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JEL: F16, F66

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Jobs in global supply chains: a macroeconomic assessment*

Takaaki Kizu† Stefan Kühn‡ Christian Viegelahn§

29 February, 2016

Abstract In its recent *World Employment and Social Outlook*, the ILO published estimates of the number of jobs related to global supply chains (GSCs) for 40 countries in 1995-2013. This paper provides a detailed description of the methodology that was used for the estimation and documents in more detail global linkages in production, becoming apparent on the labour market. The paper also shows new evidence on the number of jobs supported by different export destinations and analyzes the number of GSC-related jobs in different country groups. In particular, we find evidence for the changing role of China, from a country in which GSC-related jobs are located to a country whose import demand creates these jobs elsewhere. We also show that production linkages between emerging economies create an increasing number of jobs. When focusing on jobs related to manufacturing GSCs, trends in GSC-related jobs reveal the increasing importance of the services sector. Finally, we conduct a sectoral regression analysis and provide evidence that increased GSC participation of a sector as a supplier can be associated with a drop in the wage share.

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1 Introduction

In the past decades, production in the global economy has seen increased fragmentation into different activities and tasks along global supply chains (GSCs). The development of GSCs has in particular been facilitated by the reduction in trade and transport costs, but also by advancements in information and communication technology, making the provision of different services across borders easier. These changes have not only had an impact on how firms organize production (Antras and Helpman, 2004; Antras and Chor, 2013). They also have come along with substantial changes on labour markets worldwide with a large number of jobs that are directly or indirectly dependent on production linkages between countries. These are jobs in production units that have been outsourced or offshored by lead firms, located in other countries.

In order to assess the number of this type of jobs, we have developed estimates for 40 countries in 1995-2013. These estimates of GSC-related jobs have been published by the International Labour Organization (ILO) in its recent *World Employment and Social Outlook* (ILO, 2015). The purpose of this paper is twofold. First, this paper includes a detailed description of the methodology that was used to produce these estimates. Second, this paper shows more detailed results, including yet unpublished figures. In particular, we provide new evidence on the global interconnectedness of production that becomes apparent on the labour market, and document the number of GSC-related jobs by country group and export destination. The paper also sheds light on the role of manufacturing GSCs for job creation.

GSCs undoubtedly play an important role in providing new opportunities for workers that would not exist if production was organized in a local manner. However, some criticize GSCs for the asymmetries in power they may create in some instances, thereby endangering sustainable and balanced economic growth (Hoejmose, Grosvold and Millington, 2013). In order to assess the relationship between GSCs and the labour market, this paper also contributes to the literature by investigating the link between GSC participation of sectors as suppliers and the wage share, using sectoral data.

To estimate the number of jobs related to GSCs, this paper relies on macroeconomic and labour market data, including international input-output tables and data on sectoral employment from the World Input Output Database (WIOD). This database contains data for 35 sectors and 40 countries for the years from 1995 to 2011. On the basis of these data, we produce an estimate of the number of GSC-related jobs. According to our estimation methodology, this estimate shows the number of jobs in a particular country that are dependent on global exports to another country, which we define as export destination. For example, the number of jobs in China that are dependent on the United States as export destination includes both, jobs in China that depend on Chinese exports to the United States as well as jobs in China that depend on any other country's exports to the United States. Defining GSC-related jobs in this way allows us to capture direct as well as indirect

production linkages between countries, when counting the number of jobs.

Indeed, the destination-specific demand vector that most appropriately reflects output related to GSCs needs to be chosen in order to estimate the number of GSC-related jobs as accurately as possible. The methodology applied in this paper includes global exports to the particular destination into the demand vector. In other words, GSC-related jobs are jobs related to the foreign demand for imports. The demand vector chosen takes into account both demand for intermediate and final goods and services.

Different researchers and international organizations have recently come up with related jobs estimates. For example, Jiang (2013) estimates *jobs in global production networks*, but employ a relatively narrow definition of the demand vector. Following this definition, only jobs that are dependent on intermediate goods exported to be used in exports of a foreign country count as jobs in global production networks. While such a definition ensures that the jobs are truly part of a GSC, it ignores instances where final goods form part of the GSC which is the case when the outsourced or offshored task consists of the final assembly of a good. It equally ignores instances, where the initial stage of an otherwise domestic supply chain is outsourced or offshored.

Timmer, Erumbam, Stehrer and de Vries (2014) estimate the number of *manufactures global value chain workers* with a final demand vector that includes total final manufacturing demand by all countries in their study. Hence, they compute the number of jobs forming part of the supply chain producing manufacturing output, not distinguishing between supply chains that are purely domestic or, in fact, global. Their premise is that manufacturing supply chains are highly integrated and hence can always be considered global. However, their methodology ignores GSCs where the demanded output are services or agricultural goods. Moreover, if final demand from all sectors were used in their methodology, their estimate would be by definition equivalent to total employment.

The European Commission estimates *employment supported by exports* (EC, 2015). However, they consider the EU as one trading bloc and ignore intra-EU trade as source for jobs related to GSCs. With their methodology, jobs related to Czech exports of car parts to Germany, made for a German car manufacturer, for example, would not be counted as employment supported by exports.

Besides presenting in detail the estimates of the number of GSC-related jobs, this paper also investigates whether the share of exported goods and services used as imported inputs to produce other countries' exports has an impact on the sectoral wage share. This commonly used forward GSC participation measure measures GSC participation from the perspective of suppliers. Results indicate that the wage share decreases with a higher forward GSC participation.

Section 2 of this chapter presents in detail data and methodology used to estimate the number of workers in GSCs. Section 3 presents detailed trends in the number of GSC-related workers, disaggregated according to various dimensions. Section 4 discusses the results of a sector-level

analysis in which the empirical relationships between forward GSC participation and the wage share are explored. The final section concludes.

2 Estimates of jobs related to global supply chains

2.1 Data

Estimates of the number of jobs related to GSCs are constructed on the basis of international input-output tables, available for 40 countries for 1995-2011 from the World Input Output Database (WIOD). The estimates are also based on a socio-economic accounts database that contains sectoral employment numbers for the same time span, also available from WIOD.[1] In terms of coverage, the database covers 7 emerging economies (Brazil, China, India, Indonesia, Mexico, the Russian Federation and Turkey) as well as 33 developed economies (Australia, Canada, EU-27 countries, Japan, Republic of Korea, Taiwan (China) and the United States). The economy is disaggregated into 35 sectors, among which there are 14 manufacturing sectors.

The ILO's *Trends Econometric Models* database contains the female employment shares disaggregated into 14 sectors for the country and time coverage of the WIOD database.[2] These shares have been applied to the sectoral employment numbers from the socio-economic accounts to obtain female employment by sector. Since the WIOD database has a larger disaggregation than the *Trends Econometric Models* database, the same share is applied to all subsectors that correspond to a sector in the *Trends Econometric Models* database. Under the assumption that the share of women that work in GSC-related activities is the same as the share of women that work in non-GSC-related activities for each sector, the sectoral employment data by sex allows to compute the number of female GSC-related jobs.

Data from WIOD are only available for the years from 1995 to 2011, which is then identical to the period for which GSC jobs estimates can be constructed on the basis of input-output tables. In order to extend the time coverage of the GSC jobs estimates to more recent years, we set up a regression model and project GSC jobs for 2012-13. The projections then correspond to our GSC jobs estimates for 2012-13. The regressions make use of data on GDP growth, export value and import value, taken from the IMF *World Economic Outlook* database (October 2014). Sectoral value added comes from the United Nations Statistics Division, while data on inward FDI is taken from UNCTAD. The data source for total employment is again the ILO's *Trends Econometric Models* database.

[1] See www.wiod.org for a detailed description and Timmer (2012) for the documentation of the database.
[2] Data are available from http://www.ilo.org/legacy/english/weso/2015/WESO_jan2015.xlsx.

2.2 Methodology: estimates for 1995-2011

This section describes the methodology that is used to estimate the number of GSC-related jobs in 1995-2011. More specifically, this is the number of jobs in a certain country that are dependent on global exports to a certain export destination.

The content of the world input-output tables can be written in general matrix notation, where the number of countries is C and the number of sectors is S. On the basis of the information provided in the world input-output tables, gross output that serves final demand can be summarized for all countries and sectors in a $SC \times C$ vector F, where $f_{sc,c'}$ is the element of the vector that refers to output of sector s of country c that serves final demand in destination c'. Similarly, gross output of a certain sector and a certain country that enters as intermediate input into a certain destination sector and destination country can be written in a $SC \times SC$ matrix M, where $m_{sc,s'c'}$ is one element of this matrix that refers to gross output in sector s and country c that enters as an intermediate input into the production of destination sector s' of destination country c'.

On the basis of vector F and matrix M, one can define a vector X that refers to total gross output. X is defined as the sum over all columns of F and M. Each element of this vector, x_{sc}, describes total gross output in sector s of country c and can be calculated as $x_{sc} = f_{sc,c'} + \sum_{s'c' \in \Omega} m_{sc,s'c'}$, where Ω is the set of all possible destination country-sector combinations. This vector has the dimension $SC \times 1$. As next step, a vector $\bar{X}$ can be defined. This vector has the same dimension as X and each element of this element is calculated as the inverse of the corresponding element in X. In other words, it holds that $\bar{x}_{sc} = \frac{1}{x_{sc}}$, where $\bar{x}_{sc}$ is an element of $\bar{X}$. This vector serves as an input to a matrix A of dimension $SC \times SC$, which is defined as $A = Mdiag(\bar{X})$.[3] Matrix A also has the dimension $SC \times SC$. The elements of matrix A can be interpreted as technical coefficients that specify how much of each input from the different sectors and different countries are used in the production of one unit of gross output in a particular destination sector and country.

On the basis of A, the Leontief inverse matrix can be calculated as $L = (I - A)^{-1}$ with I being the identity matrix. The Leontief inverse L is a matrix of dimension $SC \times SC$ that in each column includes the gross output requirements in the different sectors and countries that are needed to produce one more unit of output demanded in the destination sector and country. The Leontief inverse is illustrated in Table 1. An element $L_{sc,s'c'}$ of this matrix illustrates the output requirements for sector s of country c in order to produce one unit of output in destination sector s' of country c'.

[3] The matrix operation *diag* creates a square matrix in which the elements of vector $\bar{X}$ are on the diagonal and all the other elements of the matrix are set to zero.

Table 1: Linking demanded output to sectoral gross output requirements

			Sector the demanded output belongs to						
			Country 1			...	Country C		
			Sector 1	...	Sector S	...	Sector 1	...	Sector S
Sector contributing to the demanded output	Country 1	Sector 1	$L_{11,11}$		$L_{11,S1}$		$L_{11,1C}$		$L_{11,SC}$
		...							
		Sector S	$L_{S1,11}$		$L_{S1,S1}$		$L_{S1,1C}$		$L_{S1,SC}$
	...	...							
	Country C	Sector 1	$L_{1C,11}$		$L_{1C,S1}$		$L_{1C,1C}$		$L_{1C,SC}$
		...							
		Sector S	$L_{SC,11}$		$L_{SC,S1}$		$L_{SC,1C}$		$L_{SC,SC}$

The Leontief inverse matrix is key to the calculation of the number of jobs in global supply chains. This is because the Leontief inverse can also reveal the labour requirements in the different sectors and countries that are needed to produce one more unit of demanded output of a particular sector and country, when it is combined with information on labour productivity. A $SC \times 1$-dimensional employment vector E is available from the socio-economic accounts of the WIOD database, where an element of that vector e_{sc} contains the number of workers in sector s of country c. On the basis of the vectors E and X, we can generate a productivity vector P where each element of this vector p_{sc} describes the average labour requirements per unit of output in sector s of country c, calculated as $p_{sc} = \frac{e_{sc}}{x_{sc}}$.

Moreover, a $SC \times 1$-dimensional demand vector $D^{c'}$ needs to be specified for each destination country c'. The Leontief inverse just contains the information which gross output requirements in the different sectors and countries are needed to produce *one* more unit of gross output of a particular destination sector and country. The demand vector contains the information *how many and which* units of gross output of a particular destination sector and country are demanded. For a particular destination country $c' = \bar{c}$, each element of the demand vector $D^{c'=\bar{c}}$ can be specified as

$$d_{sc}^{c'=\bar{c}} = f_{sc,c'}^{c'=\bar{c}} + \sum_{s'c' \in \Omega^{c'=\bar{c}}} m_{sc,s'c'} \quad \text{for } c \neq \bar{c} \tag{1}$$

$$d_{sc}^{c'=\bar{c}} = 0 \quad \text{for } c = \bar{c} \tag{2}$$

where $\Omega^{c'=\bar{c}}$ is a subset of Ω that only includes those destination country-sector combinations that are related to destination country $c' = \bar{c}$. The demand vector that is chosen for the calculation of jobs included in GSCs hence includes the demand in the destination country for foreign final and intermediate goods and services.

As next step, a $SC \times SC$-dimensional $J^{c'}$ matrix for a particular destination country c' is computed. It contains the sectors and countries where the jobs are located in the different rows and destination

sectors and countries of origin of the exports in the columns. For destination country $c' = \bar{c}$, the particular element $j^{c'=\bar{c}}_{scs'\tilde{c}}$ of this matrix specifies the number of jobs in sector s of country c that are dependent on exports to destination sector s' of destination country $c' = \bar{c}$ that come from country of origin of exports $\tilde{c}$. This matrix can be calculated as $J^{c'=\bar{c}} = diag\left(\bar{P}\right)\ L\ diag\left(D^{c'=\bar{c}}\right)$.

As last step, a $SC \times SC$-dimensional J matrix is defined that is based on the different matrices $J^{c'}$ created for each export destination. In particular, columns of matrices $J^{c'}$ are summed up over all countries of origin of exports. A particular element of J is defined as $j_{sc,s'c'} = \sum_{\tilde{c}\in\Phi} j^{c'=\bar{c}}_{scs'\tilde{c}}$, where Φ is the set of all countries of origin of exports. Matrix J then provides information on all the jobs by sector and country where these jobs are located and by destination sector and destination country.

Our estimates of GSC-related jobs should be interpreted as upper bound estimates of the true number of jobs linked to GSCs in the countries analysed. First, as already noted in ILO (2015), productivity in exporting firms tends to be higher, suggesting that exporters use relatively fewer inputs, including less labour, than non-exporters to produce their share in output (Bernard et al., 2007). Second, in some instances, certain exports of final goods should not be counted as forming part of GSCs, while, by contrast, exported intermediate goods and services are, by definition and in all cases, part of a GSC. For example, jobs related to the final assembly of mobile phones exported from China to the United States should, in principle, not be counted as part of a GSC if the lead firm is a company based in China. They would, however, be related to a GSC if the lead firm were in the United States. Data limitations prevent us from an assessment of the volume of exports of final goods and services by the country of origin of the lead firm. Therefore, similar to other studies (OECD et al., 2013; OECD and World Bank, 2014; UNCTAD, 2013), our methodology takes into account all exports of final goods and services, regardless of the country of origin of the lead firm. Indeed, excluding jobs related to the exports of final goods from the estimate of GSC-related jobs would be problematic as this would eliminate all outsourced or offshored jobs related to the assembly of final products and would greatly underestimate the actual number of GSC-related jobs.

Finally, due to the nature of our methodological approach, there may be instances where GSC-related jobs are counted more than once, which may lead to an over-estimation of the number of GSC-related jobs. In the "trade-in-value-added" perspective that we adopt, such double-counting can still occur, for example when domestic value-added is first exported to another country as an intermediate good or service, but eventually re-imported back to the source country and consumed there. This portion of domestic-value added is double-counted when it crosses national borders more then once, going back and forth between source and destination country, as pointed out in recent research (Koopman et al., 2014). However, the case described is more likely to occur in the case of small open economies, which is why it is unlikely to affect aggregate numbers at a significant magnitude.

2.3 Methodology: estimates for 2012-13

GSC jobs estimates can only be constructed on the basis of WIOD for 1995-2011. We derive estimates for 2012-13 on the basis of a GSC jobs projection model. The model applies panel regression techniques and estimates the growth rates of jobs in a particular country and sector (agriculture, manufacturing, other industry and services) that depend on exports to a particular destination country. Different regressions are estimated for every sector-destination country combination. Based on the regression results obtained, we generate predictions for 2012-13, which are then at a relatively high level of disaggregation.

The dependent variable that is chosen is the annual growth rate of GSC-related jobs. To explain this growth rate, we include various regressors into the model. In order to control for the macroeconomic situation in the country for which GSC jobs are estimated and in the destination country to which exports are shipped, we first of all include the respective GDP growth rates into the regression. In addition, to take into account sector-specific economic developments, the sectoral value added growth rate is used as a regressor.

Given that GSCs cause trade flows, regressions also include the growth rate of the total export value in the country for which GSC jobs are estimated and the growth rate of the import value in the destination country. To take into account that at least some GSC-related jobs are created through inward FDI, also the inward FDI as a share of GDP forms part of the set of regressors. Finally, the inclusion of total employment growth as regressor into the regression controls for demographics as well as overall labour market developments.

Given that regressions are estimated separately for every sector-destination panel, we on the whole run 164 regressions (4 sectors, 41 destinations including rest of the world). All explanatory variables tend to be highly significant. However, even though the coefficients for inward FDI, exports and imports carry the expected positive sign, coefficients cannot necessarily be interpreted causally and also the sign of the coefficient may not necessarily be indicative for the true relation. This is due to the partially high multi-collinearity between the regressors, which at least in some instances occurs by construction, given that, for example, export growth or sectoral value added growth feed into GDP growth. However, multi-collinearity does not undermine the quality of projections in a projection model, so that we use this model to predict the number of GSC-related jobs for two years into the future.

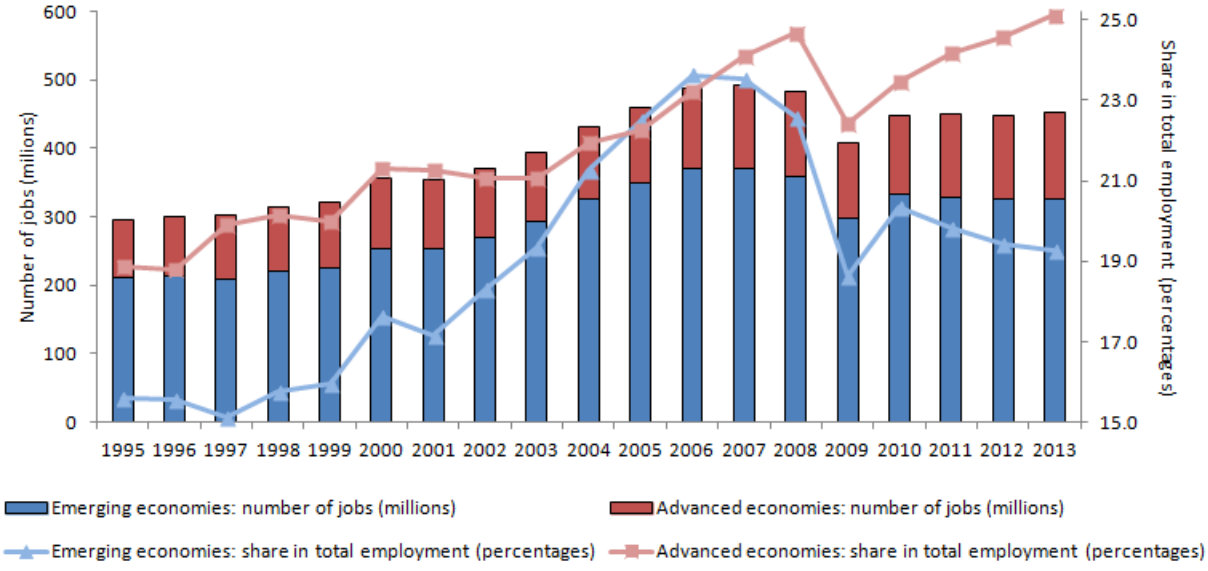
3 How many workers are in jobs related to global supply chains?

Based on the methodology described above, it is estimated that the number of GSC-related jobs has increased rapidly over the past decades, both in absolute terms and as a share of total jobs.

As reported in ILO (2015), 453 million people were employed in GSCs in 2013, compared with 296 million in 1995, in the 40 countries for which estimates are available (Figure 1).[4] Emerging economies drive most of the overall increase in GSC-related jobs, contributed with an estimated 116 million more jobs as of 1995. Overall, GSC-related jobs represent 20.6 per cent of total employment among the countries analysed, compared with 16.4 per cent in 1995.

Much of this increase in the number of GSC-related jobs took place before the crisis, with GSCs rapidly expanded during the 1990s and early 2000s, while their expansions slowed during the late 2000s. The recent slowdown is driven by emerging economies, in particular China. GSC-related jobs in emerging economies that form part of the sample increased by 160 million in 1995-2007, and then decreased by 44 million in 2008-2013. The latter decrease suggests that there is some evidence for previously outsourced or offshored activities being brought back to the country of origin of the lead enterprise, a so-called "back-shoring" or "re-shoring" of production (Constantinescu et al., 2015; Buono and Vergara Caffarelli, 2013). The stagnant expectations for trade growth in the coming years suggest that the number of GSC-related jobs is not likely to rebound in the near future.

Figure 1: Number and share of jobs associated with GSCs, 1995-2013



Notes: This chart shows, on the left-hand scale, the number of GSC-related jobs and, on the right-hand scale, the share of GSC-related jobs in total employment.
Source: ILO (2015), Figure 5.2.

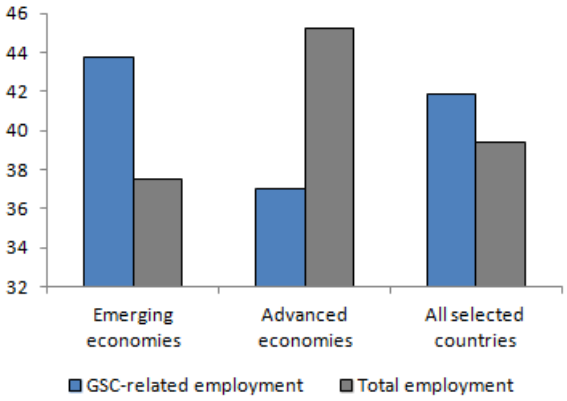
[4] If only those jobs linked to the exports of intermediates were considered, and jobs linked to the exports of final goods were excluded from the estimate, the number of GSC-related jobs would be just above 250 million. Based on the methodology of Timmer et al. (2014), that includes all workers who form part of the domestic and international value chain producing global manufacturing output, we compute 855 million workers worldwide forming part of the global supply chain in 2008.

In 2013, almost 190 million women were in GSC-related jobs in the 40 countries for which estimates are available. The share of women in total GSC-employment has broadly remained constant, corresponding to 41.9 per cent in 2013 compared with 41.6 per cent in 2000 (Figure 2). This share is 2.5 percentage points higher than the share of women in total employment in 2013. Hence, the rise of GSCs appears to help mitigating persistent differences in employment trends across sexes.

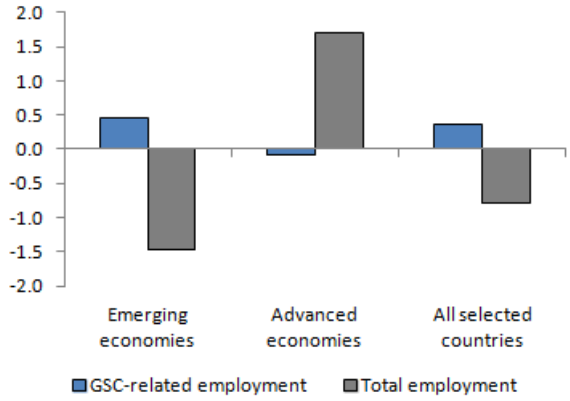
As documented in ILO (2015), emerging economies have a share of women in GSC-related employment that is higher than the female share in total employment and it has been increasing over the past decade, broadling reflecting the global pattern. In advanced economies, women accounted for a significantly lower share in GSC-related jobs than in total employment throughout the 2000-13 period. This share has broadly remained unchanged, while women's share in total employment actually increased between 2000 and 2013. One reason for the stagnant gains in the share of women in GSC-related jobs in advanced economies is the retrenchment in female manufacturing jobs over this period.

Figure 2: Share of women employed in GSCs and in the total economy

a. Share (per cent, 2013)



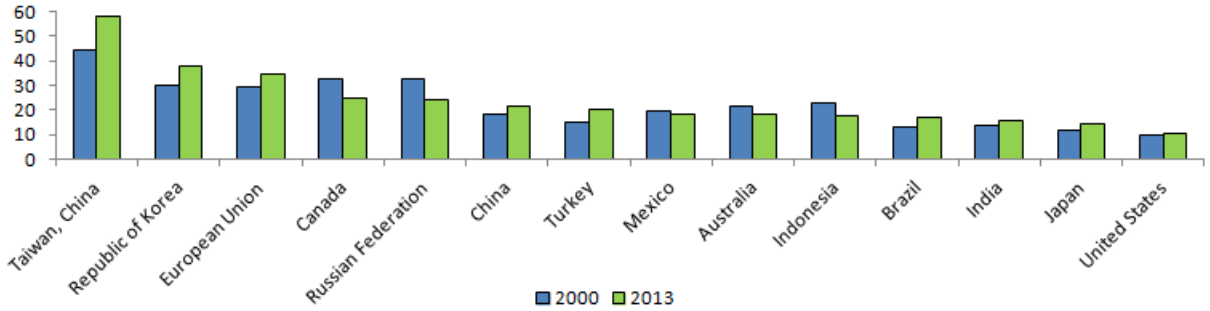
b. Change in the share (percentage points), 2000-13



Note: Panel a (b) shows the share (changes in the share) of female employment for jobs that are dependent on foreign demand (blue column) and in general (gray column). Source: ILO (2015), Figure 5.4 for panel a.

When looking at cross-country patterns of GSC-related jobs, the largest shares of GSC-related jobs in total employment among the 40 countries included into the estimates are observed in Taiwan (China), where 57.7% of the workers are employed in GSC-related jobs, and the Republic of Korea, and the European Union where respectively 37.8% and 34.6% of all workers are in GSC related jobs (Figure 3), as noted in ILO (2015).

Figure 3: Share of jobs associated with GSCs by country (%), selected years

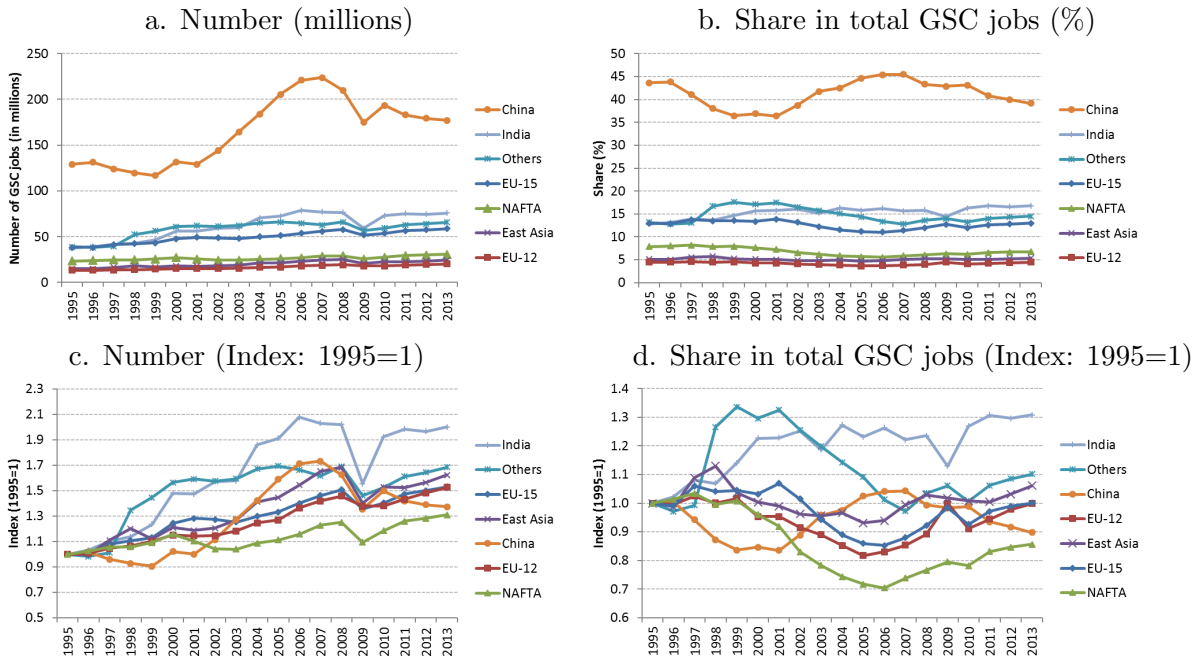


Notes: This chart shows the share of GSC-related jobs in total employment by country.

The least foreign-demand dependent labour markets are in Japan and the United States, where respectively 14.7 and 10.7 per cent of workers are in GSC-related jobs. This is partly owing to the large internal market and domestic oriented supply chains, but also because outsourcing or offshoring to high-cost locations such as the United States and Japan is likely to be less profitable for foreign firms than to other locations, at least across a wide range of sectors (Jackson, 2013).

Most countries including the largest emerging economies, China and India, have seen an increase in the share of GSC-related jobs over the last decade. It is only Canada, the Russian Federation, Mexico, Indonesia and Australia that have seen a decrease in the share of GSC-related jobs in total employment in 2000-13.

Figure 4: GSC-related jobs located in different groups of countries in which jobs are located, 1995-2013

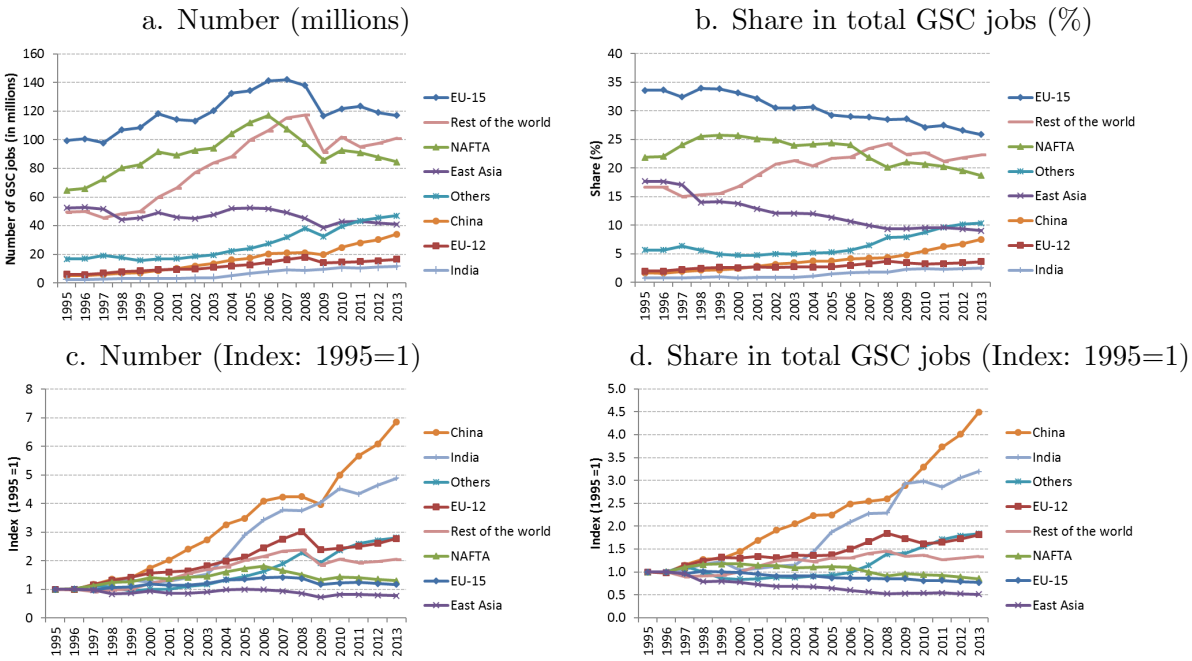


Notes: This chart shows the number (panels a and c) and the share of GSC-related jobs in total GSC employment for different country groups in which these jobs are located (panels b and d). The chart shows both the actual numbers (panels a and b) and numbers indexed to 1 in 1995 (panels c and d). *Others* refers to economies not included into the other aggregates and is composed of Brazil, Russia, Indonesia, Australia and Turkey. *EU-12* refers to the 12 countries that became EU member in 2004 and 2007. *East Asia* includes Japan, Taiwan (China) and the Republic of Korea.

Figure 4 shows trends in GSC-related jobs by country or country group, both in terms of absolute numbers and the share of each country group as a percentage of total GSC-related jobs in the 40 sample countries. In 2013, the total estimated number of GSC-related jobs in the sample countries stood at 453 million, of which China hosted 177 million jobs, accounting for as much as 39.2 per cent of all GSC-related jobs. Second largest location was India, where GSC-related jobs were estimated to be at 76 million, or 16.8 per cent of the total GSC-related jobs (Figure 4, panels a and b).

As can be seen in the large number of GSC-related jobs that China hosts, it is likely that China will continue to be the location with most GSC-related jobs in the years ahead. However, it is worth noting that China's share in the total GSC-related jobs has recently stopped expanding while India's share gradually increases over time (Figure 4, panels c and d). The increase in GSC-related employment has been the weakest for the NAFTA countries United States, Canada and Mexico. This country group has seen an increase in the number of GSC-related jobs by only around 30% in 1995-2013, which is smaller than the increase observed for other country groups.

Figure 5: GSC-related jobs supported by different groups of export destination countries, 1995-2013



Notes: This chart shows the number (panels a and c) and the share of GSC-related jobs in total GSC employment for different export destination country groups that these jobs depend on (panels b and d). The chart shows both the actual numbers (panels a and b) and numbers indexed to 1 in 1995 (panels c and d). *Other* refers to economies not included into the other aggregates and is composed of Brazil, Russia, Indonesia, Australia and Turkey. *EU-12* refers to the 12 countries that became EU member in 2004 and 2007. *East Asia* includes Japan, Taiwan (China) and the Republic of Korea.

GSC-related jobs are defined as jobs dependent on global exports to a particular export destination. Hence the number of GSC-related jobs can also be disaggregated by export destination. Global exports to some countries or country groups create more jobs than global exports to others. In terms of the export destinations that support GSC-related job creation, Figure 5 reveals that EU-15 and NAFTA are the two most important country groups. Exports to and among these countries create the largest number of GSC-related jobs. In 2013, exports to and among EU-15 countries supported 117 million GSC-related jobs, while exports to and among NAFTA countries supported 85 million jobs.

However, recent trends show that the relative importance of exports to and among EU-15 and NAFTA countries in terms of GSC-related job creation has been declining. In 1995, exports to EU-15 and NAFTA supported 33.6 and 21.9% of all GSC-related jobs, respectively. In 1995-2013, however, the share of EU-15 countries as export destination in total GSC employment declined by 7.8 percentage points down to 25.8%. Similarly, the importance of NAFTA countries as export destinations has declined by 3.2 percentage points down to 18.7%.

In contrast, countries like China and India, as well as countries outside the sample of 40 countries (Rest of the World), are emerging as significant export destinations. The fastest growing number of GSC-related jobs are associated with China as export destination. By 2013, the number of jobs related to global exports to China has increased almost seven-fold when compared with 1995.

Table 2 shows for 1995, 2008 and 2013 the global export destinations that create the majority of GSC-related jobs in each of the countries that form part of our sample of 40 countries. The table documents that the export destination that creates the highest number of GSC-related jobs did not change for any country between 1995 and 2008. Between 2008 and 2013, in contrast, we observe changes for almost half of the countries in our sample.

One major trend that can be observed is the gaining prominence of China as export destination that creates most GSC-related jobs in a country. In 2013, China has become most important for Japan, the Republic of Korea, Taiwan (China), Brazil, the Russian Federation, Indonesia, Australia, the United States, Germany, Finland and Sweden. This is a change when compared with 1995 and 2008. In these two earlier years, the export destinations that created most of the GSC-related jobs were the United States for Brazil, Japan, the Republic of Korea, Taiwan (China) and Sweden. It was Germany for the Russian Federation and Finland, it was Japan for Indonesia and Australia, it was France for Germany and it was Canada for the United States. Hence, Chinese import demand has particularly driven the creation of new GSC-related jobs in these countries.

Another finding from Table 2 is that, in 32 out of the 40 countries, only three countries, Germany, China and the United States, are the most important export destinations to create GSC-related jobs. Indeed, the United States and China account for a large share of global final and intermediate demand for goods and services. Germany on the other hand is highly integrated in European supply chains. Hence, it is the most important driver of GSC jobs for around half of the EU countries and Turkey. Mexico and Canada feature by far the most concentrated GSC job dependency, with around half of all GSC-related jobs relying on global exports to the United States. On the other end, countries such as Greece, Latvia or Germany have a relatively low GSC job dependency on a single country.

Table 2: Number of GSC-related jobs by country (total and for most important destination country in terms of jobs), Selected years

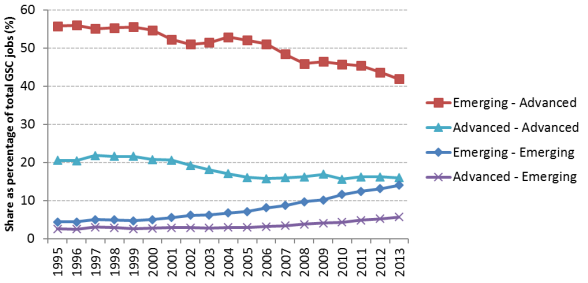
Years		1995				2008				2013			
Country Groups	Location country	Total number of GSC jobs (000s)	Most important export GSC jobs destination	Number of GSC jobs related to most important destination (000s)	Share of GSC jobs related to most important destination (%)	Total number of GSC jobs (000s)	Most important GSC jobs destination	Number of GSC jobs related to most important destination (000s)	Share of jobs in GSCs related to most important destination (%)	Total number of GSC jobs (000s)	Most important export GSC jobs destination	Number of GSC jobs related to most important destination (000s)	Share of GSC jobs related to most important destination (%)
EU-15	AUT	1,049	DEU	251	23.9	1,975	DEU	251	12.7	1,971	DEU	378	19.2
	BEL	1,844	DEU	330	17.9	2,362	DEU	330	14.0	2,312	DEU	281	12.2
	DEU	8,822	FRA	794	9.0	16,430	FRA	794	4.8	16,294	CHN	1,493	8.9
	DNK	818	DEU	137	16.8	1,122	DEU	137	12.3	998	DEU	111	11.2
	ESP	2,317	FRA	361	15.6	4,500	FRA	361	8.0	4,502	FRA	538	11.9
	FIN	678	DEU	76	11.2	987	DEU	76	7.7	937	CHN	119	12.7
	FRA	5,101	DEU	742	14.5	6,261	DEU	742	11.9	6,115	DEU	734	12.0
	GBR	6,291	USA	904	14.4	8,023	USA	904	11.3	8,738	USA	910	10.4
	GRC	375	DEU	58	15.5	610	DEU	58	9.5	604	USA	37	6.1
	IRL	590	GBR	139	23.5	1,056	GBR	139	13.1	1,059	USA	138	13.0
	ITA	5,047	DEU	819	16.2	6,933	DEU	819	11.8	7,209	DEU	829	11.5
	LUX	132	FRA	20	15.4	269	FRA	20	7.6	299	DEU	27	9.1
	NLD	2,924	DEU	511	17.5	3,998	DEU	511	12.8	4,231	DEU	617	14.6
	PRT	1,021	DEU	186	18.3	1,425	DEU	186	13.1	1,225	ESP	226	18.4
	SWE	1,363	USA	153	11.2	1,924	USA	153	7.9	1,827	CHN	154	8.4
EU-12	BGR	1,089	DEU	114	10.5	1,735	DEU	114	6.6	1,596	TUR	194	12.2
	CYP	65	GBR	11	16.4	86	GBR	11	12.3	84	GRC	7	8.1
	CZE	2,254	DEU	655	29.1	3,076	DEU	655	21.3	3,255	DEU	698	21.4
	EST	333	FIN	54	16.3	329	FIN	54	16.5	317	FIN	43	13.5
	HUN	1,336	DEU	287	21.5	2,145	DEU	287	13.4	2,478	DEU	372	15.0
	LTU	550	RUS	94	17.1	598	RUS	94	15.7	589	RUS	62	10.6
	LVA	357	RUS	47	13.0	415	RUS	47	11.2	315	LTU	25	7.8
	MLT	53	ITA	9	17.1	86	ITA	9	10.6	91	GBR	11	11.6
	POL	3,684	DEU	1,234	33.5	6,025	DEU	1,234	20.5	6,317	DEU	1,225	19.4
	ROM	2,188	DEU	366	16.7	2,974	DEU	366	12.3	3,390	DEU	358	10.6
	SVK	923	DEU	201	21.8	1,312	DEU	201	15.3	1,324	DEU	214	16.2
	SVN	394	DEU	111	28.1	505	DEU	111	21.9	440	DEU	74	16.8
NAFTA	USA	13,513	CAN	1,596	11.8	15,924	CAN	1,596	10.0	16,077	CHN	1,918	11.9
	CAN	3,852	USA	2,155	55.9	4,540	USA	2,155	47.5	4,406	USA	2,073	47.0
	MEX	6,035	USA	3,529	58.5	8,824	USA	3,529	40.0	10,153	USA	5,279	52.0
China	CHN	129,130	USA	26,752	20.7	209,965	USA	26,752	12.7	177,278	USA	28,751	16.2
India	IND	37,920	USA	8,923	23.5	76,636	USA	8,923	11.6	75,890	USA	15,692	20.7
East Asia	JPN	6,333	USA	1,395	22.0	11,156	USA	1,395	12.5	8,584	CHN	1,828	21.3
	KOR	5,142	USA	1,021	19.8	8,198	USA	1,021	12.4	9,462	CHN	2,113	22.3
	TWN	3,528	USA	985	27.9	5,901	USA	985	16.7	6,302	CHN	1,891	30.0
Other	BRA	8,018	USA	1,212	15.1	16,844	USA	1,212	7.2	18,610	CHN	2,764	14.9
	RUS	13,569	DEU	2,142	15.8	19,952	DEU	2,142	10.7	18,770	CHN	1,990	10.6
	IDN	13,332	JPN	3,161	23.7	22,479	JPN	3,161	14.1	21,015	CHN	2,521	12.0
	AUS	1,499	JPN	231	15.4	2,329	JPN	231	9.9	2,110	CHN	560	26.6
	TUR	2,574	DEU	700	27.2	4,382	DEU	700	16.0	5,187	DEU	685	13.2

Notes: *Other* refers to economies not included into the other aggregates and is composed of Brazil, Russia, Indonesia, Australia and Turkey. *EU-12* refers to the 12 countries that became EU member in 2004 and 2007. *East Asia* includes Japan, Taiwan (China) and the Republic of Korea.

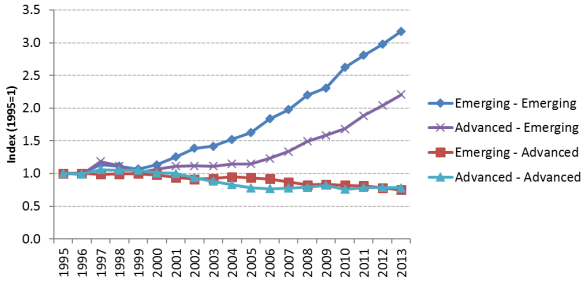
Figure 6 shows the destination linkages among emerging and advanced economies. The share of GSC-related jobs dependent on exports to and among emerging economies is expanding both in emerging and advanced economies, especially in emerging economies. On the other hand, the shares of GSC-related jobs dependent on exports to and among advanced economies are declining both in emerging and advanced economies. Thus, the results show that emerging economies are not only hosting many of the GSC-related jobs worldwide, but are also creating the demand that supports GSC-related jobs in other emerging economies.

Figure 6: GSC-related jobs linkages between emerging and advanced economies, 1995-2013

a. Share in total GSC jobs (%)



b. Share in total GSC jobs (Index: 1995=1)



Note: In each combination, the first group indicates the locations where GSC-related jobs are hosted, while the second group indicates the export destination where demand for GSC jobs is generated (e.g. "Emerging-Advanced" combination indicates the GSC-related jobs created in emerging economies due to the export to advanced economies). The groups of emerging economies and advanced economies is defined in section 2.1 of this paper.

Next, we show GSC-related jobs by broad sector, distinguishing between jobs in agriculture, non-manufacturing industry, manufacturing and services. As was also put forward in ILO (2015), employment gains in services sectors were the main factor behind the rise in the number of GSC-related jobs in the 40 countries between 2000 and 2013 (Figure 7). However, in emerging economies, manufacturing has been the predominant sector in GSC-related job creation, consistent with the strong overall employment growth in this sector. In advanced economies, the number of GSC-related jobs in agriculture and industry has remained relatively stable, despite an overall decline in the number of jobs in these sectors, leading to an increase in the share of GSC-related jobs in proportion to the total number of sectoral jobs.

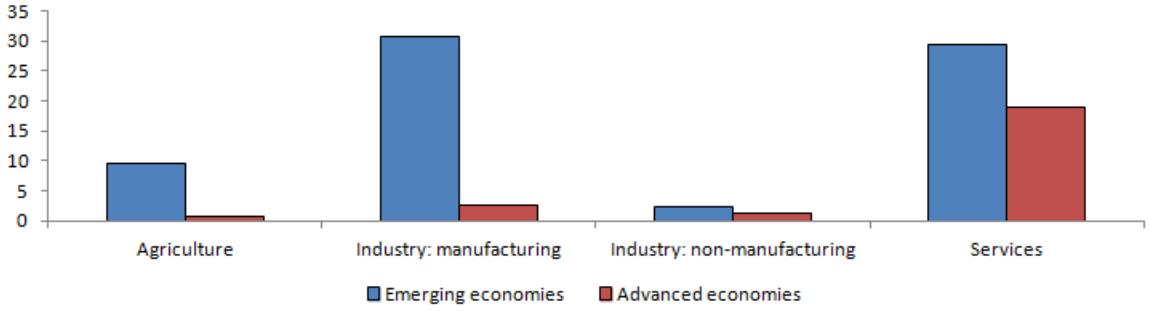
Most of the GSC-related services jobs can be found in wholesale and retail trade as well as in transport and logistics, which are intrinsically more closely linked to GSCs than other services sectors. Much of the increase in GSC-related services jobs in advanced economies is, however, also driven by the business services sector, which includes services such as consulting and IT.

The growth in GSC-related services jobs reflects the increased tradability of services, made possible by the IT revolution, which has considerably reduced transaction costs related to services, allowing

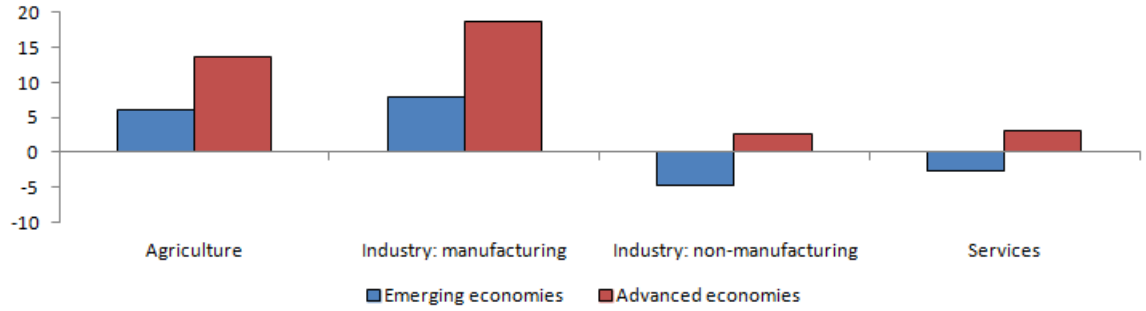
for an almost instantaneous exchange of information. As a consequence, a large range of services can be provided over almost unlimited distances, which has boosted the importance of the role that services play in GSCs. As a case in point is the so-called "servicification" of manufacturing, where manufacturing GSCs use more and more services inputs, creating jobs not only in the manufacturing sector itself, but also in services sectors. Due to the improved tradabiltiy of services, services inputs can be off-shored to lower cost locations; therefore growth of GSC-related services jobs are observed not only in advanced economies but also emerging economies. This suggests that the opportunities for the emerging economies in terms of GSC-related job creation lies in both manufacturing and services sectors.

Figure 7: Change in the number and share of GSC-related jobs by sector, 2000-13

a. Change in the number of GSC-related jobs (millions)



b. Change in the share of GSC-related jobs in total jobs by sector (percentage points)

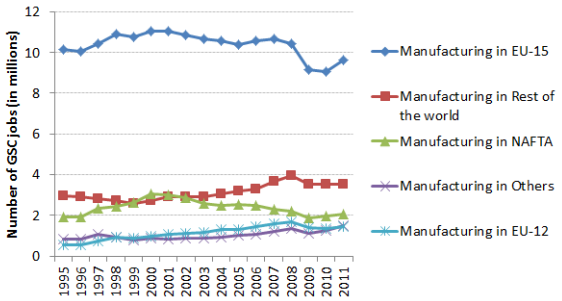


Note: Panel a (b) shows the change in the number (share) of GSC-related employment in total employment by broad sector for emerging economies (blue column) and advanced economies (red column). Source: ILO (2015), Figure 5.5 for panel b.

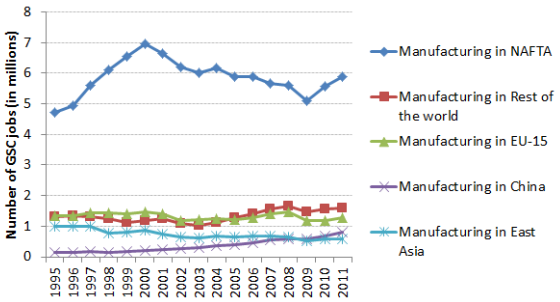
Figure 8 illustrates the five most important export destinations (in terms of country and broad sector) that sustain GSC-related manufacturing jobs for each country where these jobs are located. The figure shows that most of the GSC-related manufacturing jobs in EU-15 are created through manufacturing exports to and among EU-15 countries (panel a). Also for the new EU member states (EU-12), manufacturing exports to and among EU-15 countries create most of the GSC-related jobs (panel f), illustrating the the high degree of integration of economies within the EU.

Figure 8: Number of GSC-related manufacturing jobs created in different locations, by export destination country-sector that sustains these jobs (millions), 1995-2011

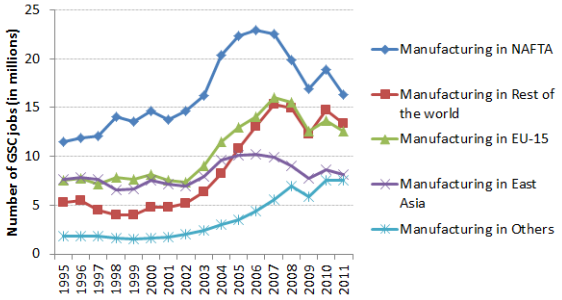
a. EU-15 as jobs location



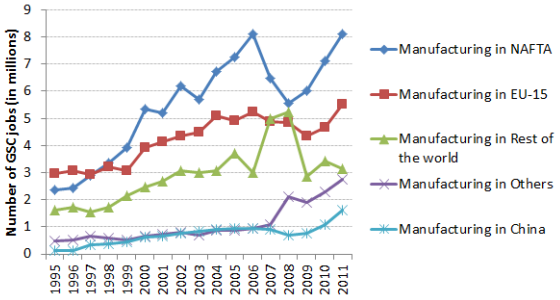
b. NAFTA as jobs location



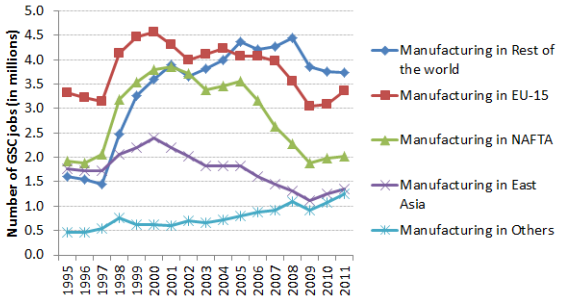
c. China as jobs location



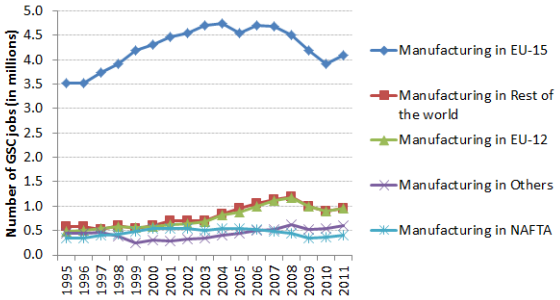
d. India as jobs location



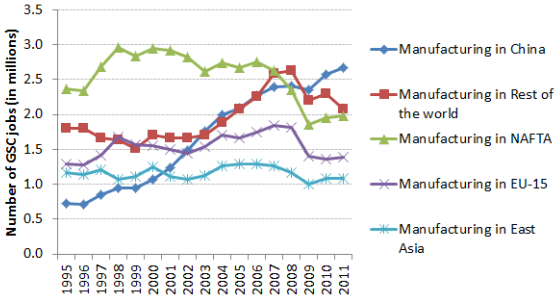
e. Others as jobs location



f. EU-12 as jobs location



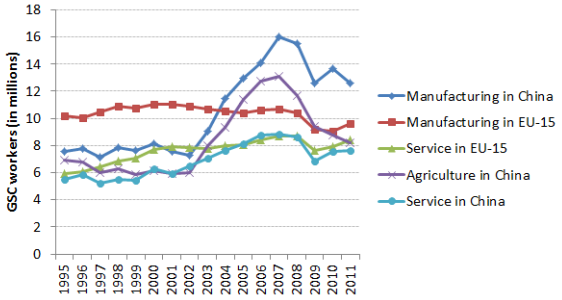
g. East Asia as jobs location



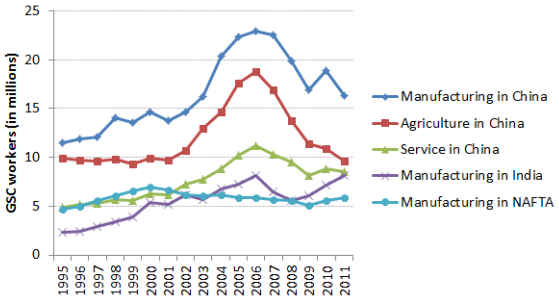
Notes: *Other* refers to economies not included into the other aggregates and is composed of Brazil, Russia, Indonesia, Australia and Turkey. *EU-12* refers to the 12 countries that became EU member in 2004 and 2007. *East Asia* includes Japan, Taiwan (China) and the Republic of Korea.

Figure 9: Number of GSC-related jobs supported by exports demanded by the manufacturing sector of different destinations, by country-sector where jobs are located (millions), 1995-2011

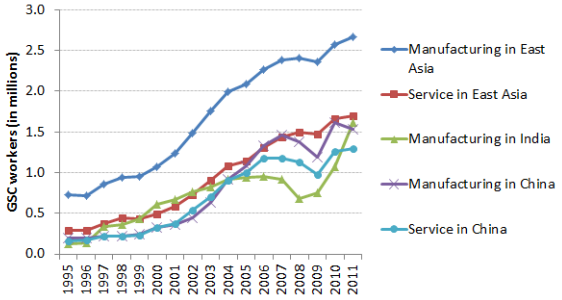
a. EU-15 as export destination



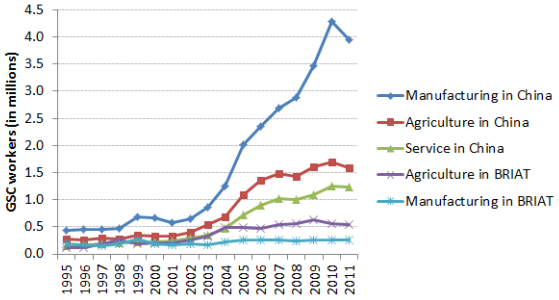
b. NAFTA as export destination



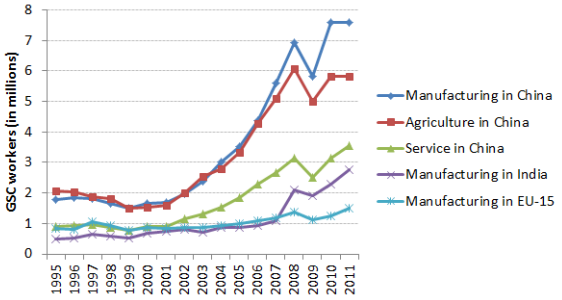
c. China as export destination



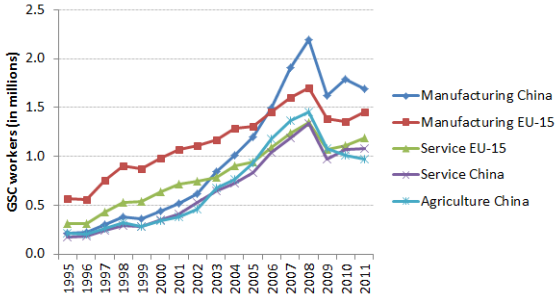
d. India as export destination



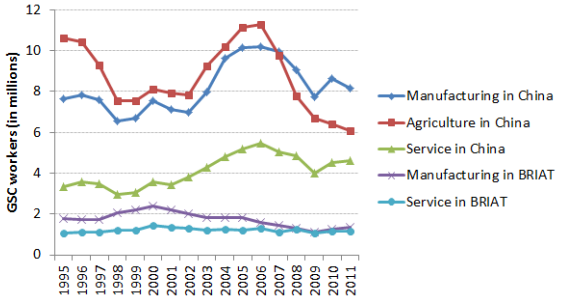
e. Others as export destination



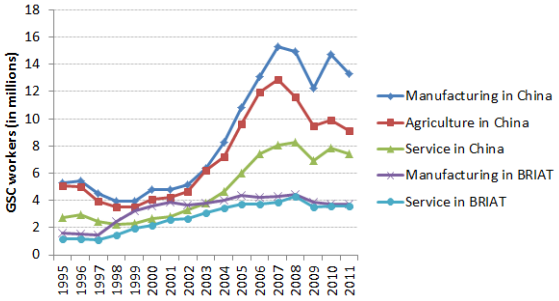
f. EU-12 as export destination



g. East Asia as export destination



h. Rest of the World as export destination



Notes: *Other* refers to economies not included into the other aggregates and is composed of Brazil, Russia, Indonesia, Australia and Turkey. *EU-12* refers to the 12 countries that became EU member in 2004 and 2007. *East Asia* includes Japan, Taiwan (China) and the Republic of Korea.

The figure also shows that it is exports to and among NAFTA countries, that create the majority of GSC-related jobs in NAFTA itself, but also in China and India (panels b, c and d). Manufacturing exports to China are the most significant job generator in East Asia (panel g), highlighting the importance of China as outsourcing or offshoring location for firms from this region.

Figure 9 shows the five most important jobs locations in terms of the number of GSC-related jobs by country and broad sector, sustained by exports demanded by the manufacturing sector of different export destinations. It illustrates the important role that manufacturing GSCs worldwide have to sustain jobs in the Chinese manufacturing sector. Demand created by the manufacturing sector also supports a high number of services jobs in GSCs worldwide, in particular in EU-15, China and East Asia. This can be interpreted as some evidence for the labour market impact of the "servicification" of manufacturing, discussed earlier.[5]

4 Forward global supply chain participation and the wage share: a sectoral analysis

Trade theory would suggest that the global division of labour through GSCs is economically beneficial for advanced and developing economies. As Baldwin (2013) puts it, GSCs have "revolutionized development options facing poor nations", giving them the possibility of benefiting from gains generated through supply chains. Indeed, participation in GSCs can provide significant economic benefits to both lead and supplier firms and, indeed, results from a vast body of trade literature that uses firm-level data suggest that these economic benefits seem to materialize in many cases. The question arises whether at least some of these economic benefits at the same time translate into benefits for the production factor labour.

In this section, we focus on the relationship between forward GSC participation and the wage share. In a sectoral analysis, we analyze whether a higher level of sectoral participation in GSCs translates into a higher wage share. Forward participation takes the suppliers' perspective and is measured by the share of exported goods and services in a particular sector and country, which are used as imported inputs to produce other countries' exports.

The use of this measure has several advantages. While it is relatively restrictive in terms of the types of GSC participation that it covers, given that it only refers to exported goods and services that end up being exported further, it has the advantage to include the value added dimension. Hence if a sector moves towards higher-value-added activities in GSCs, this will be reflected in an increase of this measure. Such an increase in the value added content of GSC activities in contrast

[5]Figures 8 and 9 do not include 2012 and 2013 figures, given that the GSC jobs projection model described in section 2.3 does not estimate GSC jobs by export destination sector.

does not necessarily come along with a larger share of GSC-related jobs in total employment, which some could consider as an alternative measure of forward GSC participation. However, especially in the context of an analysis of how gains generated by GSC participation are distributed, we would like to take into account this additional dimension.

When interpreting results, one should note that a sectoral analysis cannot pin down which firms and mechanisms are driving the results. For example, it could be that firms adjust wages, once they start to participate in GSCs. It could also be that firms that already participate in GSCs, but then increase their participation, adjust wages. Third, it could be those firms that do not participate in GSCs that adjust wages. Finally, there could be a composition effect, so that firms entering and exiting GSCs, or even firms entering and exiting the market have an impact on the relation that is empirically observed at the sectoral level. However, a sectoral analysis allows an assessment of whether stronger GSC participation of a sector as a whole can, on average, be related to a higher wage share. While studies using firm-level data typically focus on a particular country, a cross-country-sector framework is able to provide a broader perspective and assesses average relationships across countries and sectors.

4.1 Data

In order to assess the impact of GSC participation on the wage share at the sectoral level, we require sectoral data on GSC participation as well as sectoral data on wages and value added. The OECD Global Value Chain Indicators database provides information on the degree of forward participation in GSCs, calculated on the basis of the model that also underlies the OECD-WTO Trade in Value Added (TiVA) database. The database covers 58 countries and distinguishes between 18 different sectors, where data are available for the years 1995, 2000, 2005, 2008 and 2009.

The wage share is calculated from two alternative databases, the World Input-Output Database (WIOD) and the UNIDO INDSTAT database, which contain both information on labour compensation and value added, where the wage share is calculated as the ratio of the two. While WIOD includes data for 40 countries, INDSTAT has a wider country coverage, so that the wage share can be calculated for 63 countries. With regards to the number of sectors, WIOD has data on 35 sectors that cover the three broad sectors, agriculture, industry and services. In contrast, INDSTAT only has information on industrial sectors and covers 23 sectors. The time period covered by WIOD is 1995-2011, while INDSTAT as a longer time coverage, encompassing the years of 1963-2011. However, while an almost balanced panel database on wage shares can be derived from WIOD, the database on wage shares from INDSTAT is strongly unbalanced.

The data on GSC participation and the wage share are matched, ensuring before matching that the definition of sectors coincides between the respective databases. The coverage is determined by the overlap in coverage between the respective data sources and the need to in some instances

aggregate data across different sectors. We end up with a matched database with data for the five years 1995, 2000, 2005, 2008 and 2009, which has a coverage of 40 countries and 18 sectors, when WIOD is used as data source for the wage share. The coverage is 35 countries and 9 sectors with INDSTAT as the data source.

4.2 Methodology

In order to determine the relation between forward GSC participation and the wage share, the following equation is estimated with OLS panel fixed effect regression techniques:

$$WS_{ict} = \alpha + \beta GSC\_PART_{ict} + \gamma\epsilon_{it} + \delta\epsilon_{ct} + \epsilon_{ic} + \epsilon_{ict} \tag{3}$$

where WS stands for the wage share. GSC_PART is a measure of forward GSC participation. For forward participation, the share of exported goods and services used as imported inputs to produce other countries' exports is used.

ϵ_{it}, ϵ_{ct}, ϵ_{ic} and ϵ_{ict} respectively stand for sector-time, country-time and country-sector fixed effects, and the idiosyncratic error term. i is a sector index, c is a country index and t is a year index. Standard errors reported in the following subsection are clustered at the country-sector level.

4.3 Results

Table 3 shows significantly negative impacts of forward GSC participation on the wage share for advanced economies (columns 3 and 4) and, at least to some extent, also for developing economies (column 5). The impact in advanced economies is estimated to be quantitatively larger than the impact in developing economies. Also the overall impact is found to be significant, regardless of which data sources are used to calculate the wage share (columns 1 and 2).

These results are in line with earlier country-level research on the impact of globalization on the wage share (Harrison, 2005; Jayadev, 2007; Rodrik, 1998; Stockhammer, 2013). Given the ongoing public interest and policy debates over the trend declines in labour shares and the impact of such declines on aggregate demand and inequality, the role of GSC participation requires further attention.

Table 3: Estimated impact of GSC forward participation on the wage share

Dependent variable: wage share	(1) All countries WIOD	(2) All countries INDSTAT	(3) Developed economies WIOD	(4) Developed economies INDSTAT	(5) Emerging/ developing economies WIOD	(6) Emerging/ developing economies INDSTAT
GSC forward participation	-0.023*** (0.006)	-0.026*** (0.007)	-0.031*** (0.008)	-0.027*** (0.008)	-0.010* (0.005)	-0.018 (0.015)
Sector-time FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-time FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Within R2	0.20	0.37	0.21	0.37	0.37	0.75
# country-sectors	717	283	594	239	123	44
# observations	3585	940	2970	833	615	107

Note: ***, ** and * indicate significance at the 1-, 5- and 10-per-cent level. Clustered standard errors are in brackets.

Further analysis published in ILO (2015) shows that the decrease in the wage share is largely driven by impacts on average labour productivity that differ from impacts on average wages. While there is a positive and significant impact of GSC forward participation on productivity, at least in advanced economies, no such impact is found on the average wage. As a result of the positive impact of GSC participation on labour productivity and the absence thereof on wages, workers receive a smaller share of the value added that a sector generates.

As pointed out in ILO (2015), these results are in line with the available firm-level evidence that does not tend to find any strong evidence of an impact of increased GSC participation on wages (Heyman et al., 2007; Almeida, 2007). Indeed, it is quite challenging to examine the causal effect of GSC participation on wages (Javorcik, 2014). For example, even though many studies find that foreign affiliates of multinational enterprises pay higher average wages than domestic firms (Aitken et al., 1996; Budd et al., 2005; Lipsey and Sjöholm, 2004; Robertson et al., 2009; Warren and Robertson, 2011), this is not necessarily caused by GSC participation. There is self-selection into GSC participation of those firms that are more productive and pay higher wages already before engaging in GSCs.

5 Conclusion

This paper describes the methodology that we used to produce estimates of the number of jobs in global supply chains (GSCs), recently published in the ILO's *World Employment and Social Outlook* report (ILO, 2015). The paper shows the resulting estimates in some more detail and also examines the impact of a sector's participation in GSCs as supplier on the wage share.

International input-output databases in combination with sectoral employment data provide the opportunity to compute internationally comparable and consistent estimates of GSC-related jobs. The estimates of the number of GSC-related jobs that we produce are based on data from the World Input-Output Database (WIOD). According to our estimation methodology, GSC-related jobs are those jobs that are dependent on global exports of intermediate and final goods and services to a particular destination country. While acknowledging that the resulting jobs estimate is likely to be an upper bound of the true number of GSC-related jobs, our measure includes all workers in GSC-related activities, including those working on the final assembly of products.

This paper also describes how we extend the GSC-related jobs measure in two dimensions beyond what is directly computable from the WIOD database. First, women's GSC participation is computed using data on female employment by sector. Second, this paper describes the methodology that is used to project GSC-related jobs for two years ahead, beyond the coverage of the WIOD database.

As described in ILO (2015), 453 million jobs were related to GSCs in the 40 countries that form part of the sample in 2013, an increase from 296 million jobs in 1995. GSC-related job numbers increased strongly towards the crisis, but have stagnated since then, in particularly driven by a recent decline in the number of GSC-related jobs in emerging economies. Women's share in GSC jobs is larger than in the overall economy, driven mainly by emerging economies. Moreover, the estimated GSC job numbers show a strong expansion of GSC-related jobs in the services sector in both advanced and emerging economies.

In this paper, we show that the recent decline in the number of GSC-related jobs in emerging economies is mainly driven by China, even though GSCs worldwide still play a very important role in sustaining Chinese jobs. Exports to and among EU-15 countries sustain the majority of GSC-related jobs in our sample of 40 countries. However, some of the advanced economies have recently lost importance. In contrast, the number of jobs that are sustained by exports to and among emerging economies, in particular China, is increasing. In terms of numbers, most of the GSC-related jobs in the 40 countries that form part of the sample are located in emerging economies and depend on exports to and among advanced economies.

In addition to describing estimates of GSC-related jobs, this paper conducts a sectoral regression analysis that aims at determining the impact of a sector's GSC participation as supplier on the wage

share. Results point to a negative impact, in particular driven be advanced economies, suggesting that the production factor labour does not necessarily always benefit from acting as a supplier to GSCs. The underlying reasons and the channels driving these results remain to be analyzed in more detail.

There are current efforts by international institutions to produce input-output tables with an even larger country coverage than the one offered by the World Input-Output Database. On the basis of these new data becoming available, future research aims at expanding the coverage of estimates of GSC-related jobs to a larger set of countries and engaging in further methodological improvements in order to come closer to an adequate global estimate of jobs related to GSCs.

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