added and employment per sector and region with gross output per sector from GTAP. We denote gross output per sector in region r by $x_r = (x_{r,1}, x_{r,2}, ..., x_{r,s})'$, where s captures the number of sectors and defines the dimension of this vector. It allows us to construct the vectors of the ratio of labour value added (l_r^v) and employment (l_r^e) to gross output per sector for each region:

$$l_r^v = \left(l_{r,1}^{va}, l_{r,2}^{v}, ..., l_{r,s}^{v}\right) \tag{1}$$

$$l_r^e = \left(l_{r,1}^{emp}, l_{r,2}^{e}, ..., l_{r,s}^{e}\right) \tag{2}$$

[7] See Table A.8 in the appendix for the used correspondence table.

[8] Table A.14 in the appendix summarizes which countries have used as a proxy in the two steps described above.

Our data allows us to split these vectors into skilled and unskilled components and will be the input for the Leontief-inverse matrices. The next step to do this is the construction of the multi-region input-output tables and the corresponding Leontief-inverse matrices. We discuss this process in the following section.

2.2 Constructing a Global Input-Output Table

The GTAP database contains the input-output, trade and final demand data needed to construct a multi-region input-output table. Peters et al. (2011) describe in detail how to create a MRIOT out of the GTAP database. We follow them closely. A similar approach has also been applied by Johnson and Noguera (2012a), using GTAP 7, to assess trade in value added. Timmer et al. (2014) analyse global supply chains using a similar method and the WIOD database. For a useful starting point into multi-region input-output models the reader is also referred to Miller and Blair (2009). The notation and steps described here follow closely the work of Fernández et al. (2016) on global value chains for carbon dioxide (CO_2) emissions.

We denote matrices and vectors by upper case and lower case letters respectively. As standard in the input-output literature, we will denote transactions between regions (exports and imports) by subscripts, where r denotes the source region and p the destination region. The number of regions in the dataset is denoted by n, such that $r, p \subseteq [1, n]$. The same notation applies for transactions between sectors, where k will denote source sectors and j destination sectors and $k, j \subseteq [1, s]$, where s denotes the number of sectors. We follow another input-output convention and define transactions across the rows of matrices as sales (exports) and transactions across columns as expenditures (imports).

We then realise that gross output per sector is the sum of intermediate goods, used for further production within a country or abroad, and final demand, which is consumed at home or exported. This relationship is captured by equation (3) in matrix notation:

$$\begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ \vdots \\ x_n \end{pmatrix} = \begin{pmatrix} A_{11} & A_{12} & A_{13} & \cdots & A_{1n} \\ A_{21} & A_{22} & A_{23} & \cdots & A_{2n} \\ A_{31} & A_{32} & A_{33} & \cdots & A_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ A_{n1} & A_{n2} & A_{n3} & \cdots & A_{nn} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \\ \vdots \\ x_n \end{pmatrix} + \begin{pmatrix} y_{11} & y_{21} & \cdots & y_{n1} \\ y_{12} & y_{22} & \cdots & y_{n2} \\ y_{13} & y_{23} & \cdots & y_{n3} \\ \vdots & & & \\ y_{1n} & y_{2n} & \cdots & y_{nn} \end{pmatrix} l \ , \tag{3}$$

Again, $x_i = (x_1, x_2, x_3, \ldots, x_n)'$ denotes sectoral gross output for all n regions. The elements of vector x_i are the regional gross output vectors from above. The first term on the right hand side captures transactions of intermediates on a global scale, normalized to gross output. The second term denotes global transactions of final demand. Transactions of intermediates from region r to region p are captured by matrices A_{rp}, which are of dimension $s \times s$. Whenever $r = p$, these matrices capture domestic transactions of intermediates. Accordingly, a_{kj} as an element of A_{rp} captures the direct requirements of sector j from sector k to produce one unit of output. The global scale of this direct intermediates requirements matrix ensures that also imported requirements are considered.

Elements y_{pr} of the second term on the right hand side in equation (3) capture transactions of final demand between regions. It includes final goods and services for household consumption as well an investment. Specifically, $y_{pr} = (y_{pr,1}, y_{pr,2}, \ldots, y_{pr,s})'$ is a column vector of dimension s and each element $y_{pr,z}$ denotes the final demand in sector z in region p for final products from region r. Finally, l denotes a column vector containing ones with dimension n in order to take row-sums of the final demand matrix.

Assessing direct flows of intermediates between sectors and countries, however, is not enough to analyse factors or jobs embodied in global supply chains. It has to be considered that also those directly traded intermediates required inputs as well. Those inputs could have been produced at home in the same sector, at home in another sector or even abroad as part of internationally fragmented production process. The intermediates used to produce these intermediates also required inputs, and so on. To capture all these production stages, which take place in different sectors and countries, we rely on Leontief's well established results in input-output methodology (e.g. Miller and Blair, 2009). First, we condense equation (3) to $x = Ax + y$, where A is the condensed matrix of global direct intermediate requirements, also known as MRIO matrix. Its dimension is therefore defined by the number of regions n and sectors s in the model: $(n \cdot s) \times (n \cdot s)$. Vector y collects global final demand and has dimension $(n \cdot s) \times 1$. We then solve this expression for x:

$$x = (I - A)^{-1}\, y \tag{4}$$

Matrix I is the identity matrix and $(I - A)^{-1}$ is the famous Leontief-inverse matrix. It captures the total, meaning the direct but also indirect, unit input requirements on a global scale. It can be interpreted as a geometric series (see Johnson and Noguera, 2012a), where $(I + A)y$ captures direct output and the intermediates needed to produce it. The term $(I + A + A^2)y$ then additionally captures the intermediates to produce the intermediates of the first round and so on.

Transactions across the rows and columns of the Leontief-inverse are interpreted in a similar way as the MRIO matrix. The rows of the Leontief-inverse denotes direct and indirect unit input requirements from domestic and foreign producers to produce one unit of output. The elements of its sub-matrices $(I-A)^{-1}_{rp}$, denoted by $(i-a)^{-1}_{kj}$, collect the direct and indirect inputs needed from sector k in country r to produce one unit of output in sector j in country p. This framework allows us to track the production process stage by stage to the final product. The next step is to slice up those global value chains for transactions of labour value added and jobs (see Timmer et al., 2015 and Cali et al., 2016 for comparable attempts).

Let us first define matrices V and L, as diagonal matrices of dimension $(n \cdot s) \times (n \cdot s)$ and having the vectors l_r^{va} and l_r^{emp} on their diagonals. Those two matrices are multiplied with the Leontief-inverse matrix in order to scale it to the direct and indirect flows of labour value added and employment embodied in intermediates: $V\,(I-A)^{-1}$; $L\,(I-A)^{-1}$. Please note that we can construct these matrices for skilled and unskilled labour by replacing l_r^{va} and l_r^{emp} with versions for skilled/unskilled labour value added/jobs. The final step involves the introduction of final demand in this set-up. For this we use a more detailed representation of final demand used in equation (3). We define Y as a $(n \cdot s) \times (n \cdot s)$ matrix capturing again global flows of final demand:

$$Y = \begin{pmatrix} Y_{11} & Y_{21} & \cdots & Y_{n1} \\ Y_{12} & Y_{22} & \cdots & Y_{n2} \\ Y_{13} & Y_{23} & \cdots & Y_{n3} \\ \vdots & & & \\ Y_{1n} & Y_{2n} & \cdots & Y_{nn} \end{pmatrix}; \tag{5}$$

Like before, transactions of final goods from region r to region p are captured by matrices Y_{pr}, their dimension is $s \times s$. Whenever $r = p$, these are traded within countries. For us this representation has the advantage that production of final goods per sector instead of per country can be assessed. Applied to the framework above, this last step enables us to track labour value added and employment through each step of the production process to the final goods produced by a country. In other words we can represent global value chains (GVC) for these products with respect to labour value added and employment. For this, we define the flux of labour value added and employment to final goods produced by each region as matrices F^{va} and F^{emp} of dimension $(n \cdot s) \times (n \cdot s)$ as:

$$F^{va} = V\,(I-A)^{-1}\,Y\ , \tag{6}$$

$$F^{emp} = L\,(I-A)^{-1}\,Y\ . \tag{7}$$

The interpretation of matrices F^{va} and F^{emp} is analogue to the interpretation of the MRIO and Leontief-inverse matrices. They capture the direct and indirect flows of labour value added and employment to produce final goods within countries and sectors, taking global value chains into account. These matrices allow us to decompose the value of the final goods produced into the value added contributions by each sector and country in the dataset. In our case the whole world is covered as a rest of world region is included in the model. The input-output data for this region is sourced from GTAP as is the value added data. For the employment per gross output value of this region we use employment and gross output data from the BRIC countries (Brazil, Russia, India and China) as proxy (see Erumban et al., 2015 for a similar approach in the WIOD database). We will further discuss the interpretation of these matrices using a graphical example in the empirical section.

Alternatively, researchers might rather be interested analyse labour value added or employment embodied in the final goods a country consumes rather than in the goods it produces. To do so only the order of the subscripts in sub-matrices Y_{pr} have to be switched so they become Y_{rp}. Or, in other words, a researcher might transpose matrix Y. Researchers interested in the factor content of trade alone might just delete the $Y_{r,p=r}$ elements from vectors y_r (see Johnson and Noguera, 2012a for such an approach).

As a result of these efforts described in this section we were able to construct data global value chains for more sectors and countries as used by Cali et al. (2016) and the WIOD database (see Timmer et al. 2015). Compared to the latter one our database includes a considerable number of developing countries, especially the r4d partner countries South Africa, Bangladesh, Vietnam, Ghana, Ethiopia and Madagascar. In the empirical part of this paper we will demonstrate potential applications of this database by analysing how the international fragmentation of production processes for final goods in manufacturing affected demand for labour. We will take a closer look especially on the r4d partner countries. But before we discuss these issues we will take a closer look on the limitations of the data we have constructed here. In order to be useful for the applied researcher she should be familiar with the underlying assumptions and limitations of the data constructed here.

2.3 Assumptions and Limitations of the Database

We will now discuss the assumptions that had to be taken in order to calculate the MRIO matrices and the satellite data on employment as well as paths for improvement of the database. For the employment data we had to rely on other sources than the GTAP database. We merged data on employment from WIOD, national sources and the ILO, which is sourced mainly from labour force surveys. Due to data availability a lot of imputations had to be implemented on the ILO data. Also, merging different data sources raises questions of compatibility. We tried to use similar methods of imputations as Erumban et al. (2012) used for constructing the employment data in the WIOD database. The reason is that WIOD data on employment is the primary source of our employment data (see Table A.13 in the appendix). Also, the assumptions used to expanded the 11 GTAP compatible sectors available from the ILO to 25 sectors and split this data for total employment into two skill shares are very strong. Because of these ad hoc assumptions the data on employment should be applied with much care.

For most of the countries in our dataset, however, no imputations of employment data has been conducted, however (see Table A.13 in the appendix). Also, employment data of all important hubs for global supply chains, the EU, the US and China (see UNCTAD, 2015), are taken from WIOD. This should limit any bias in the Leontief-iverse from the imputations. Nevertheless, improving the quality of the employment satellite data is vital for the further use of this database. One approach to do so could be to obtain more data from national statistical sources. The r4d partner countries play an important role in this attempt. Secondly, the ad hoc assumptions used to interpolate missing data should be replaced by an econometric approach. Missing data could be predicted from existing WIOD data by estimating a suitable production function.

We turn to the construction of the MRIO matrix itself. Its sub-matrices for national transactions of intermediates, $A_{r,p=r}$, are constructed from national IO tables. For this database this information was taken from the GTAP database. GTAP collects the raw tables, harmonizes them and balances them for CGE analyses (see McDougall, 2001). Unfortunately, data for the sub-matrices capturing bilateral trade in intermediates, $A_{r,p}$ is not collected by any national statistical office (see Johnson and Noguera, 2012a and Timmer et al., 2015). Also, trade of final goods between sectors, $y_{r,p}$, is typically not documented as well. The input-output literature circumvents this problem by applying a proportionality assumption when constructing the MRIO (see Johnson and Noguera, 2012a and Timmer et al., 2015). Details on how to apply this assumption on the GTAP database can be found in Peters et al. (2011).

In GTAP, for each sector the overall split of imports of final demand and intermediates is available, but not its source countries and sectors. However, gross trade flows are available on a bilateral basis. To obtain bilateral trade in intermediates and final demand, we split bilateral gross trade flows using the overall split of imported intermediates and final goods in the destination country. The imported intermediates are then distributed across sectors proportionally to the use of imported intermediates per sector. This assumption implies, for example, that if Japan imports 20% of its steel from China, then 20% any intermediate use of steel in Japan is assumed to be imported from China (see also Timmer et al. 2015). A strong assumption that hardly fits the facts.

Feenstra and Jensen (2012) find that the proportionality assumption only weakly correlates with direct measures of intermediate imports in the US. In general the proportionality assumption underestimates the use of foreign intermediates according to the results of Puzzello (2012). Timmer et al. (2015) improved the precision of the WIOD database by using more detailed trade statistics. However, they applied the same proportionality assumption, but on more detailed trade data. Nevertheless, this limited potential bias a lot (see Dietzenbacher et al., 2013 for details). A similar approach should be considered for this dataset as well. Another bias arises from large export processing sectors in many important developing countries, most prominently China. In these sectors intermediates are imported solely for the purpose of producing products for export, such as mobile phones, for example.

In those sectors the used production technology differs from the one used by producers for the domestic market (see Johnson and Noguera, 2012a). Export processing sectors typically use less value added per output and have different input requirements than producer for the domestic market. Johnson and Noguera (2012a) correct the input-output coefficients of China and Mexico of their MRIO matrix using the procedure of Koopman et al. (2008). They find that not accounting for export processing sectors overestimates the domestic value added embodied in the exports of these countries. As similar procedure should be considered for this database as well. Priority should be given on the one hand to processors which are important to global value chains, such as China and Mexico. But some of the R4D partner countries, for example Vietnam, have large processing sectors as well. However, the data requirements for doing so are huge.

3 Fragmentation of Production and Labour Demand

In this section we will asses the vertical fragmentation of 14 manufacturing sectors[9] in 60 (1997) to 64 (2011) economies from 1997 to 2011. Under vertical fragmentation we understand a process in which a firm allocates several tasks in the production process of a final good to other countries and sectors. This process has been empirically observed since the mid-1980s and coined as the "second unbundling of globalisation" by Baldwin (2006). We will assess whether the countries in our dataset have experienced such unbundling of their production processes in 1997 – 2011, with a special focus on the r4d partner countries.

[9] Including the sectors construction and utilities (electricity, gas and water).

Specifically, we ill allocate final goods to those countries where the final step of production takes place. For example, if a car leaves the assembly line in Germany it will be allocated to Germany. This would be the case also if all used intermediates of this car would have originated from other countries and only assembling would have been conducted in Germany. The car is also allocated to Germany if is exported to a French consumer after it leaves the German factory.

In a second step we will take a short look on how this process has affected labour demand. For this we will assess how the share of skilled and unskilled labour value added (w.r.t. total value added used to produce a final product) and employment (w.r.t. total employment used to produce a final product) has developed over this period. This exercise is closely related to the work of Timmer et al. (2014). But we us a different IO dataset (GTAP instead of WIOD), which includes a larger set of developing economies and more recent data (2011 instead of 2008). Before we start our analysis we discuss the construction of our measure of vertical fragmentation.

3.1 Preparing the data and measuring vertical integration

First, we aggregated the GTAP data to 25 sectors and the 60 countries present in GTAP 5 (1997) as described above. This implies 14 available manufacturing sectors. The r4d partner countries are included into the dataset in the years their data becomes available in GTAP. Then the Leontief-inverse matrices and matrices F^{va} and F^{emp} are constructed with this aggregation. Please note that although we will focus on the manufacturing sectors in this section, we calculated matrices F^{va} and F^{emp} for each year using all 25 sectors. This is necessary to account for the inputs provided by the other sectors (most importantly: services) in the production of manufactures.

On the other hand, this means that our analysis is limited by the sector aggregation available in GTAP and the availability of data on sectoral employment. The precision of input-output analyses is closely connected to this sector aggregation. In an ideal world we could conduct our analysis on a product by product basis. Taking the final production of a car, for example, this would allow us to assess which intermediates from which sectors and countries, and the intermediates to produce these intermediates and so on, have been used for this car. Knowing this we could decompose the same production chain to value added. As billions of final and intermediate products are produced globally such a MRIO matrix would be prohibitively large, not to mention issues of data availability. We have to aggregate products to sectors, but the higher this aggregation is, the less precise the MRIO analysis becomes.

This implies that sector aggregation in MRIO analysis causes bias in the estimated linkages between sectors. The less sectors available, the higher this bias becomes (see, e.g. Steen-Ohlsen et al., 2014). In this section we aggregated to 25 sectors per country in order to stay compatible to WIOD employment data. For an analysis of value added alone we could use the 57 GTAP sectors. However, in order to have the same bias in both datasets, we opted for the 25 sector aggregation in both datasets. A similar reasoning as for sector aggregation is also true for country aggregation. International linkages of production become less precise the less countries are available in the database (see again Steen-Ohlsen et al., 2014). Note that in the GTAP releases after 1997 many more countries become available. However, we opted to calculate the MRIO matrices for the 60 countries (plus the r4d countries when they become available) for all years in order to have the same bias present in all years. Furthermore, Férnandez-Amador et al. (2016) show that bias from country aggregation in MRIO analyses is small.

As a measure of vertical integration in the manufacturing sectors we calculate the content of directly and indirectly used foreign value added (inputs from capital and labour) in the production of domestic final goods.To do so matrix V in expression (6) was chosen to contain the share of total value added per unit of gross output on its diagonal and Y, as usual, collects final demand produced in all the sectors in all the regions in our dataset[10].

The final goods are produced within the countries and can either be consumed at home or exported. Important is that those goods are allocated to the country where the last step of production took place, just before delivery to the final consumer. The resulting matrix F^{va} then allows us to decompose the final value of these products to the sectors and countries that contributed value added to its production. We illustrate this concept using a simplified graphical representation of matrix F^{va} as shown in Figure 1.

As discussed in the previous section, each of its cells collects the direct and indirect value added needed from sector k in country r to produce one unit of final demand in sector j in country p. Let us take the seventh column of this matrix, representing the aggregated manufacturing sector in Bangladesh (indicated by the blue arrow). Each of its cells captures the direct and indirect input of labour and capital from domestic and foreign sectors to produce final goods leaving the factories in Bangladesh[11]. Accordingly taking column sums of this matrix returns the value of final demand each sector produces. The sum of all column-sums then results in world GDP.

[10] We value these final goods at ex-factory prices. This is the value of a final product after leaving the factory but before sold to the consumer.

[11] The seventh row of the matrix, indicated by the red arrow, in Figure 1 then shows how labour and capital in the manufacturing sector of Bangladesh is distributed along domestic and foreign production chains.

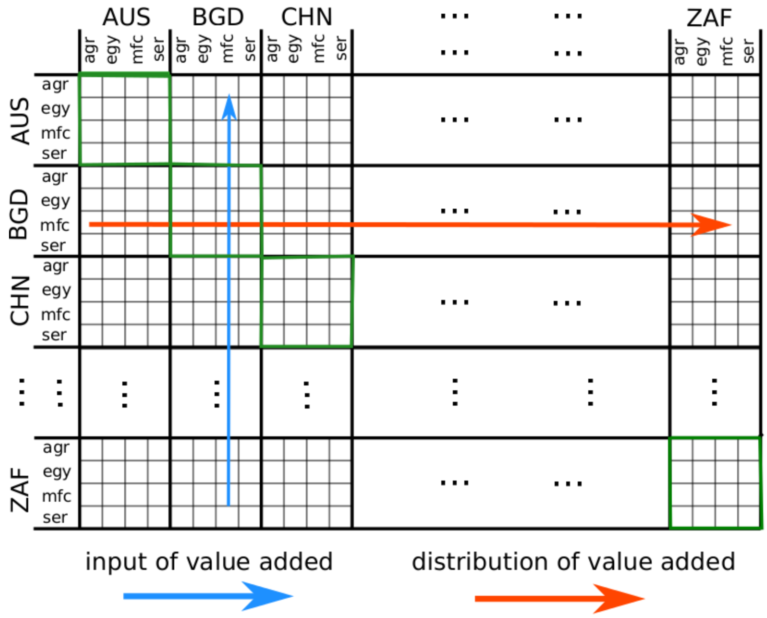


Figure 1: Graphical representation of matrix F^v

Note: For this graphical representation of matrix F^{va} we reduced the number of countries and aggregated the 25 sectors to four broad sectors: agricultue (agr), energy (egy), manufacturing (mfc) and services (ser).

For our purposes we can then calculate the share of foreign value added in the output of each sector. The more fragmented the production process in a given sector is across sectors and national borders the higher this ratio will be. It serves us as a measure for the integration of a sector in GVCs. An increase in the foreign content of output over time indicates that a sector becomes increasingly integrated to GVCs. Note that our measure is defined on value added at each stage of production, defined as gross output minus intermediates used to produce it. Taking into account that intermediates are often shipped forward and backwards between countries before finally being assembled to a final product, our measure avoids the double counting problem of measures based on the gross value of intermediates (see Francois et al., 2015 and Koopman et al., 2014).

We now derive our measure in a formal way. Let us denote the national sub-matrices of F^{va} as F^{va}_{rp} and its elements as f^{kj}_{rp}. To get the value of final output in sector j ($FO(j)$) in each sector we have to take column sums for each sector over all sub-matrices F^{va}_{rp}:

$$FO(j) = \sum_k \sum_r f^{kj}_{rp}. \tag{8}$$

The foreign value added to final output ($FGNO(j)$) is then calculated in the same way but domestic sub-matrices ($F^{va}_{r=p}$) are ignored:

$$FGNO(j) = \sum_{k} \sum_{r \neq p} f^{kj}_{rp}. \tag{9}$$

Accordingly the ratio of foreign share of final output value in sector j ($FSHR(j)$) is then defined as:

$$FSHR(j) = FGNO(j)/FO(j). \tag{10}$$

The foreign content in all manufacturing sectors is then obtained by summing $FSHR(j)$ over all manufacturing sectors. This measure has indeed increased a lot in Bangladesh between 1997 and 2011. The foreign value added embodied in Bangladeshi manufacturing goods has increased from 13.2% in 1997 to 21% in 2011. We will now use this measure of vertical integration in an analysis for 14 manufacturing sectors in the countries in our dataset. For this at least 840 different GVCs are available to us in each year. A special focus will be given on the r4d partner countries Bangladesh, Ethiopia, Ghana, Madagascar, Vietnam and South Africa.

3.2 A descriptive analysis of GVCs in the manufacturing sector

We begin this section with the analysis for the manufacturing sector as a whole. We also divide the countries in our sample into two development groups, high income and developing economies, following the classification of the United Nations. In Table 1 we show the share of foreign value added on total output of the manufacturing sector both groups well as for the r4d partner countries for all years in our dataset. Indeed, vertical fragmentation of manufacturing production increased considerably in both groups between 1997 and 2011. Integration into global value chains in developing economies even surpassed the one in high income countries until 2007. Then, this trend reversed in those countries. The global recession likely played a major part in this trend reversion. Over the whole period the foreign value added in production increased by 6.1 percentage points in the high income group and by 1.3 percentage points in the developing world. In 2011 the manufacturing sector in the high income countries is became stronger integrated to GVCs than the manufacturing sector in developing economies.

The pattern of integration into global value chains differs a lot among the r4d partner countries. Bangladesh and Vietnam, the only r4d countries for which data is available from 1997 to 2011, show a strong and increasing international fragmentation of their production

Region	1997	2001	2004	2007	2011	Δ 97-11	Δ 04-11
			Development Groups:				
High Income	16.58%	16.66%	18.49%	20.56%	22.68%	6.10%	4.19%
Developing	19.55%	20.62%	23.38%	21.95%	20.87%	1.32%	-2.51%
			r4d Partner Countries:				
Bangladesh	13.17%	16.75%	16.55%	18.79%	20.98%	7.81%	4.43%
Ethiopia	n.a.	n.a.	24.77%	22.75%	20.65%	n.a.	-4.12%
Ghana	n.a.	n.a.	49.37%	30.36%	29.44%	n.a.	-19.93%
Madagascar	n.a.	20.50%	29.19%	28.18%	23.57%	3.07%	-5.62%
Vietnam	42.07%	47.11%	44.99%	46.38%	46.90%	4.84%	1.91%
South Africa	n.a.	20.57%	20.59%	24.76%	23.98%	3.41%	3.39%

Note: The last column of the table shows the change in the foreign content of manufacturing output between 1997 and 2011 ($FSHR$) in percentage points. For the r4d partner countries this value has been calculated for the time period their data was available.

Table 1: Content of foreign value added in output - manufacturing

in manufactures over the whole period. Also manufacturing in Madagascar and South Africa became more integrated to GVCs between 2001 and 2011. For Ghana and Ethiopia we observe a strong decrease in foreign value added embodied in their manufacturing output from 2004 to 2011, whether it increased before we cannot say. Madagascar shows a similar trend as the overall group of developing countries, experiencing an increase in foreign inputs first with a strong decline after 2004. South Africa, the most developed country among the r4d countries, experienced a rather constant share of foreign value added in manufacturing during the decade after 2001. As a next step we break our analysis up for the 14 manufacturing sub-sectors in our sample. This will allow us to assess whether the development discussed above was driven by certain sectors.

In Table 2 we present $FSHR(j)$ for the 14 manufacturing sectors in both development groups. In the high income countries the highest degree of vertical fragmentation throughout the whole period was present in the sectors electronic equipment and machinery as well as leather/textiles, chemicals and transport equipment (cars) sectors. The highest integrated is the petroleum and coal sector. The lack of own natural resources in many countries in our dataset explains this as discussed in Timmer et al. (2014). These countries rely on imported fossil fuels so the foreign content in these sectors has to be high. Over time the foreign content of output increased most in the chemical, transport equipment (cars) and utilities sectors. Wood production has become less integrated in these 14 years.

Petroleum and coal as well as electronic equipment and machinery and transport equipment (cars) are the highest integrated manufacturing sectors in the developing economies over the whole period. Noteworthy, food and beverages is among the least integrated sectors in both groups. One of the reasons for this could be high non-tariff measures in agriculture (see Lee and Swagel, 1997). Over the whole period vertical integration in

Sector	1997	2001	2004	2007	2011	Δ 97-11	Δ 04-11
			High Income Countries				
Construction	10.57%	11.02%	12.98%	14.92%	16.10%	5.52%	3.11%
Chemicals, Rubber, Plastic	19.21%	18.62%	22.06%	24.96%	27.72%	8.51%	5.66%
Electricity, Gas, Water	10.60%	10.06%	12.70%	15.77%	18.14%	7.54%	5.44%
Electronic Equipment, Machinery	19.70%	19.99%	21.15%	22.94%	24.89%	5.19%	3.74%
Food, Beverage, Tobacco	14.26%	13.87%	15.53%	17.17%	19.48%	5.22%	3.95%
Leather Products	26.40%	26.83%	23.70%	25.16%	27.62%	1.22%	3.92%
Wood Products	17.11%	17.32%	14.11%	14.89%	16.07%	-1.04%	1.96%
Basic and Fabricated Metals	23.21%	22.53%	21.07%	25.68%	29.08%	5.87%	8.01%
Mineral Products, nec	15.28%	15.34%	17.67%	19.57%	22.09%	6.81%	4.42%
Manufactures, nec	19.00%	19.17%	19.10%	21.21%	23.19%	4.19%	4.09%
Petroleum, Coal Products	55.61%	62.12%	57.13%	57.15%	55.79%	0.18%	-1.34%
Paper, Publishing	13.26%	13.07%	14.60%	15.44%	16.67%	3.41%	2.07%
Textiles	22.76%	21.84%	21.75%	22.48%	24.90%	2.14%	3.14%
Transport Equipment	22.36%	22.59%	25.82%	28.08%	30.03%	7.66%	4.21%
			Developing Economies				
Construction	15.81%	16.00%	19.21%	18.47%	17.10%	1.29%	-2.10%
Chemicals, Rubber, Plastic	23.99%	25.02%	25.43%	24.15%	24.71%	0.72%	-0.71%
Electricity, Gas, Water	12.17%	12.58%	14.60%	14.73%	16.23%	4.06%	1.63%
Electronic Equipment, Machinery	32.78%	34.40%	35.16%	31.18%	28.00%	-4.78%	-7.16%
Food, Beverage, Tobacco	12.97%	14.62%	15.16%	14.37%	14.80%	1.83%	-0.36%
Leather Products	15.09%	20.66%	21.30%	19.64%	18.88%	3.79%	-2.42%
Wood Products	12.46%	13.75%	18.51%	18.64%	17.59%	5.12%	-0.93%
Basic and Fabricated Metals	21.25%	22.81%	26.13%	26.20%	27.07%	5.82%	0.95%
Mineral Products, nec	14.36%	14.57%	17.33%	16.96%	17.63%	3.27%	0.30%
Manufactures, nec	21.09%	23.05%	24.81%	23.07%	22.29%	1.20%	-2.52%
Petroleum, Coal Products	30.18%	28.31%	34.67%	34.86%	37.11%	6.93%	2.44%
Paper, Publishing	18.90%	19.92%	23.15%	21.20%	20.39%	1.49%	-2.76%
Textiles	17.49%	21.42%	25.65%	23.65%	22.94%	5.45%	-2.71%
Transport Equipment	27.82%	28.08%	32.27%	30.91%	27.85%	0.03%	-4.42%

Table 2: Content of foreign value added in output - 14 manufacturing sectors

developing economies was strongest for petroleum and coal, basic metal and textile production. Interestingly the production of electronic equipment became less integrated to global supply chains over time. Also, while most sectors in the developing group increased their integration to global supply chains over the whole period, between 2004 and 2011 an opposite trend was visible (see Table 2). We will now assess whether the r4d partner countries followed this general trend of the developing economies in our data.

Table 3 reveals a divided trend of integration to GVCs in the six partner countries in 2004 – 2011. We preferred to look at this period in Table 3 because for all of the six r4d countries data was available. In three of them, Ethiopia, Ghana and Madagascar, production of manufactures became less integrated to global supply chains in that period. In other words they followed the trend of the overall group of developing countries. However, the other three of them show a different pattern of production fragmentation. In Bangladesh virtually each of of the manufacturing sectors located parts of their production process to other countries in this period. Interestingly, the sector with the least increase of integration to global value chains was the textile sector. South Africa follows the same trend, all but

Sector	BGD	ETH	GHA	MGD	VNM	ZAF
Construction	4.10%	-0.99%	-10.60%	-5.69%	1.41%	1.88%
Chemicals, Rubber, Plastic	2.74%	-8.91%	-17.90%	-5.31%	0.03%	3.82%
Electricity, Gas, Water	4.16%	-1.48%	0.47%	20.63%	2.96%	12.17%
Electronic Equipment, Machinery	4.23%	-6.30%	-18.24%	-2.24%	3.61%	1.88%
Food, Beverage, Tobacco	5.98%	-4.30%	-21.68%	-2.19%	7.47%	2.48%
Leather Products	7.11%	-6.65%	-14.27%	-5.15%	0.57%	3.09%
Wood Products	2.63%	-5.11%	-6.72%	-5.23%	-1.15%	1.79%
Basic and Fabricated Metals	4.83%	-5.40%	-17.09%	-5.33%	-1.84%	2.49%
Mineral Products, nec	4.03%	9.59%	-19.56%	6.95%	-1.16%	4.08%
Manufactures, nec	4.17%	-5.95%	21.06%	-5.71%	-0.22%	2.04%
Petroleum, Coal Products	11.35%	8.51%	-40.93%	-2.13%	-5.18%	15.80%
Paper, Publishing	3.48%	-5.73%	-19.45%	-5.17%	-5.40%	1.26%
Textiles	0.53%	-5.35%	-29.93%	-3.30%	2.66%	1.52%
Transport Equipment	1.72%	-8.27%	-13.63%	-2.50%	-5.52%	-0.03%

Note: Table 3 shows the change of the foreign value added content of output in percentage points for each of the 14 manufacturing sectors in the six r4d partner countries between 2004 and 2011. We opted for the reduced time frame in order to have comparable numbers for each of the r4d partner countries.

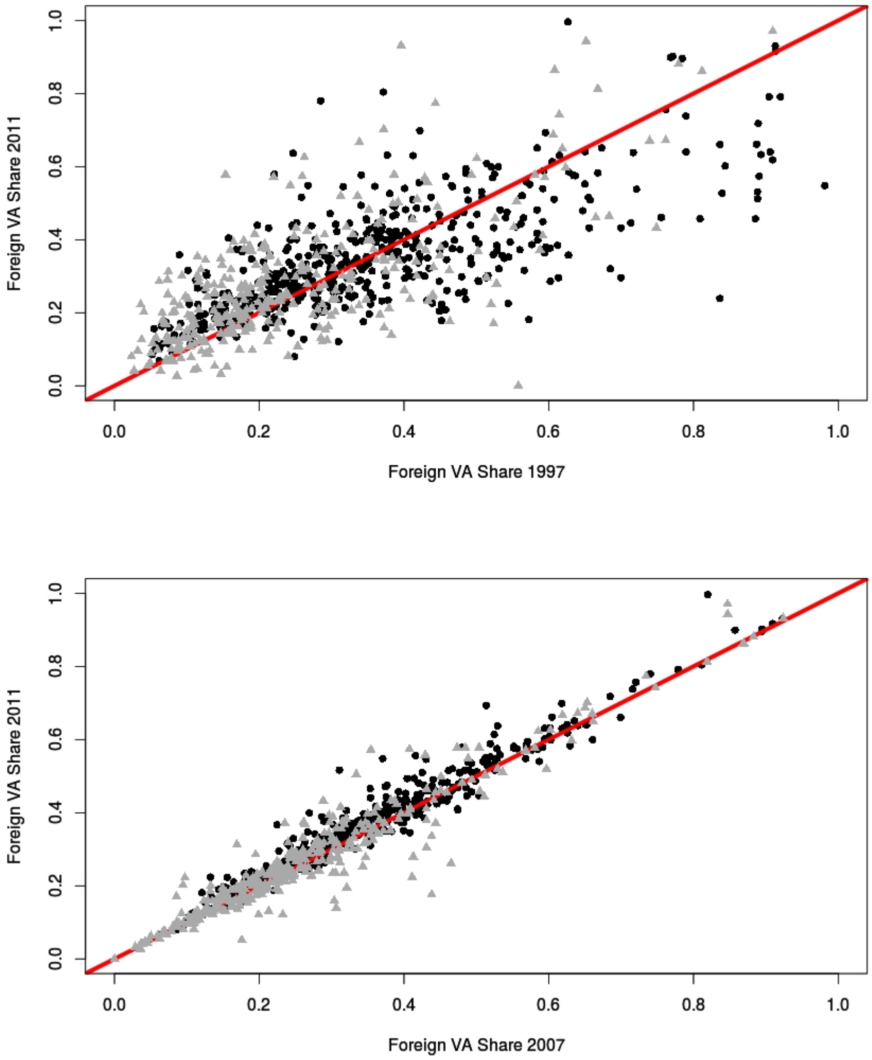
Table 3: Content of foreign value added in output - changes 2004 - 2007

one of the manufacturing sectors became more integrated to global value chains. The picture is more mixed in Vietnam. While about half of its sectors became more integrated to global value chains, the opposite is true for the other half. In Ethiopia and Ghana we observe a higher concentration of domestic value added in almost all sectors in this period. Despite a clear trend in the group of developing countries, integration into GVCs seems to be rather heterogeneous at a country level. Therefore we switch to a broader perspective again.

For the whole period covered in the dataset, 1997 – 2011, we have data on the foreign content embodied in the final products of 840 manufacturing sectors[12]. Almost 40% of them, or 336, belong to developing countries. The other 504 belong to high income countries. To assess whether these sectors have been increasingly integrated into global supply chains we compare the share of foreign content ($FSHR(j)$) in the output of these sectors in 1997 with its share in 2011 (upper panel). In the lower panel we compare $FSHR(j)$ in 2007 with $FSHR(j)$ in 2011. Again, if this share increases over time, then production in this sector has become more fragmented, meaning several tasks of the production chain have been located to other countries. We show this in Figure 2 by including a red line on the diagonal. Data points above this line indicate that the foreign content has increased for this sector, the opposite is true for points below the line. Black dots indicate sectors in high income countries, grey triangles indicate sectors in developing countries.

Over the whole period the integration of manufacturing in global supply chains increased for high income and developing economies. But this development was very heterogeneous on the sectoral level. As it can be seen in the upper panel of Figure 2 many sectors

[12] For this analysis we ignore the r4d countries for which data was not available over the whole period.



Note: The figure shows the foreign value added content in the 840 manufacturing sectors in our dataset for which we have data over the whole period 1997 – 2011. The upper panel plots the share of foreign value added on output in 1997 against this share in 2011. In the lower panel the foreign value added share in 2004 is plotted against 2011. Sectors in high income countries are denoted by a black circle, grey triangles indicate sectors in developing countries.

Figure 2: Foreign value added content in 840 GVCs in manufacturing sectors

became increasingly integrated into GVCs, but for many the opposite is true. Overall, 55.8% of the manufacturing sectors in high income countries experienced higher international fragmentation of production. Of the manufacturing sectors in developing countries 64.3% became more integrated into global value chains. However, while less sectors have experience stronger integration in the high income countries, manufacturing production as a whole has become more internationalized in this group, as seen in Table 1. Our results are in line with Timmer et al. (2014) and Johnson and Noguera (2012a) who found increasing vertical fragmentation in their data as well. The pattern presented in Figure 2 changes a lot when the effect of the great recession on global value chains is looked at in more detail.

We do this in the lower panel of Figure 2, which presents the same information as the upper panel, but for a shorter time period: 2007-2011. In this period production of manufactured products in high income countries fragmented even more across national borders. For 78% of these sectors this was the case. On the other hand, almost half (44.3%) of the manufacturing sectors in developing countries the content of foreign value added decreased in that period. It appears the great recession lead to increasing fragmentation of production in high income countries and a domestic concentration of production in developing ones. In Figure 4 in the appendix we repeat this exercise for aggregated manufacturing. The observed patterns of the international fragmentation of manufacturing production remains the same when looked at a country level.

Obviously some countries became more integrated into global supply chains in the period of 1997 – 2011 while other did not. Recent literature using similar data, like Baldwin (2006), Johnson and Noguera (2012a) and Timmer et al. (2014) mention technological progress in communication and transportation as potential causes. It has allowed firms to allocate each step in the production chain to the place where it can be processed at cheapest costs. Some countries in our data were able to attract such re-allocations, others not. This is true also for the r4d countries. Policies aimed an national upgrading, non-tariff measures, labour market and trade policies may decide whether a country/sector become integrated to GVCs or not.

Also, distance to the large supply-chain hubs, identified by Baldwin (2006 and 2014) as "Factory North America", "Factory Europe" and "Factory Asia", may be a decisive factor in whether a country integrates into global supply chains or not. The fragmentation of tasks along different countries still requires close contacts between head-quarter firms in high income countries and outsourced production in developing countries (see Baldwin, 2014). Bangladesh and Vietnam are close to "Factory Asia". But the other countries of the r4d project are far away from each of the three global "factories". Of these countries only South Africa experienced an increase of foreign value added in its production. This means also policies needed for a successful integration into global supply chains differ for these countries. Also the great recession may played a role in reversing the trend of increasing fragmentation of manufacturing production in developing economies. If global integration of these countries resumes again has to be seen. Los et al. (2015) find that this is indeed the case. However, Baldwin and Venables (2013) argue that for certain skill intensive tasks, which require high technology as well, it is possible that global fragmentation has come to an end.

These tasks have to remain clustered in space due to strong localized complementarities. Also, technological progress might enable many firms to take offshored low skill intensive tasks back home. However, such a development will surely not bring back employment lost by the previous outsourcing of these tasks. Answering these questions will be left for further research. Instead, we will now look take some careful steps into the analysis how the quality and quantity of employment has been affected by fragmentation of production processes.

We have observed an increase in foreign value added embodied in the final products in the manufacturing sectors in many countries. According to Baldwin (2014) this is good news for the competitiveness of the firms producing those goods, but bad for the factors employed in the outsourced tasks. We will assess now whether skilled or unskilled labour has profited in high income, developing and the r4d partner countries in our sample.

3.3 International supply chains and labour demand

In this section we want to discuss which type of labour has profited from the increasing international fragmentation in the production manufacturing goods. We can do this since our dataset comprises data on labour value added and employment of two skill types, skilled and unskilled labour. We will use the same methodology as described in expressions (6) and (7), but break up total value added and employment embodied in domestic final production to skilled and unskilled value added/employment. For this we use variations of matrices V and L in expressions (6) and (7). Alternatively, their diagonals will collect the share of skilled and unskilled labour value added per unit of gross output and skilled, unskilled and total employment per gross output on their diagonal. The resulting matrices F^{slva}, F^{ulva}, F^{semp}, F^{uemp} and F^{emp}, are delivered with this paper.

We calculate total value added ($FO(j)$) and employment ($FE(j)$) embodied in final output in sector(j) as discussed in expression (8). Then we repeat this exercise for skilled and unskilled value added/employment, resulting in skilled/unskilled value added ($FO^{sk/usk}(j)$) and skilled/unskilled employment ($FE^{sk/usk}(j)$) embodied in the final products produced by sector j. To get the share of the skill levels in total value added and employment embodied in the final products we just take ratios of those expressions:

$$VASHR^{sk/usk}(j) = FO^{sk/usk}(j)/FO(j), \tag{11}$$

and

$$ESHR^{sk/usk}(j) = FE^{sk/usk}(j)/FE(j), \tag{12}$$

Ratio $VASHR^{sk/usk}$ allows us to determine whether the factor share of skilled and unskilled labour in the production of manufactures has increased or decreased over time. Ratio $ESHR^{sk/usk}$ allows us to do the same for employment. In Table 4 we present $VASHR^{sk}$ and $VASHR^{usk}$ in 1997 and 2011 aggregated for all manufacturing sectors. This information is presented for the group of high income countries and the group of developing economies as well as for the six r4d partner countries. Table 5 presents the same information with respect to employment embodied in domestic final production. Both tables allow us to discuss how the demand for skilled and unskilled labour was affected by the global fragmentation of production chains. In a traditional Heckscher-Ohlin framework one would expect that a country that is relatively abundant in skilled labour exports goods that use skilled labour intensively. The opposite is expected from countries that are relatively abundant in unskilled labour.

This logic can be transferred to the assessment of global value chains (see Timmer et al., 2014). In a world where it becomes more easy to relocate individual tasks of the production process to the country with the lowest costs, one would expect that countries abundant in skilled labour would specialize in tasks that require skilled labour, such as marketing, research and development, just to name a few. Tasks that require unskilled labour are then allocated to countries that are abundant in unskilled labour. Note from Table 5 that the high income countries in our sample are relatively abundant in skilled labour while the development group is relatively more abundant in unskilled labour. One would then suspect that the process of international fragmentation identified above has lead to higher demand of skilled labour in the high income group and more demand for unskilled labour in the developing group.

Tables 4 and 5 show that this is not what has happened between 1997 and 2011. In both groups the share of skilled value added employed in the production of manufacturing has actually increased while the share of unskilled factor income has decreased. The same is true for employment. Globally, demand for skilled labour in manufacturing production has increased while the demand for unskilled labour decreased. This is somewhat surprising given that the "second unbundling" allows firms to move tasks that intensively require unskilled labour to low wage countries. Also the supply of unskilled labour has increased dramatically due to the integration to trade of China and India, especially since China's acceptance into the WTO.

	VA 1997 (in %)		VA 2011 (in %)		Δ 97-11	
	sk.	*/ usk.*	*sk.*	*/ usk.*	*sk.*	*/ usk.*
			Development Groups			
High Income	19.33%	39.13%	25.58%	32.55%	6.24%	-6.58%
Developing	10.20%	37.12%	14.70%	31.79%	4.49%	-5.33%
			r4d Partner Countries			
Bangladesh	7.12%	34.80%	9.50%	29.84%	2.38%	-4.96%
Vietnam	11.31%	40.95%	14.97%	31.48%	3.67%	-9.47%
Madagascar	9.32%	45.20%	15.64%	37.42%	6.31%	-7.79%
South Africa	11.72%	40.67%	18.86%	26.27%	7.14%	-14.40%
Ethiopia	10.51%	29.73%	9.40%	29.98%	-1.11%	0.25%
Ghana	32.16%	23.24%	36.98%	23.33%	4.82%	0.09%

Note: Table 4 shows the share of labour value added on total output of manufactures in 1997 and 2011. This is done for skilled and unskilled labour in two development groups and the r4d partner countries. The last column shows the change in this share between 1997 and 2011, except for those countries where data was not available for the whole period. For Madagascar and South Africa the numbers in Table 4 refer to the period 2001 – 2011. For Ethiopia and Ghana they refer to 2004 – 2011.

Table 4: Share of labour value added in total output of manufacturing - skilled and unskilled

The r4d partner countries follow the same trend as the overall group of developing countries. Most of them show an increase (decrease) of their $VASHR^{sk}$ ($VASHR^{usk}$) and $ESHR^{sk}$ ($ESHR^{usk}$) values. This is especially true for Bangladesh and Vietnam, the two countries for which we identified a strong fragmentation of manufacturing production in 1997 – 2011. However, though not integrating to GVCs, also Madagascar and South Africa show the same pattern with respect to the demand for skilled an unskilled labour. Only Ethiopia shows a decrease in the importance of skilled labour value added and the opposite for unskilled labour value added. In Ghana the share of labour value added for both skills increased , but only slightly for unskilled labour. However, when it comes to employment also those countries follow the pattern of the other developing countries in our sample. Please note also that data availability for those countries is restricted to 2004 – 2011. So any comparison of these countries with the group average has to be taken with care.

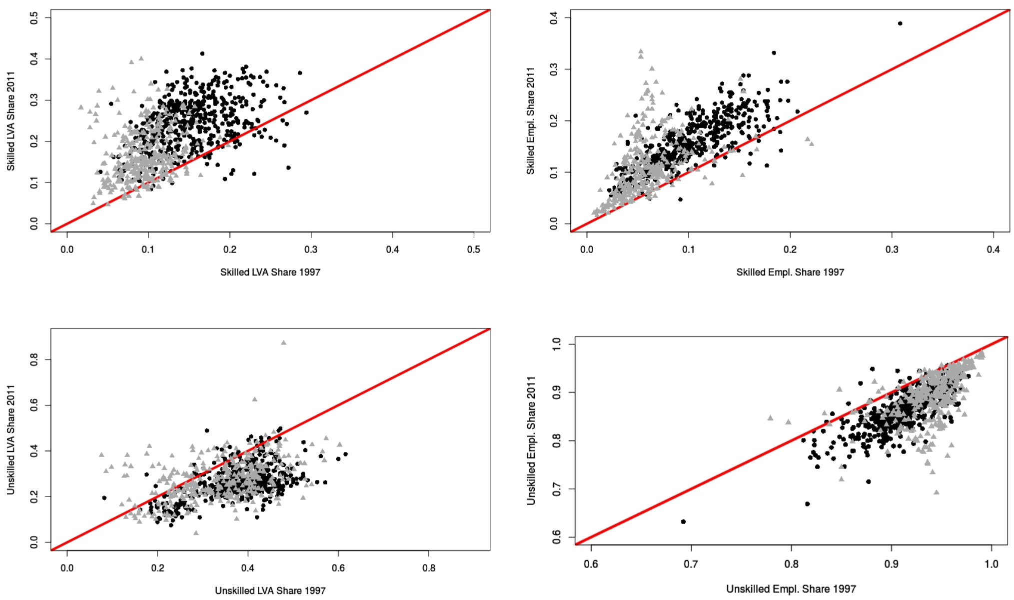
We will now bring this analysis to a more detailed level again. In Figure 3 we asses how the share of labour value added (left panels) and employment (right panels) with respect to total value added and employment for skilled and unskilled labour has developed in 1997 – 2011. This is done for each of the 840 sectors in our dataset. Again, black circles will denote the manufacturing sectors in high income countries and grey triangles their counterparts in developing economies. Also, we restrict ourselves to the countries for which data is available in the whole period.

In 93.3% of the manufacturing sectors in the high income countries the share of high skilled labour value added has increased. For developing economies this number is 90.8%. As it

	EMP 1997 (in %)		EMP 2011 (in %)		Δ 97-11	
	sk.	*usk.*	*sk.*	*usk.*	*sk.*	*usk.*
			Development Groups			
High Income	11.30%	88.70%	16.05%	83.94%	4.76%	-4.76%
Developing	3.58%	96.42%	5.86%	94.14%	2.29%	-2.29%
			r4d Partner Countries			
Bangladesh	1.94%	98.07%	4.53%	95.47%	2.60%	-2.60%
Vietnam	3.06%	96.94%	4.97%	95.03%	1.91%	-1.91%
Madagascar	3.80%	96.20%	4.90%	95.10%	1.10%	-1.10%
South Africa	7.76%	92.19%	10.55%	89.44%	2.79%	-2.74%
Ethiopia	7.24%	92.76%	9.09%	90.91%	1.86%	-1.86%
Ghana	9.20%	90.80%	10.31%	89.69%	1.11%	-1.10%

Note: Table 5 shows the share of skilled and unskilled jobs in manufactures in 1997 and 2011. This is done for two development groups and the r4d partner countries. The last column shows the change in this share between 1997 and 2011, except for those countries where data was not available for the whole period. For Madagascar and South Africa the numbers in Table 5 refer to the period 2001 – 2011. For Ethiopia and Ghana they refer to 2004 – 2011.

Table 5: Share of skilled and unskilled jobs in total manufacturing employment



Note: The left panels in Figure 3 show the share of skilled and unskilled labour value added with respect to total output value in 840 manufacturing sectors in 1997 and 2011. The right panels show the same information for the share of skilled and unskilled employment in total manufacturing employment. Sectors in high income countries are denoted by a black circle, grey triangles indicate sectors in developing countries.

Figure 3: Shares of skilled an unskilled labour in total Value Added/Employment

is evident from Figure 3 this increase was substantial for many sectors. In high income countries its (unweighed) share increased most strongly in wood products (13.9%), textile (13.6%) and leather (13.5%) products as well as other manufacturing (12.6%). Also in the developing group the strongest increase of the skilled labour value added share was in the wood products sectros (10.3%) as well as in the textile (9.2%) and leather (8.3%) sectors. Skilled employment as a share of total employment in manufacturing increased even in 97% of the manufacturing sectors in high income countries. In developing countries this was the case in 92.9% of all manufacturing sectors.

The (unweighed) share of skilled employment was highest for metal products (6.8%), utilities (6.1%) and non metallic minerals (6.1%) in high income countries. In the developing economies the increase of the share of skilled employment was highest in utilities (5.4%), metals (5.2%) and peroleum products (4.3%). In these sectors the share of unskilled employment of course decreased by the same percentages. Finally, the share of unskilled labour value added in high income countries has decreased in 93.9% of all sectors. This decrease was strongest in the textiles (-12.8%), leather (-12.7%) and metal (-12.1%) sectors. In developing economies less, or 80.4% of all sectors experienced a decrease in the share unskilled labour value added. Mostly affected were metals (-12.7%) non-metallic minterals (-11.9%) and chemicals (-10.2%). Thus, in both development groups relative factor income has shifted towards skilled labour (see Timmer et al., 2014 for similar results).

Staying in a Heckscher-Ohlin framework our results are not surprising for the high income countries only. However, the results are consistent with the model of Rodrik (1997) where the liberalization of capital flows leads to a decrease in the bargaining power of unskilled labour. This results in a relative decrease in employment and factor income of unskilled labour in high income economies and developing countries. At least of the developing world this does not mean that there was a reduction in employment of unskilled labour in absolute terms. On the contrary, in the r4d countries unskilled employment decreased only in South Africa. In Bangladesh and Vietnam it more than doubled between 1997 and 2011, in Madagascar it increased by 50% in 2001 – 2011. In Ghana and Madagascar it grew by 13 and 1.5% in the shorter time period of 2004 – 2011, respectively.

However, from the question of quality of employment a relative decline in factor income combined with rising absolute employment implies that there was not much room for wage increases for unskilled labour in these countries. What remains is the question why also skilled employment increased in these countries in relative, but also absolute terms[13].

Timmer et al. (2014) argue that differences in skill definitions in high income and developing countries could be responsible for this. Based on the work of Feenstra and Hanson

[13] The number of skilled jobs increased by more than 600% in Bangladesh and Vietnam and doubled in Madagascar. It grew by 13.2, 16.4 and 19.6% in South Africa, Ethiopia and Ghana, respectively. All numbers refer to the time period for which data is available for each country.

(1997), they argue that firms in high income countries indeed located less skill intensive tasks to cheaper low income countries. The tasks remaining in the high income countries are then more skill intensive by definition. However, if the tasks outsourced to the developing countries are relatively more skill intensive than the existing tasks here, then skill intensity might increase also in the target country.

We also have to mention that the gain of skilled labour in high income countries may have been clear from the perspective of traditional trade theories, such as the Heckscher-Ohlin model. Looking at trade as trade in tasks instead of final products this is not so clear a priori. Technological progress in communications puts also skilled jobs in high income countries at risk (see Baldwin, 2006). Imagine an in-house software programmer in a car manufacturer in Germany occupied mainly with routine programming tasks. Though highly skilled, this job can easily be outsourced to an IT company in India.

On the other hand, workers remaining in the manufacturing sector in high income countries may have specialized in tasks that can not be offshored so far and require skilled labour (see Baldwin, 2006). If both effects were at work the second one has dominated and explains our results. These examples should underline that the "second unbundling" has it made difficult to assess who profits and who loses from globalisation (see Baldwin, 2014). The tasks conducted by today's winners of outsourcing might soon be outsourced as well. This environment will make employment policies of governments not easier.

4 Summary

During the past decades production processes have become increasingly fragmented. Before a final product leaves the assembly line its components cross many borders and sectors. To track factor inputs and employment through these global value chains this paper documents the construction of a new dataset based on input-output data obtained from the GTAP database. It includes data on global value chains for factor inputs and employment for up to 64 countries and 25 sectors for the years 1997, 2001, 2004, 2007 and 2011. We illustrated potential applications of this data by assessing whether the production of final goods in 14 manufacturing sectors has become more fragmented on a global level between 1997 and 2011 in the countries in our dataset. Then the data was used to shed light on the question how this process has affected factor incomes and employment of skilled and unskilled labour. We followed similar research of Timmer et al. (2014) but used more recent data and extended their results to a larger number of developing countries. We focused especially on the r4d partner countries Bangladesh, Ethiopia, Ghana, Madagascar, South Africa and Vietnam.

Manufacturing production became more fragmented 1997 – 2011, though the great recession reversed this trend at least temporarily in many developing countries. Among the partner countries of the r4d project Madagascar followed this trend closely. Bangladesh, Vietnam and South Africa, however, increased the vertical fragmentation of their production over the whole period. For Bangladesh and Vietnam this can be explained by their proximityto one of the most important global hubs of value chains, East Asia. Ethiopia, Madagascar and Ghana are far away from these hubs, which may explain to some degree their non-integration to global value chains between 2004 and 2011. This era of international fragmentation of production was accompanied by higher demand for skilled and a decrease of demand for unskilled labour. We found this to be the case whether countries became integrated to global value chains or not. On the flip side, factor income and relative employment of skilled labour has increased in high income and developing economies. These results are consistent with the predictions of Rodrik (1997) where the liberalization of capital flows decreased the bargaining power of unskilled labour.

This of course only scratches on the potential of applications of this database. We concentrated on the production of manufactured goods finished within a country. However, vertical fragmentation of production implies that many tasks in domestic production are outsourced to other countries. Especially for developing economies this could imply a shift of production away from final goods produced within their borders towards tasks contributing to final goods finalized in other countries. After all, vertical fragmentation allows countries to specialize in tasks they have a comparative advantage. For developing countries this is an opportunity as they do not have to build a full supply chain within their country in order to industrialize (see Baldwin, 2014). In our analysis this has not been taken into account when analysing the employment effects of vertical fragmentation. We leave this for further research.

In a world of geographically fragmented production processes employment policies have to go beyond the manufacturing sectors. Recent literature shows that a competitive manufacturing sector is increasingly reliant on intermediates and services produced outside the manufacturing sector (see Francois et al., 2015 and Johnson and Noguera, 2012). One has just to think on the importance of communication technology which makes outsourcing of tasks possible to begin with. This has important implications on employment. For high income countries there is evidence in the literature that the loss of employment in the manufacturing sectors was more than offset by job creation in the services sector (see Baldwin and Evenett, 2012, Los et al., 2015 and Timmer et al, 2014). Aslo, development strategies such as import substitution, which means that developing countries attempt to build complete supply chain within within their borders, may destroy employment rather than create it in a world of fragmented supply chains (see Baldwin, 2014). This database can help to shed light on this issue from the point of view of developing economies. Governments have to take these issues into account and this database can be of support in quantitative studies in this area.

For the database itself many paths for improvement remain. The proportionality assumption on intermediate trade applied typically in the input-output literature may cause considerable bias. New research in this area should be incorporated into the database presented here. Also, large export processing sectors in many developing countries are not accounted for in this database so far. In a future release the input-output data of this database should be corrected for these activities. The main area of improvement, however, concerns the data on employment used to construct this database. A future release of this dataset would benefit enormously if better source data could be obtained for its construction. Also ad hoc assumptions to interpolate missing data should be replaced by econometric approaches.

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A Appendix

Number	Sector	Short	ISIC Code (rev.3)
	Primary		
1.	Agriculture, Forestry, Fishing	agr	AtB
2.	Mining, Quarrying	miq	C
	Industry		
3.	Food, Beverages, Tobacco	fbt	15-16
4.	Textiles, Wearing Apparel	tex	17-18
5.	Leather, Leather Products, Footwear	lea	19
6.	Wood, Wood Products and Cork	lum	20
7.	Paper, Paper Products, Publishing	ppp	21-22
8.	Petroleum, Coke, Nuclear Fuel	p_c	23
9.	Chemicals, Rubber, Plastic Products	crp	24-25
10.	Non-metallic Minerals	nmm	26
11.	Metals, Metal Products	met	27-28
12.	Transport Equipment, Motor Vehicles	tre	35-35
13.	Electronic Equipment, Machinery	ele	29-30&33
14.	Other Manufacturing	omf	36-37
15.	Electricity, Gas, Water	egw	E
16.	Construction	cns	F
	Services		
17.	Trade, Sales, Accommodation	trd	50-52&H
18.	Land Transport	otp	60
19.	Water Transport	wtp	61
20.	Air Transport	atp	62
21.	Post and Telecommunications	cmn	64
22.	Financial Intermediation, Insurance	fin	J
23.	Real Estate, Renting, Business	bsr	70-74
24.	Recreation, Other Services	ros	OP
25.	Public Services	osg	LMN

Table A.1: Description of the 25 sectors contained in the database

Number	Sector	WIOD Sectors	GTAP Sectors
	Primary		
1.	Agriculture, Forestry, Fishing	1	1 – 14
2.	Mining, Quarrying	2	15 – 18
	Industry		
3.	Food, Beverages, Tobacco	3	19 – 26
4.	Textiles, Wearing Apparel	4	27 – 28
5.	Leather, Leather Products, Footwear	5	29
6.	Wood, Wood Products and Cork	6	30
7.	Paper, Paper Products, Publishing	7	31
8.	Petroleum, Coke, Nuclear Fuel	8	32
9.	Chemicals, Rubber, Plastic Products	9 – 10	33
10.	Non-metallic Minerals	11	34
11.	Metals, Metal Products	12	35 – 37
12.	Transport Equipment, Motor Vehicles	15	38 – 39
13.	Electronic Equipment, Machinery	13 – 14	40 – 41
14.	Other Manufacturing	16	42
15.	Electricity, Gas, Water	17	43 – 45
16.	Construction	18	46
	Services		
17.	Trade, Sales, Accommodation	19 – 21	47
18.	Land Transport	23	48
19.	Water Transport	24	49
20.	Air Transport	25	50
21.	Post and Telecommunications	27	51
22.	Financial Intermediation, Insurance	28	52 – 53
23.	Real Estate, Renting, Business	29 – 30	54 & 57
24.	Recreation, Other Services	34 – 35	55
25.	Public Services	31 – 33	56

Note: Table A.2 shows the matching of WIOD and GTAP sectors. Please see Timmer et al. (2014) and www.gtap.org for the numeration of sectors in these databases.

Table A.2: Concordance Table of WIOD and GTAP sectors

ISCED 1997	Description	WIOD Skill
1	Primary level of education	Low
2	Lower secondary level of education	Low
3	Upper secondary level of education	Medium
4	Post secondary, non-tertiary education	Medium
5b	First stage of tertiary education	High
5A	First stage of tertiary education, 1^{st} degree	High
6	Second stage of tertiary education	High

Note: Table A.3 shows level of education according to ISCED 1997 definition and the corresponding WIOD skill levels. Source: ILO (2012) and Erumban et al. (2012).

Table A.3: ISCED 1997 levels of education and WIOD sectors

	ISCO 08 Groups	Skill Level	GTAP Skill
1	Managers	3 + 4	Skilled
2	Professionals	4	Skilled
3	Technicians and associate professionals	3	Skilled
4	Clerical support workers	2	Unskilled
5	Services and sales workers	2	Unskilled
6	Skilled agricultural, forestry and fishery workers	2	Unskilled
7	Craft and related trade workers	2	Unskilled
8	Plant and machine operators, assemblers	2	Unskilled
9	Elementary occupations	1	Unskilled
0	Armed forces occupations	1 – 4	n.a.

Note: Table A.4 shows the major groups of occupations based on ISCOD 08 definition, corresponding ILO skill levels and their corresponding GTAP skill levels. Source: ILO (2012).

Table A.4: ISCED 1997 levels of education and GTAP skill levels

ISCED 1997	ISCO 08	WIOD	GTAP
1 – 2	1	Low	Unskilled
3 – 4	2	Medium	Unskilled
5 – 6	3 – 4	High	Skilled

Note: Table A.5 shows the concordance table of the skill levels used in WIOD and GTAP. The skill classification of WIOD is based on ISCED 1997 levels of education. GTAP skill levels are based on occupation. The concordance of occupation and education is taken from ILO (2012).

Table A.5: Concordance Table of ISCED 97, ISCO 08, WIOD and GTAP skill levles

Number	Sector	ILO ISIC 4	GTAP Sectors
	Primary		
1.	Agriculture, Forestry, Fishing	A	1 – 14
2.	Mining, Quarrying	B	15 – 18
	Industry		
3.	Manufacturing	C	19 – 42
4 .	Electricity, Gas, Water	D & E	43 – 45
5.	Construction	F	46
	Services		
6.	Trade, Sales, Accommodation	G & I	47
7.	Transport, Communication	H & J	48 – 51
8.	Financial Intermediation, Insurance	K	52 – 53
9.	Real Estate, Renting, Business	L & M & N	54 & 57
10.	Recreation, Other Services	R & S & T & X	55
11.	Public Services	O & P & Q & U	56

Note: Table A.6 shows the matching of ILO Sectors for ISIC 4 classification and GTAP sectors. Please see www.ilo.org and www.gtap.org and Table A.1 for more details.

Table A.6: Concordance Table of ILO ISIC 4 and GTAP Sectors

Number	Sector	ILO ISIC 3	GTAP Sectors
	Primary		
1.	Agriculture, Forestry, Fishing	A & B	1 – 14
2.	Mining, Quarrying	C	15 – 18
	Manufactures		
3.	Manufacturing	D	19 – 42
4 .	Electricity, Gas, Water	E	43 – 45
5.	Construction	F	46
	Services		
6.	Trade, Sales, Accommodation	G & H	47
7.	Transport, Communication	I	48 – 51
8.	Financial Intermediation, Insurance	J	52 – 53
9.	Real Estate, Renting, Business	K	54 & 57
10.	Recreation, Other Services	O & P & X	55
11.	Public Services	L & M &N & Q	56

Note: Table A.7 shows the matching of ILO Sectors for ISIC 3 classification and GTAP sectors. Please see www.ilo.org and www.gtap.org and Table A.1 for more details.

Table A.7: Concordance Table of ILO ISIC 3 and GTAP Sectors

Number	Sector	ILO ISIC 2	GTAP Sectors
	Primary		
1.	Agriculture, Forestry, Fishing	1	1 – 14
2.	Mining, Quarrying	2	15 – 18
	Industry		
3.	Manufacturing	3	19 – 42
4 .	Electricity, Gas, Water	4	43 – 45
5.	Construction	5	46
	Services		
6.	Trade, Sales, Accommodation	6	47
7.	Transport, Communication	7	48 – 51
8.	Business Services	8 & 0	52 – 55 & 57
9.	Public Services	9	56

Note: Table A.8 shows the matching of ILO Sectors for ISIC 2 classification and GTAP sectors. Please see www.ilo.org and www.gtap.org and Table A.1 for more details.

Table A.8: Concordance Table of ILO ISIC 2 and GTAP Sectors

Number	Sectors in Database	ZAF Sectors
		Primary
1.	Agriculture, Forestry, Fishing	Agriculture, forestry and fishing
2.	Mining, Quarrying	Coal mining
		Gold and uranium ore mining
		Other mining
		Industry
3.	Food, Beverages, Tobacco	Food
		Beverages
		Tobacco
4.	Textiles, Wearing Apparel	Textiles
		Wearing apparel
5.	Leather, Leather Products, Footwear	Leather products
		Footwear
6.	Wood, Wood Products and Cork	Wood and wood products
7.	Paper, Paper Products, Publishing	Paper and paper products
		Printing, publishing and recorded media
8.	Petroleum, Coke, Nuclear Fuel	Coke and refined petroleum products
9.	Chemicals, Rubber, Plastic Products	Basic chemicals
		Other chemicals and man-made fibers
		Rubber products
		Plastic products
10.	Non-metallic Minerals	Glass products
		Non-metallic minerals
11.	Metals, Metal Products	Basic iron and steel
		Basic non-ferrous metals
		Metal products excluding machinery
12.	Transport Equipment, Motor Vehicles	Motor vehicles, parts and accessories
		Other transport equipment
13.	Electronic Equipment, Machinery	Machinery and equipment
		Electrical machinery and apparatus
		Television, radio and communication equipment
		Professional and scientific equipment
14.	Other Manufacturing	Furniture
		Other manufacturing
15.	Electricity, Gas, Water	Electricity, gas and steam
		Water supply
16.	Construction	Building construction
		Civil engineering and other construction
		Services
17.	Trade, Sales, Accommodation	Wholesale and retail trade
		Catering and accommodation services
18.	Land Transport	Transport and storage
19.	Water Transport	Transport and storage
20.	Air Transport	Transport and storage
21.	Post and Telecommunications	Communication
22.	Financial Intermediation, Insurance	Finance and insurance
23.	Real Estate, Renting, Business	Business services
24.	Recreation, Other Services	Other producers
25.	Public Services	Medical, dental and veterinary services
		Excluding medical, dental and veterinary services
		General government services

Note: Table A.9 shows the matching of the sectors used in this dataset with the data provided by r4d partner country South Africa. Unfortunately all transport sectors in the South African data were aggregated to a single one. We used GTAP labour value added to split it into land- air- and water-transport.

Table A.9: Concordance Table of ZAF and GTAP sectors

Country	Sectors	Years
Sri Lanka	Electricity, Gas, Water; Construction; Recreation, other Ser.;	2004 – 2007
Colombia	Trade, Sales, Accommodation; Public Ser.; Recreation, other Ser.;	2004 – 2007
Peru	Electricity, Gas, Water; Recreation, other Ser.; Public Ser.;	2011
Uruguay	Electricity, Gas, Water; Recreation, other Ser.; Trade, Sales, Accommodation;	2001 – 2007
Switzerland	Recreation, other Ser.;	2007
Morocco	Recreation, other Ser.; Public Services; Business Services;	2004 – 2007
Madagascar	Recreation, other Ser.; Public Services;	2004

Note: Table A.12 shows the sectors for which ILO raw data was missing in the ISIC 3 and 4 classifications. We imputed those sectors using real growth of labour value added from GTAP as mentioned in the main text.

Table A.10: Imputations of missing sectors in ILO ISIC 3 and 4 classification

Country	Years	Years with available Data
Bangladesh	1997 – 2011	2003 & 2005
Sri Lanka	2001	2002 – 2010
Argentina	2007	1992 – 2006
Colombia	1997	2002 – 2011
Peru	1997 – 2007	2009 – 2011
Uruguay	1997	2000 – 2011
Morocco	1997 – 2001	2002 – 2008 & 2011
Madagascar	2001 – 2011	2003 & 2005
Zimbabwe	1997 – 2007	2011
Botswana	1997 – 2011	1996 & 1998 & 2000 & 2003 & 2006
Ethiopia	2004 – 2011	2005

Note: Table A.11 shows for which country and year no ILO employment data was available. These years we imputed using the methodology described in the main text. Additionally, for Bangladesh we could use average growth rates for the years 2004 – 2011 from local Labour Force Surveys. The Table also notes for each of these countries the years for which ILO data was available.

Table A.11: Countries for which employment was imputed for whole years

Country	Years
Malaysia	1997
Philippines	1997
Thailand	1997 & 2001
Sri Lanka	1997
Venezuela	1997 – 2007
Chile	1997 – 2007

Note: Table A.12 shows the countries and years for which only ILO raw data of ISIC 2 classification was available. In these cases the business services sector had to be expanded in order to get 11 sectors.

Table A.12: Imputations of Business Services (ILO ISIC 2) – Countries and Years

Country	Source	Imputations?	Country	Source	Imputations?
Australia	WIOD	No	Greece	WIOD	No
New Zealand	ILO (ISIC 3 & 4)	No	Ireland	WIOD	No
China	WIOD	No	Italy	WIOD	No
Japan	WIOD	No	Luxembourg	WIOD	No
Korea	WIOD	No	Netherlands	WIOD	No
Taiwan	WIOD	No	Portugal	WIOD	No
Indonesia	WIOD	No	Spain	WIOD	No
Malaysia	ILO (ISIC 2 & 3 & 4)	Yes	Sweden	WIOD	No
Philippines	ILO (ISIC 2 & 3)	Yes	Switzerland	ILO (ISIC 3 & 4)	No
Thailand	ILO (ISIC 2 & 3 & 4)	Yes	Bulgaria	WIOD	No
Vietnam	ILO (ISIC 3)	No	Croatia	ILO (ISIC 3 & 4)	No
	local source		Czech Republic	WIOD	No
Bangladesh	ILO (ISIC 3)	Yes	Hungary	WIOD	No
India	WIOD	No	Malta	WIOD	No
Sri Lanka	ILO (ISIC 3)	Yes	Poland	WIOD	No
Canada	WIOD	No	Romania	WIOD	No
United States	WIOD	No	Slovakia	WIOD	No
Mexico	WIOD	No	Slovenia	WIOD	No
Colombia	ILO (ISIC 2 & 3)	Yes	Estonia	WIOD	No
Peru	ILO (ISIC 4)	Yes	Latvia	WIOD	No
Venezuela	ILO (ISIC 2 & 4)	Yes	Lithuania	WIOD	No
Argentina	ILO (ISIC 3 & 4)	Yes	Russia	WIOD	No
Brazil	WIOD	No	Cyprus	WIOD	No
Chile	ILO (ISIC 2 & 3)	Yes	Turkey	WIOD	No
Uruguay	ILO (ISIC 3 & 4)	Yes	Morocco	ILO (ISIC 3)	Yes
Austria	WIOD	No	Ghana	ILO (ISIC 4)	Yes
Belgium	WIOD	No	Ethiopia	ILO (ISIC 3)	Yes
Denmark	WIOD	No	Botswana	ILO (ISIC 3)	Yes
Finland	WIOD	No	Madagascar	ILO (ISIC 3)	Yes
France	WIOD	No	Zambia	ILO (ISIC 4)	Yes
Germany	WIOD	No	Zimbabwe	ILO (ISIC 4)	Yes
United Kingdom	WIOD	No	South Africa	local source	Yes

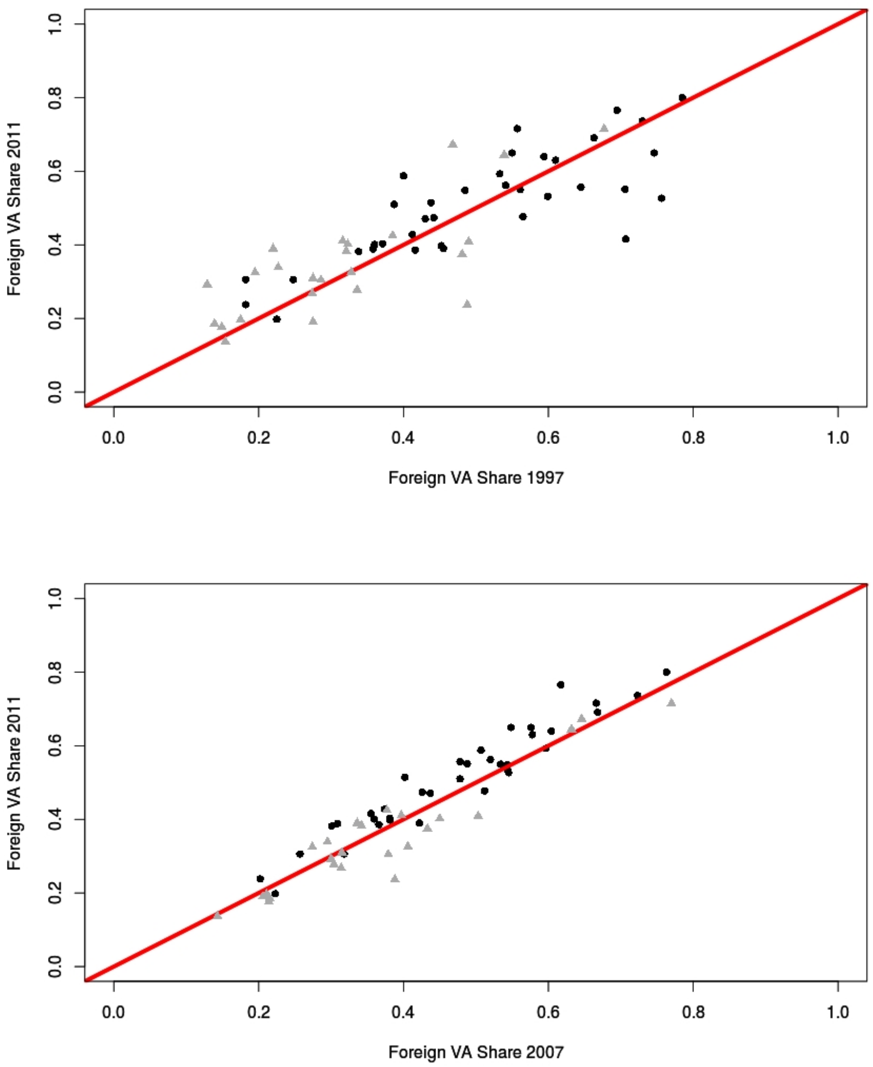
Note: Table A.13 shows the source of the employment data for each countries and if imputations have been conducted for at least one sector in at least one year.

Table A.13: Summary of data sources for employment per sector

Country	**Proxy**
New Zealand	Australia
Malaysia	Indonesia
Philippines	Indonesia
Thailand	Indonesia
Vietnam	Indonesia
Bangladesh	India
Sri Lanka	India
Colombia	Brazil
Peru	Brazil
Venezuela	Brazil
Argentina	Brazil
Chile	Brazil
Uruguay	Brazil
Switzerland	GER/AUT/FRA
Bulgaria	SWE/DNK
Croatia	Slovenia
Morocco	Turkey
Ghana	South Africa
Ethiopia	South Africa
Botswana	South Africa
Madagascar	South Africa
Zambia	South Africa
Zimbabwe	South Africa

Note: Table A.14 shows the proxy countries which were used to weight value added in the GTAP data in order to expand the 11 ILO sectors to 25 sectors and to conduct the split into skilled and unskilled labour.

Table A.14: Proxy countries for expanding ILO sectors and conducting the skill split



Note: The figure shows the foreign value added content in manufacturing for the 60 countries in our dataset for which we have data over the whole period. The upper panel plots the share of foreign value added on output in 1997 against this share in 2011. In the lower panel the foreign value added share in 2004 is plotted against 2011. High income countries are denoted by a black circle, grey triangles indicate developing countries.

Figure 4: Foreign value added content in manufacturing - 60 countries