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Global value chains and labour markets - Wages, employment or both: Input-output approach

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GDAŃSK UNIVERSITY OF TECHNOLOGY
FACULTY OF MANAGEMENT AND ECONOMICS

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Abstract

This article examines the overall effect of global value chains (GVCs) on labour market outcomes, namely wages and labour demand. The analysis exploits the World Input-Output Database (WIOD, 2016 release) covering 43 countries and 54 sectors from 2000 to 2014. GVC involvement is measured by the recently developed GVC participation indexes (based on both backward and forward linkages) and relative GVC position (Wang et al., 2017a, 2017b). The estimates employ the three-least-squares method. The results indicate that GVC position is negatively correlated both with wages and with employment, while the effect of GVC participation as such depends on whether backward or forward linkages are considered. We find some heterogeneity between countries (middle- versus high-income) and sectors (manufacturing versus services). Importantly, the labour market effect of involvement in GVCs is different from the channel of traditional trade in which the production process does not cross national borders. The R codes for calculation of input-output measures of GVC are provided.

JEL: F14, F16, J31, J21

Keywords: global value chains, input-output, employment, wages

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1. Introduction

The nexus between global value chains (GVCs)¹ – understood as involvement in international production fragmentation – and labour market outcomes is an intensely debated theme (see, among others, World Bank Group et al., 2017; World Bank and World Trade Organization, 2019; Jiang, 2015; Farole et al., 2018), but the various studies look at the phenomenon from different angles, since there is no single, consensus theory of GVCs.² Much of the early work on international production fragmentation was framed in models of offshoring (Feenstra and Hanson, 1996), which are the natural predecessors of GVCs. Grossman and Rossi-Hansberg (2008) use a trade-in-task model to conceptualize the impact of production relocation on the wages of domestic workers via labour-supply, relative-price and productivity effects. Shifting some production stages abroad increases labour supply from the domestic workers whose jobs were offshored, lowering wages or (especially when wages are rigid) destroying jobs. This effect may be compounded by decline in the relative prices of the goods whose production has been significantly offshored (due to falling production costs), putting additional downward pressure on wages. At the same time, though, the average productivity of domestic workers should increase (as the tasks offshored are the less productive), exerting an upward push on wages. The net result for wages depends on which of the two effects dominates. Similarly, Wright (2014) examines the effect of offshoring on employment, considering three channels: displacement, substitution and productivity. Jiang (2015) studies the employment effect of international trade in intermediate inputs not only domestically but also in partner and third countries, going beyond the direct consequences of imports (decreasing domestic employment) and exports (increasing it). A country's participation in GVCs through exports may expand employment not only at home but also in a supplier country, thanks to the import content of exports. In the same way, imports may stimulate domestic employment through their export content and, naturally, also third-country employment.

As a consequence, empirical analysis usually seeks to gauge the impact of production fragmentation on domestic workers in terms of employment, i.e. job creation or job destruction (Acemoglu et al., 2016; Harrison and McMillan, 2011; Michel and Rycx, 2011) or wages (Baumgarten et al., 2013; Ebenstein et al., 2014; Geishecker and Görg, 2013; Hummels et al., 2014; Wolszczak-Derlacz and Parteka, 2018).

1 Value chain is “the sequence of productive (i.e. value-added) activities leading to and supporting end use” (Sturgeon, 2001:11). If the value chain is divided among multiple firms and geographic locations on a global scale, we can talk about global value chains (The Global Value Chains Initiative, 2016).

2 The analytical framework for global value chains is rooted in international trade theories (especially trade in intermediates (Feenstra and Hanson, 1996; Yeats, 2001), activities of foreign direct investments (Brainard, 1997; Ethier and Markusen, 1996), production fragmentation (Arndt and Kierzkowski, 2001; Jones and Kierzkowski, 2018), globalisation second unbundling, in which Baldwin (2006) points up the role of the ICT revolution, and models of sequential production characterized in fact by complex networks rather than linear chains (Escaith, 2014).

Feenstra and Sasahara (2018) quantify the employment effects of U.S. imports and exports by global input-output analysis. They find a rise in total net labour demand due to the significant growth in service exports, outweighing the adverse impact of imports. This direct import-export channel is well described also by Autor et al. (2013), or Pierce and Schott (2016). However, these studies find an employment decline in the industries most exposed to competition from China. Antràs et al. (2017) examine the issue at firm level, finding that domestic employment may actually increase, thanks to the production expansion driven by imports, which would be one way in which the “productivity effect” works. Using the supply chain approach, Wang et al. (2018) show additional channels through which trade with China affects employment in the U.S. For instance, through the downstream channel, imports of intermediates benefit the sectors that come afterward in the value chain, even if they are not importers themselves. The mechanism here is input cost savings, implying potential employment gains in these sectors. Their overall conclusion is that both net employment and real wages gained thanks to trade with China, with heterogeneity according to workers’ educational attainment, the less educated suffering wage declines; this underscores the need to control for workers’ individual characteristics. On the other hand, Chetverikov et al. (2016) find that Chinese competition has an adverse effect on employment in the United States, and other studies, such as Ebenstein et al. (2014) and Ebenstein et al. (2017), find a negative response of U.S. wages to globalisation. Specifically, these two works, assessing occupational exposure to trade and offshoring, show that the wage decline stemmed from the reallocation of workers from higher-paid manufacturing jobs that were offshored to lower-paid sectors. The hardest hit were older workers lacking higher education and performing routine tasks. The authors also observe, however, that technological change too played a significant role in this negative wage effect. The case of the U.S. and China is definitely the most widely studied. For other countries, Foster-McGregor et al. (2016) conduct a comprehensive analysis of the impact of offshoring on labour demand in 40 countries using the WIOD and find a generally negative effect. In developing countries the deterioration affects workers with low- and medium-level education, while for the developed countries the most severe negative impact is on well-educated workers. For the period they study (1995-2009), the offshoring effect is stronger in manufacturing than in services, and stronger for broad than for narrow offshoring. Branstetter et al. (2019) perform a firm-level analysis of how Chinese import competition affects labour market outcomes in Portugal, finding an economically significant fall in employment (mostly temporary employment) at exporting firms. Jiang (2015), decomposing international trade into five components based on 1995-2009 WIOD data, observe an increase in trade-generated employment for each of the components and, in the aggregate, an expansion of employment due to trade in intermediates. For most countries more foreign than domestic jobs were created. Portella-Carbó (2016), using WIOD 2013 data for five European countries, Japan, the U.S. and China, analyses several effects of international trade on domestic employment. The conclusions, at country

level, suggest among other things that the restructuring of intermediate product value chains diminished domestic employment in most of those economies. Polgár and Wörz (2011, 2010), analysing the relationship between openness to trade and wages at industry level in 25 EU countries between 1995-2005, show that wages in Eastern Europe generally benefit from trade with the West, while trade with the East has a negative, but less significant, effect on wages in the West. Zierahn et al. (2015) find evidence of a negative wage response in manufacturing to offshoring from the EU15 to Eastern Europe and China between 2000 and 2008. Evidence of wage losses for less skilled and gains for more skilled workers due to offshoring is presented in Geishecker and Görg (2013, 2008) and Geishecker et al. (2010), for Germany, the U.K. and Denmark. A modest decline in the wages of low- and medium-skilled workers owing to offshoring is also confirmed by Wolszczak-Derlacz and Parteka (2018) in an industry-level analysis of manufacturing sectors in 40 countries between 1995 and 2009.

Recent literature has shown that not only the intensity of GVC involvement matters but also position (how far the country-sector is from the final or initial production stage). For example Hagemeyer and Tyrowicz (2017), in an analysis of Central and Eastern European countries (CEEC), confirm the importance of sectors' relative position along the value chain for employment and job creation or destruction, but also observe some heterogeneity in national responses. Shen and Silva (2018) examine the effects of value-added trade with China on labour market outcomes in the U.S., finding that the negative employment effect is greater in the sectors closer to final demand. Szymczak et al. (2019) investigate differences in the wage response to GVCs controlling for sectors' position in the value chain. For the CEE countries they study, they get a "smile curve" in wages: wages are higher in sectors closer to either end of the production chain, lower in the middle part of the chain. In consideration of this evidence, the present study employs a recently proposed measure of position within the GVC (Wang et al., 2017a).

As summarized in a detailed survey of the recent literature (Hummels et al., 2018), the previous studies can be divided into three groups, depending on whether the data are at industry, firm or worker level. Ours is in the first category, with its advantages and disadvantages (e.g. broad country coverage versus data aggregation, uniform input allocation (Wang et al., 2018) and focusing only on the demand side of the labour market, as noted in Feenstra and Sasahara (2018)).

Hummels et al. (2018) also tackle the issue of how to measure production fragmentation. Feenstra (2017) divides the measures into "first generation" statistics based on the share of imported intermediate inputs and "second generation" statistics, based on global input-output tables and export decomposition (e.g. Koopman et al., 2014; Duan et al., 2018; Pei et al., 2012).

Unlike the previous studies, the present work examines the overall effect of GVCs on labour market outcomes, considering simultaneously the potential impact both on wages and on labour demand. Our data are drawn from the World Input-Output Database (WIOD, 2016 release), which

covers 43 countries and 56 sectors from 2000 to 2014 (Timmer et al., 2015). The GVC ties are measured by the recently developed GVC participation indexes (using both backward and forward linkages) and relative GVC position (Wang et al., 2017b, 2017a). Those gauges differ from the first- and second-generation proxies for production fragmentation in being based on decomposition of production, not trade, and hence include important channels that were neglected in the earlier indexes (see Section 2). Additionally, the GVC position index is a relative measure that overcomes the limits of metrics like “upstreamness” or “downstreamness” as such, which look from one end of the chain only (distance either to final use or from initial production stage). Finally, we contribute to the literature by disentangling the effects of GVCs from those of traditional trade. The estimates adopt the three-least squares method, simultaneously modelling the effect of GVCs on wages and on employment, which are treated as endogenous variables. The analysis takes a global view: that is, the basic specifications pool all sectors and countries together (introducing the proper dummies), but extensions also examine sector and country heterogeneity, comparing high- with low-income countries, and manufacturing with service industries. Extensions include estimates for workers with different skill levels.

The rest of the paper is structured as follows. Section 2 illustrates involvement in GVCs using the measures based on backward and forward linkages, as proposed by Wang et al. (2017a, 2017b). Section 3 describes the global labour markets: employee compensation and structural changes in demand. The empirical analysis is conducted in Section 4, which models wage and labour demand regressions simultaneously, augmented by measures of GVC participation and relative position in the value chain. The analysis is followed by a number of robustness checks. Section 5 concludes.

GVC position proves to be negatively correlated both with wages and with employment, while the effect of participation depends on whether backward or forward linkages are considered. We find some heterogeneity among countries (middle- versus high-income) and sectors (manufacturing versus services). Significantly, we find that the effect of GVCs on labour market outcomes can differ radically from that of traditional trade.

2. New measures of global value chains based on input-output tables

This paper exploits the measures of GVCs presented in Wang et al. (2017a, 2017b). Since the point is to control for particular country-sector involvement in GVCs and for position in the production chain, the focus is on participation and position indices; however, the papers cited consider a much broader spectrum of characteristics of cross-country production. We adapt the methodology of Wang et al. (2017a, 2017b)³ to compute GVC characteristics using the latest release of the World Input-Output Database (2016).

³ We calculate selected measures proposed in Wang et al. (2017a, 2017b) using R codes, which are provided as supplementary materials.

To obtain new GVC measures, following Wang et al. (2017b), we start by decomposing value added (Va) and final output of goods and services (Y), applying global (B) and local (L) Leontief inverse matrices to international input-output tables (N countries, G sectors):

$$Va' = \underbrace{\hat{V}LY^D}_{V_D} + \underbrace{\hat{V}LY^F}_{V_RT} + \underbrace{\hat{V}LA^F BY}_{V_GVC} \quad (1)$$

where: Va' is a (transposed) 1xGN vector of direct value added, V is a 1xGN vector of value-added coefficients ($\hat{\cdot}$ denotes diagonalisation), Y^D and Y^F are GNx1 vectors of final production for domestic and foreign consumption and A^F is the GNxGN matrix of imported input coefficients.⁴ The forward-linkage-based decomposition of Va is from the perspective of producers. Value added is decomposed into: domestically produced and consumed Va, (denoted as V_D); production of Va embodied in final product exports (V_RT); and a last term, denoted as V_GVC. Value added embodied in final product exports (V_RT) corresponds to traditional, “Ricardian” trade in which production does not cross borders. For our purposes, the V_GVC component is most interesting; this is Va production embodied in exports of intermediate goods and services where domestic value added contributes to foreign production. Further, V_GVC might be divided into simple international production sharing, where intermediates are used by direct importers, and complex sharing, where they are either absorbed indirectly by the importing country, re-exported to third countries, or eventually returned to the home country. Similarly, final production of goods and services is decomposed:

$$Y' = \underbrace{VLY^D}_{Y_D} + \underbrace{VLY^F}_{Y_RT} + \underbrace{VLA^F B\hat{Y}}_{Y_GVC} \quad (2)$$

Y is split into pure domestic production consumed in the domestic market (Y_D), domestic production embodied in exports of final products (Y_RT), and domestic and foreign value added in intermediate imports used in final goods production or consumed directly by the source country (Y_GVC). In this backward linkage, what matters is the source of the value added. Having decomposed both downstream value added and upstream final production, Wang et al. (2017b) determine GVC participation indices, based on forward (GVC_part_f) or backward (GVC_part_b) industrial linkages, expressed by the formulas:

$$GVC_part_f = \frac{V_GVC}{Va'} , \quad GVC_part_b = \frac{Y_GVC}{Y'} \quad (3)$$

On this basis one can answer two distinct questions: “What percentage of production factors employed in a country-sector pair has been involved in cross country production sharing activities?” – corresponding to the forward-linkage-based index; and “What percentage of final products produced by a country-sector that comes from GVC activities?” (Wang et al., 2017b:13) – corresponding to the backward-linkage-based index. As the authors argue, these indices describe GVC participation more completely than such gauges as vertical specialisation (VS, VS1), found in previous works (Hummels et al., 2001; Koopman et al., 2014). Unlike those gauges, they do not overlook such significant channels of

⁴ For more detailed explanation of the methodology and formulas see Wang et al. (2017a, 2017b).

country-sector involvement in GVCs as exports of domestic value added embodied in intermediate exports used by the destination country to produce its domestically consumed final products, or foreign value added used for products consumed domestically. The GVC participation indices focus not only on trade but on production, including the involvement of domestic factors in the GVC activities of a particular industry, not considered previously. Wang et al. (2017b) show that the previous measures may overestimate actual participation value for sectors with small values of direct exports. Hence, the new approach is a more accurate instrument than those earlier measures, as it corrects for this bias. It allows focusing precisely on GVC activity as defined in the System of National Accounts standard (SNA), meaning that the production process itself involves border crossing. The separate methods of calculation – from the perspective of users and producers – help to determine the nature of a sector's participation in production fragmentation, i.e. whether it engages more in downstream or in upstream phases.

Figure 1 shows the changes in the pure domestic, traditional trade, and GVC components both for value added (upper panel) and for final production (lower panel). For both graphs the picture is similar. The traditional trade component is quite stable. There is a decline of about 4 percentage points in pure domestic Va or production between 2000 and 2014, interrupted by the global crisis, when the value of domestic component shot up, before plunging back down. This came at the expense of international trade. Nevertheless, the share of GVC activities recorded positive overall growth in the period, with minor fluctuations.

[Figure 1 about here]

More evidence that the forward- and backward-linkages measures account for different types of GVC participation is set out in Figure 2. There is sectoral heterogeneity, to be sure, but the general conclusion can only be that the share of GVC activities in decomposition of value added and final production increased between 2000 and 2014 in both manufacturing and services. There was also an increase, albeit more modest, in the traditional-trade-related components. Manufacturing shows significantly higher positive change in components related to international trade than services. The differences in the same variables between the forward and backward decompositions relate to industries' different positions within GVCs.

[Figure 2 about here]

Another important notion considered by Wang et al. (2017a) is the total production length and its decomposition as above. Again, two separate approaches are applied to get average production length based on forward or backward linkages, respectively:

$$PLv = Hu' , \quad PLy = uB , \quad (4)$$

where H is a Ghosh inverse matrix, L is a Leontief inverse matrix (again both calculated on WIOD) and u is a $1 \times GN$ summation vector. Production length relating to forward linkages (PL_v) corresponds to “total value of gross outputs that are related to one unit of value added created by primary input from a particular sector” (Wang et al., 2017a:10). This measure can be interpreted as the average number of subsequent production stages related to particular country-sector value added. Analogously, production length relating to backward linkages (PL_y) is “total value of inputs induced by a unit of final product produced in a particular sector” (Wang et al., 2017a:12); it can be interpreted as the average number of upstream sectors involved in final production. These expressions are equivalent to the formulas for upstreamness (Antràs et al., 2012; Fally, 2012) and downstreamness (Antras and Chor, 2013), but their derivation in Wang et al. (2017a) is different. The most important consequence of this alternative reasoning is that it allows further decomposition as when defining the participation indices. Hence, Wang et al. (2017a) introduce the measure of the average production length forward (PL_v_GVC), calculated as a ratio of GVC-related domestic value added to its induced gross output. Respectively, the ratio of GVC-related foreign value added to its induced gross output will be the average production length backward (PL_y_GVC). The higher the former, the longer the production chain forward, hence the farther upstream the industry. The higher the latter (backward) measure, the more production stages to the start of the chain, hence the farther downstream the industry. These production lengths are the point of departure to determine and measure a country-sector’s position along the production chain. The empirical part of the paper concentrates on the relative position of a sector in a GVC based on the ratio of forward to backward GVC production length:

$$GVC_pos = \frac{PL_v_GVC}{PL_y_GVC} \quad (5)$$

The interpretation is simple: the higher GVC_pos , the more upstream the country-sector. As the authors argue, this formula overcomes possible inconsistencies in measures based on forward or backward linkages only, insofar as it takes account of the distance to both ends of the chain; the measure is also robust to different aggregations of industries.

Figure 3 shows the average GVC production chain length (forward and backward) for different countries in 2014. High values of both indices for countries like China, Japan and South Korea imply that they participate in long value chains, with many stages both backward and forward. By contrast the length for such countries as Luxembourg and Ireland is relatively short, whether backward or forward linkages are considered. For some countries there are differences between the two indices, meaning that they are, on average, farther upstream (e.g. Finland, Norway) or downstream (India). It is crucial to recall, here, that the new measures of Wang et al. (2017a) consider only the portion of production that is an element of GVCs.

[Figure 3 about here]

3. Wages and employment in the global context

Based on WIOD's Socio-Economic Accounts (2016 release), we calculate wages as total labour compensation over total number of hours worked. The original data is expressed in nominal values. The real values expressed in 2010 USD exchange rates and 2010 constant prices are obtained by dividing the nominal ones by household consumption deflator, and are converted into USD with the use of exchange rate from 2010.⁵ In our analysis we keep data for 43 countries and 54 sectors (we exclude two sectors: "Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use" and "Activities of extraterritorial organizations and bodies"). The full list of sectors is in Table A1 in the Appendix. Figure 4 shows cross-country wage differences in the total economy.

[Figure 4 about here]

The figure shows that wages (weighted by the total number of hours worked in different sectors) range enormously, from \$1.30 an hour in India to nearly \$66.00 in Norway.

Let us now turn to the employment structure. Figure 5 displays notable changes between 2000 and 2014. The total number of hours worked in services increases throughout the period, save for a dip in 2009; in manufacturing, instead, the downtrend from 2000 to 2003 was reversed, with an expansion until 2008. The fall in 2009 was followed by three years of growth from 2010 to 2012 and two years of stability.

[Figure 5 about here]

4. Empirical analysis

4.1. Empirical specification and estimation method

As noted, the previous literature analyses the impact of GVC on either the employment or the wages of domestic workers. This study, instead, uses three-stage least squares to estimate a system of structural equations by :

$$\begin{aligned} \ln w_{ij,t} = & \alpha + \beta_1 \ln \text{Prod}_{ij,t-1} + \beta_2 \ln \text{Emp}_{ij,t-1} + \beta_3 \text{Trade}_{ij,t-1} + \beta_4 \text{GVC_part}_{ij,t-1} + \beta_5 \text{GVC_pos}_{ij,t-1} + \gamma_i + \\ & \delta_j + \theta_t + \epsilon_{ij,t} \end{aligned} \quad (6)$$

$$\ln \text{Emp}_{ij,t} =$$

⁵ The hourly wage is calculated as labour compensation over total hours worked by employees. To obtain real values in a common currency, we follow the OECD methodology, first applying the household consumption deflator to express wages in 2010 prices and then converting into US dollars at 2010 exchange rates. Alternatively, we used purchasing power parity as conversion factor. For China, WIOD 2016 lacks data on the number of hours worked by employees, reporting only the number of persons engaged. To calculate total number of hours worked in Chinese economy we use data from Penn World Table on average annual hours worked (avh) by persons engaged and multiply by the number of persons engaged. This can be considered a satisfactory proxy, in that for other countries on average the correlation between avh from WIOD and avh from Penn World Table is 0.83.

$$\alpha + \beta_1 \ln \text{Prod}_{ij,t-1} + \beta_2 \ln w_{ij,t-1} + \beta_3 \text{Trade}_{ij,t-1} + \beta_4 \text{GVC_part}_{ij,t-1} + \beta_5 \text{GVC_pos}_{ij,t-1} + \gamma_i + \delta_j + \theta_t + \epsilon_{ij,t} \quad (7)$$

where: i denotes sector, j country, and t time. Eq. (6) is a wage regression where the log of the real hourly wage (wages expressed in 2010 USD exchange rates and 2010 constant prices) is regressed on productivity (Prod), real value added over total number of hours worked; employment (Emp), total number of hours worked in the sector; and involvement in GVC, gauged by GVC_part, the participation index as in eq. 3. and by GVC_pos, the production chain position index, which refers to eq. 5. Note that GVC_part can be measured either by forward or backward industrial linkages. All regressors are expressed as lags. We assume that the effects of GVC on labour market outcomes materialise with a lag, as wage and employment adjustments are not instantaneous; a similar approach is taken by Ebenstein et al. (2017), among others. Eq. (7) represents the labour demand function which is measured by employment (Emp). In both specifications we include industry (γ_i), country (δ_j) and time (θ_t) fixed effects. The inclusion of fixed effects should solve a number of problems, such as GVC possibly being more intensive in specific industries e.g. those with relatively lower wages; GVC, wages and employment can be affected by time-varying shocks; some countries may be characterised by greater or lesser openness, hence variable intensity of involvement in GVC; and so on. We adopt the three-stage least squares estimation method (3SLS) proposed by Zellner and Theil (1962), in which $\ln w$ and $\ln \text{Emp}$ are correlated with the disturbances in the system's equations and treated as endogenous to the system.

4.2. The results

Table 1 presents the overall results embracing all countries and sectors. The GVC variables are lagged in order to solve problems of endogeneity, and there is a full set of individual effects, which to some extent should control for sector, country and time trends.

[Table 1 about here]

For the wage regression (upper panel), we get a positive and statistically significant coefficient for productivity, in accordance with theory, and a negative coefficient for employment. Traditional trade in final goods is negatively correlated with wages only in the case of backward linkages, while for forward linkages the coefficient is not statistically significant. In all specifications, GVC participation coefficient is negative and statistically significant: wages are lower in the countries and sectors more involved in GVCs. Further, the negative coefficient for GVC position means that the country-sectors relatively further from final production stage have lower wages.

The employment regression yields negative coefficients for productivity and wages, positive for traditional trade. In addition, the coefficients for GVC participation and position are negative and statistically significant for backward linkages, indicating that employment is lower in countries and sectors with greater GVC involvement. When the GVC ties are measured by forward linkages,

however, the correlation becomes positive: the greater the GVC participation, the higher the labour demand.

This initial general specification suggests some interesting conclusions. First, traditional trade and GVC can have differing impacts on labour market outcomes. Second, for the most part, GVC involvement is negatively correlated with labour market outcomes – except for employment paired with forward linkages. Finally, the country-sector pairs farthest from final consumption have lower wages and employment. Country and sector heterogeneity are examined more thoroughly below.

[Table 2 about here]

Table 2 separates the results for two distinct groups of countries: middle-income and high-income, following the World Bank classification. We concentrate here on trade and GVC (other independent variables are included but not reported), which turn out to produce different outcomes in the two groups, with the labour markets of middle-income countries negatively affected by globalisation. For example, in the wage regression traditional trade (backward linkages) is negatively correlated with wages only in the middle-income countries, and positively for high-income countries and forward linkages. Further, GVC participation correlates positively with wages in the high-income and negatively in the low-income countries, regardless of type of linkage. Finally, the coefficient for the index of GVC position is negative for middle-income countries and statistically insignificant for high-income countries.

Turning to employment, the correlation with traditional trade does not differ between country types; however, greater GVC participation is positively correlated with employment in high-income countries and negatively in middle-income when measured by backward linkages. GVC position, whether measured from the perspective of producer or supplier, is negatively correlated with labour demand in both sets of countries.

Table 3 analyses sectoral heterogeneity, with separate consideration of manufacturing and services.

[Table 3 about here]

GVC position is negatively correlated both with wages and with employment in both manufacturing and services. The other measures of globalisation show more noticeable correlations in manufacturing. Traditional trade and GVC participation are both negatively correlated with wages in manufacturing. For employment, the picture is less clear; traditional trade is positively correlated with employment in services when measured by backward linkages and in manufacturing when measured by forward linkages. For GVC participation, the negative effect is found for manufacturing when backward linkage is utilised; when the forward index is applied, there is a positive correlation with employment in both manufacturing and services.

When the analysis is more detailed – breaking the sample down both between manufacturing and services and between middle- and high-income countries – the situation is more complicated (Table A2

in Appendix). GVC participation is negatively correlated with wages in manufacturing in middle-income countries when measured by backward linkage and in both manufacturing and services with forward linkage. For high-income countries, GVC participation is positively correlated with wages both in manufacturing and in services. Interestingly, GVC participation has a negative effect on employment only in manufacturing sectors in the middle-income countries; for the rest, the correlation is positive. Finally, in most specifications GVC position follows the generally negative correlation with labour market outcomes: the further the sector-country is from the final demand, the lower are wages and labour demand.

4.3. *Extensions and robustness*⁶

We have run a number of robustness checks. First, we augment the regression with additional country-specific variables: the human capital index, GDP per capita, and openness measured by either exports or imports over GDP, additional data from Penn World Table (Feenstra et al., 2015). These additional variables may or may not be statistically significant – the human capital index, for instance, is statistically significant and positive for the labour demand equation and not statistically significant for wages – but the sign of the relationship between different GVC measures and labour outcomes is confirmed.

Second, we check for the robustness of our sectoral variables, as by calculating real hourly wages at PPP, employing the ratio of capital per hours worked (used instead of value added per hours worked, since these two variables are strongly correlated, a coefficient of correlation 0.85), and gauging labour compensation per persons engaged (not per total hours worked). None of these adjustments greatly alter the final conclusions. The only substantial change is that when wages are expressed in PPP and backward linkage is applied, the coefficient of GVC participation loses statistical significance for the wage regression.

Third, we check country and sector heterogeneity more thoroughly, excluding one country or one sector at a time to see whether some specific countries or sectors drive the results. The mean coefficients obtained from this exercise are very close to those from the baseline estimations.

Finally, we run the estimations for workers in different skill categories: high, medium and low, according to education level. To calculate wages and employment of high-, medium- and low-skilled workers, we use information on their shares in labour compensation and in total hours worked from WIOD 2013, which unfortunately gives these data only for 35 industries and for 1995–2009. We accordingly limit the analysis to 2000–2009 (so as to overlap with our data on GVC ties) and 40 countries (no data for Switzerland, Croatia or Norway). The shares of the three categories in any given, more highly aggregated industry are applied to its disaggregated components in order to map 54 sectors

⁶ Detailed results for this section are available as supplementary materials.

in WIOD 2016.⁷ We conduct an analogous analysis with structural equations for wages and labour demand separately for high-, medium- and low-skilled workers. The results are presented in Table 4.

[Table 4 about here]

For wages, the negative effect for traditional trade and GVC participation, gauged by backward linkages, occurs only among medium-skilled workers; for the others, the effect is not statistically significant. For employment, backward GVC participation shows a negative correlation only for low-skilled workers, while forward participation is positively correlated for all three skill groups. For all specifications (wages, employment, type of linkage), GVC position is negatively correlated with outcome variables regardless of skill category. These results are in accordance with previous studies (Wang et al., 2018; Ebenstein et al., 2017; Geishecker and Görg, 2008; Wolszczak-Derlacz and Parteka, 2018), which make it clear that the costs and benefits of production fragmentation are not distributed equally by skill level. Note that our analysis is for employed workers only, so no conclusions can be drawn about how production fragmentation affects displacement of workers or the earnings of those displaced.

5. Conclusion

This study examines the nexus between sector-country participation in GVCs and labour market outcomes in a global context, using recent input-output-based measures of GVC ties. The picture is quite complex. The results differ according to whether wages or labour demand is the dependent variable and, importantly, whether trade or GVC involvement is measured by backward or forward linkage.

Essentially, the data indicate that GVC position is negatively correlated both with wages and with employment, while the effect of GVC participation as such depends on whether the gauge is backward or forward linkage. Backward linkages are negatively correlated with both wages and employment. We find some heterogeneity between countries (middle- versus high-income) and sectors (manufacturing versus services). Notably, the effect of GVC participation on labour market outcomes can differ radically from that of traditional trade. Finally, the data confirm that the costs and benefits of involvement in GVCs can be differently distributed according to workers' skill levels.

It is important to note one major limitation of this study. Namely, it is based on sectoral analysis, not micro-level data in which workers' actual occupations can be taken into account. Ebenstein et al. (2017), for example, find no effect of trade on wages at sectoral level, but they do find an impact when the individual occupational variable is added. Moreover, it is worth pointing out that our analysis

⁷ WIOD 2016 has 56 industries according to ISIC Rev 4, whereas WIOD 2013 has 35 industries according to NACE rev 1. Mapping the industries, where we have a higher level of aggregation in WIOD 2013, e.g. AtB (agriculture, hunting, forestry and fishing), we apply the labour shares of specific workers to all the disaggregated industries in WIOD 2016: in this case, to A01, A02 and A03.

concentrates on establishing broad empirical facts rather than causal interpretation. Causality needs to be explored more thoroughly.

Nevertheless, our study contributes to the literature on the labour market outcomes of global production fragmentation. Its chief value consists in the simultaneous analysis of wages and labour demand gauging GVC participation by both forward and backward linkages, distinguishing traditional trade from GVC ties, and controlling for country-industry position in the production chain. Since the GVC ties are investigated decomposing value added or production, which can be calculated for a large number of countries and sectors with freely available input-output tables (as opposed to firm- or worker-level data), the approach can be used to explore many different aspects of production sharing. For example, future research might well move toward a general equilibrium model in which different types of GVC ties are taken into account simultaneously.

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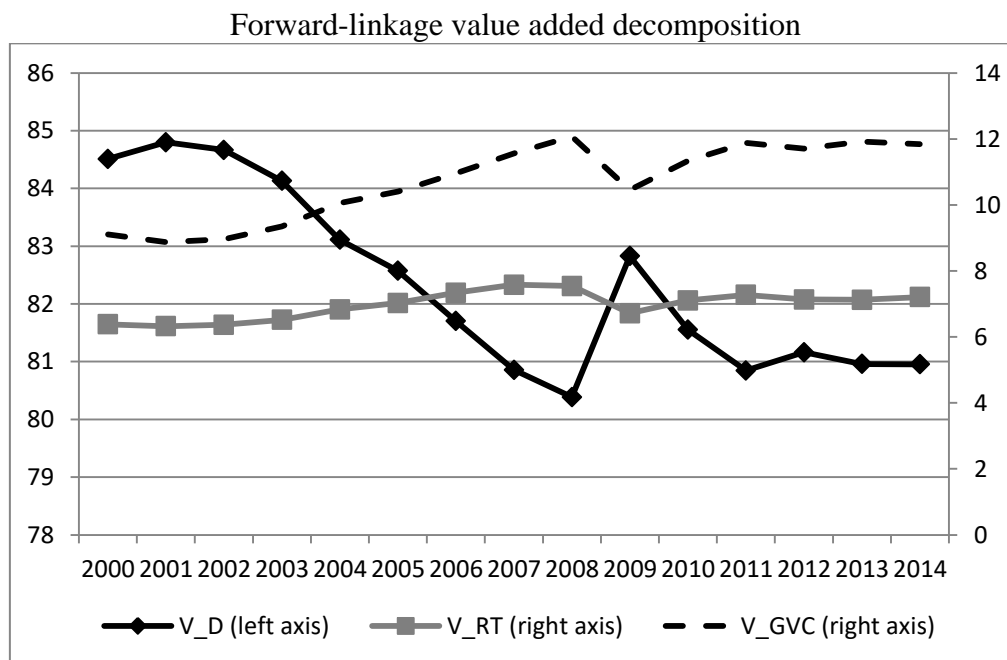
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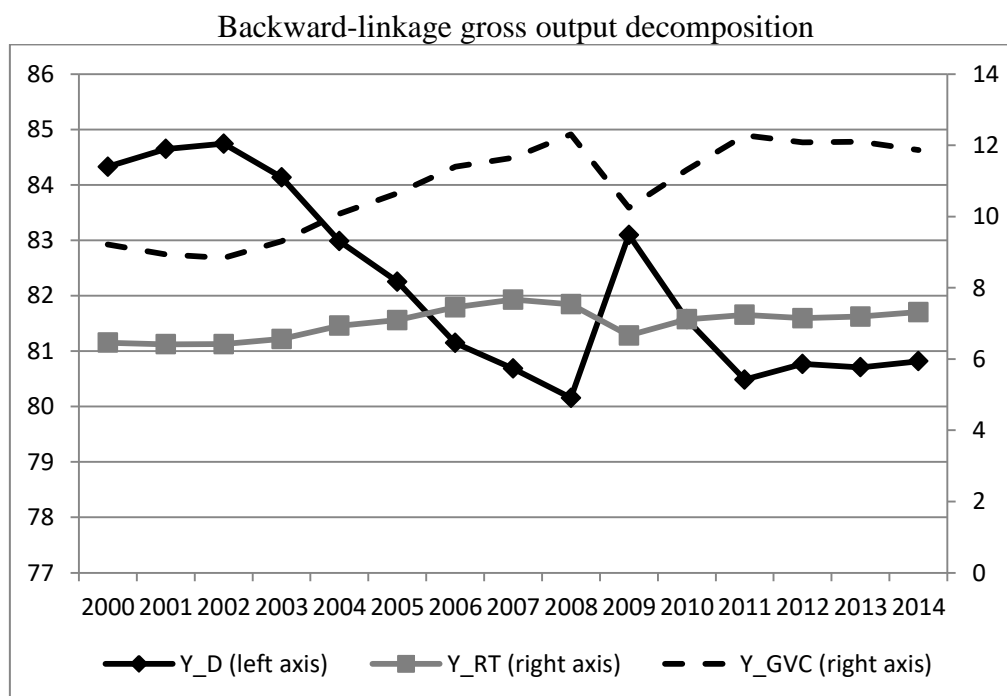
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Tables and Figures

Figure 1. Decomposition of value-added and production into domestic and international components 2000 – 2014, backward and forward linkages, total economy

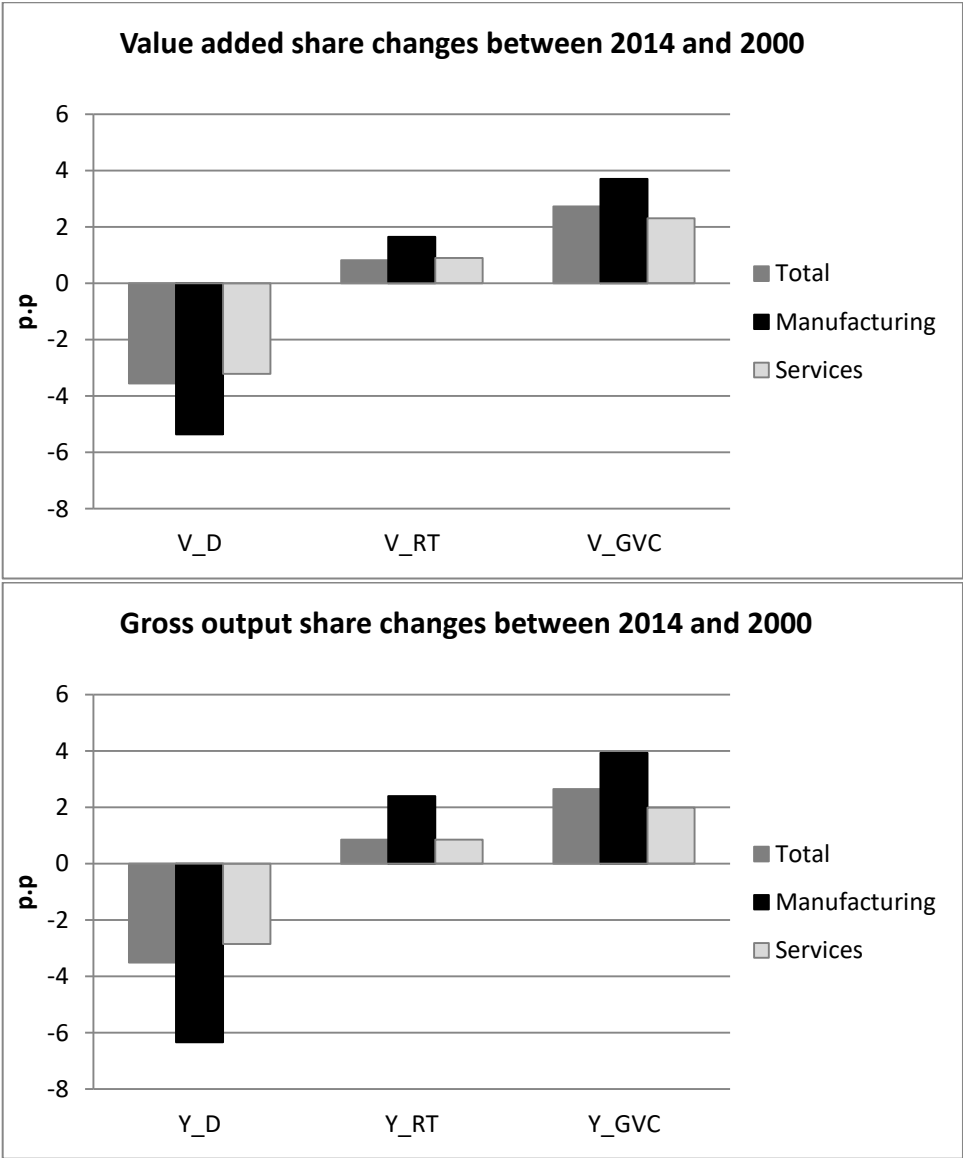


Notes: own elaboration based on Wang et al. (2017b) methodology, using WIOD 2016; averages weighted by value added



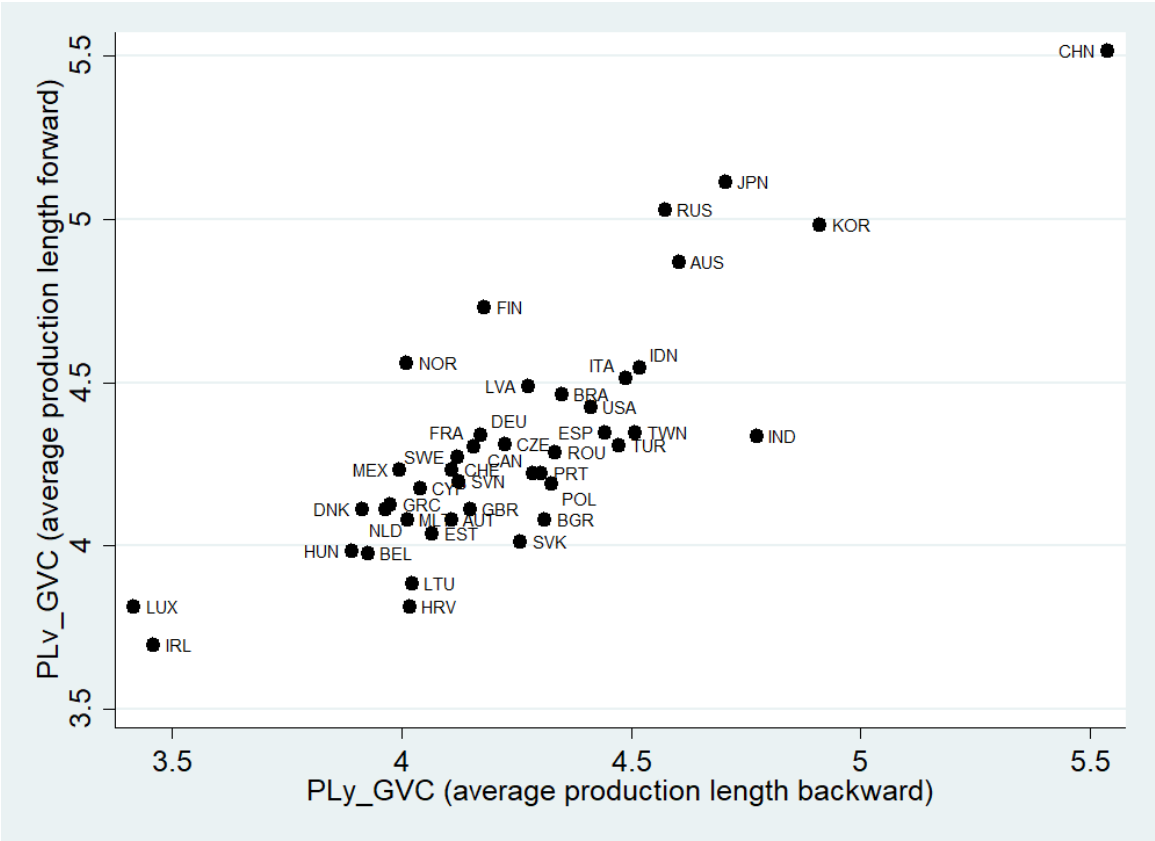
Notes: own elaboration based on Wang et al. (2017b) methodology, using WIOD 2016; averages weighted by gross output

Figure 2. Sector level forward and backward linkages changes between 2014 and 2000



Notes: own elaboration based on Wang et al. (2017b) methodology, using WIOD 2016; share changes expressed in percentage points: shares in 2014 minus shares in 2000, averages weighted by value added or by gross output.

Figure 3 Average production length (forward and backward) – means by country, 2014.



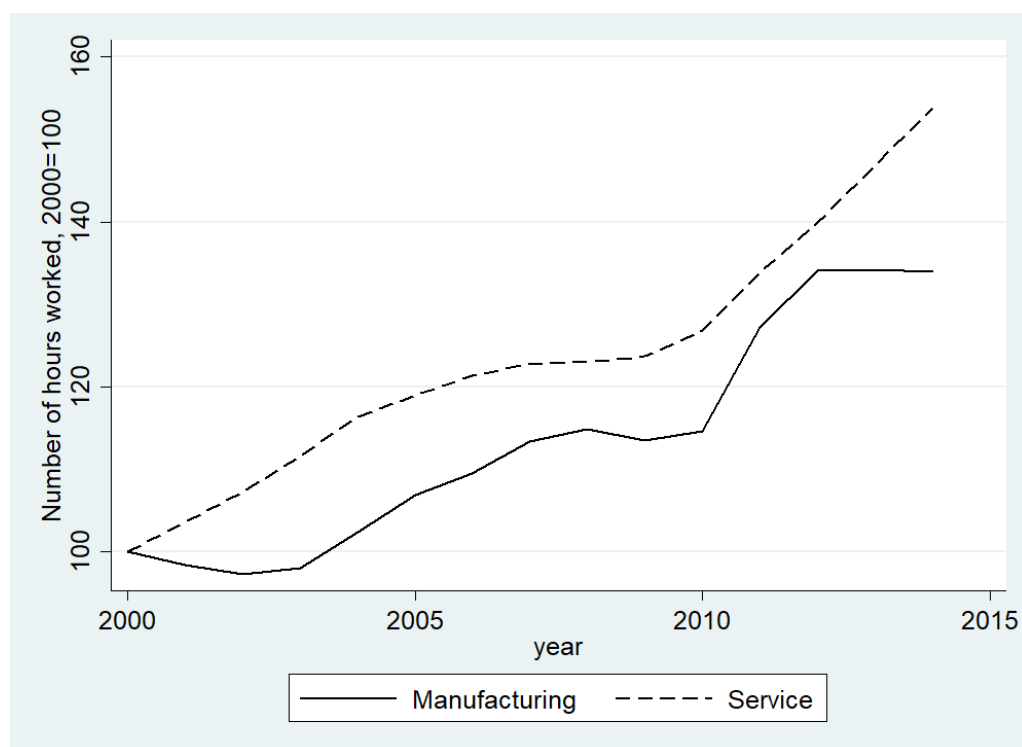
Notes: own elaboration based on Wang et al. (2017a) methodology, using WIOD 2016; averages weighted by total hours worked in industry.

Figure 4. Cross-country differences in average wages per hour, 2014



Notes: wages weighted by total number of hours worked in sectors,
Source: own elaboration with socioeconomic accounts data from WIOD 2016

Figure 5. Changes in employment (number of total hours worked) (2000=100)



Source: own elaboration with socioeconomic accounts data from WIOD 2016

Table 1. Estimation of wage and employment regressions – full sample of sectors and countries

	Backward linkages				Forward linkages			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable: $\ln w$								
$\ln \text{Prod}_{ij,t-1}$	0.434*** [0.004]	0.421*** [0.004]	0.423*** [0.004]	0.433*** [0.004]	0.423*** [0.004]	0.423*** [0.004]	0.423*** [0.004]	0.425*** [0.004]
$\ln \text{Emp}_{ij,t-1}$	-0.153*** [0.003]	-0.151*** [0.003]	-0.151*** [0.003]	-0.154*** [0.003]	-0.155*** [0.003]	-0.150*** [0.003]	-0.151*** [0.003]	-0.154*** [0.003]
$\text{Trade}_{ij,t-1}$	-0.029* [0.016]			-0.051*** [0.017]	-0.003 [0.024]			-0.018 [0.024]
$\text{GVC_part}_{ij,t-1}$		-0.104*** [0.029]		-0.097*** [0.031]		-0.044** [0.018]		-0.058*** [0.019]
$\text{GVC_pos}_{ij,t-1}$			-0.069*** [0.019]	-0.082*** [0.021]			-0.069*** [0.019]	-0.106*** [0.021]
Dependent variable: $\ln \text{Emp}$								
$\ln \text{Prod}_{ij,t-1}$	-0.103*** [0.010]	-0.076*** [0.010]	-0.070*** [0.010]	-0.104*** [0.010]	-0.094*** [0.010]	-0.101*** [0.010]	-0.070*** [0.010]	-0.099*** [0.010]
$\ln w_{ij,t-1}$	-0.616*** [0.011]	-0.640*** [0.011]	-0.631*** [0.011]	-0.614*** [0.011]	-0.635*** [0.011]	-0.617*** [0.011]	-0.631*** [0.011]	-0.620*** [0.011]
$\text{Trade}_{ij,t-1}$	0.349*** [0.032]			0.198*** [0.033]	0.382*** [0.048]			0.181*** [0.048]
$\text{GVC_part}_{ij,t-1}$		-0.318*** [0.060]		-0.361*** [0.061]		0.507*** [0.036]		0.410*** [0.039]
$\text{GVC_pos}_{ij,t-1}$			-0.799*** [0.039]	-0.612*** [0.041]			-0.799*** [0.039]	-0.633*** [0.041]
N	29764	31316	31280	29735	30954	31254	31280	30925

R2 (lnw)	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
R2 (lnEmp)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Industry, country and time dummies included in all specifications, 3SLS regressions.

Source: own compilation

Table 2. Estimation of wage and employment regressions - different country groups

	Backward linkages		Forward linkages	
	Middle income countries	High income countries	Middle income countries	High income countries
	(1)	(2)	(3)	(4)
Dependent variable: lnw				
Trade $ij, t-1$	-0.160*** [0.055]	0.007 [0.017]	0.08 [0.089]	0.054** [0.024]
GVC_partij,t-1	-0.227** [0.110]	0.090*** [0.030]	-0.372*** [0.067]	0.093*** [0.020]
GVC_posij,t-1	-0.242*** [0.056]	-0.019 [0.021]	-0.300*** [0.055]	0.007 [0.021]
Dependent variable: lnEmp				
Trade $ij, t-1$	0.743*** [0.084]	0.148*** [0.034]	0.348** [0.138]	0.363*** [0.049]
GVC_partij,t-1	-2.024*** [0.165]	0.591*** [0.061]	0.085 [0.104]	0.733*** [0.039]
GVC_posij,t-1	-0.305*** [0.086]	-0.623*** [0.042]	-0.623*** [0.086]	-0.399*** [0.042]
N	5594	24141	5878	25047
R2 (lnw)	0.75	0.83	0.75	0.83
R2 (lnEmp)	0.91	0.90	0.91	0.90

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Industry, country and time dummies included in all specifications, 3SLS regressions. Other independent variables: lnProdij,t-1, lnwij,t-1 or lnEmpij,t-1 included as in eq. (5) and (6), not reported. Middle income countries: BGR, BRA, CHN, IDN, IND, MEX, ROU, RUS, TUR.

Source: own compilation

Table 3. Estimation of wage and employment regressions – different sectors group

	Backward linkages		Forward linkages	
	Manufacturing	Services	Manufacturing	Services
	(1)	(2)	(3)	(4)
Dependent variable: lnw				
Trade $ij, t-1$	-0.080*** [0.021]	-0.028 [0.023]	-0.126*** [0.024]	-0.003 [0.060]
GVC_partij,t-1	-0.099*** [0.038]	0.077* [0.044]	-0.031 [0.023]	-0.116*** [0.035]
GVC_posij,t-1	-0.152*** [0.032]	-0.080*** [0.026]	-0.170*** [0.032]	-0.099*** [0.026]
Dependent variable: lnEmp				
Trade $ij, t-1$	0.08 [0.052]	0.340*** [0.040]	0.186*** [0.058]	0.180* [0.103]
GVC_partij,t-1	-0.239** [0.093]	0.184** [0.076]	0.158*** [0.058]	0.533*** [0.060]

GVC_posij,t-1	-0.788*** [0.079]	-0.451*** [0.045]	-0.782*** [0.078]	-0.407*** [0.045]
N	10334	16663	10879	17114
R2 (lnw)	0.94	0.88	0.94	0.88
R2 (lnEmp)	0.91	0.93	0.91	0.93

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Industry, country and time dummies included in all specifications, 3SLS regressions. Other independent variables: $\ln\text{Prod}_{ij,t-1}$, $\ln w_{ij,t-1}$ or $\ln\text{Emp}_{ij,t-1}$ included as in eq. (5) and (6), not reported.
Source: own compilation

Table 4. Estimation of wage and employment regressions – different workers group: high (HS), medium (MS) and low skilled (LS), time period: 2000 – 2009, number of countries: 40

	Backward linkages			Forward linkages		
	(1)	(2)	(3)	(4)	(5)	(6)
	HS	MS	LS	HS	MS	LS
Dependent variable: lnw						
Trade $ij,t-1$	-0.031 [0.021]	-0.047* [0.025]	0.00 [0.020]	-0.009 [0.029]	-0.017 [0.035]	0.042 [0.029]
GVC_partij,t-1	-0.059 [0.039]	-0.103** [0.047]	-0.014 [0.039]	0.026 [0.025]	-0.038 [0.029]	-0.018 [0.025]
GVC_posij,t-1	-0.173*** [0.026]	-0.116*** [0.031]	-0.152*** [0.026]	-0.155*** [0.026]	-0.128*** [0.031]	-0.159*** [0.026]
Dependent variable: lnEmp						
Trade $ij,t-1$	0.222*** [0.045]	0.291*** [0.044]	0.191*** [0.050]	0.096 [0.065]	0.274*** [0.063]	0.204*** [0.072]
GVC_partij,t-1	0.046 [0.086]	0.062 [0.084]	-0.232** [0.096]	0.865*** [0.054]	0.840*** [0.052]	0.588*** [0.060]
GVC_posij,t-1	-0.752*** [0.056]	-0.649*** [0.055]	-0.589*** [0.063]	-0.585*** [0.056]	-0.486*** [0.055]	-0.520*** [0.063]
N	17874	17874	17874	18505	18505	18505
R2 (lnw)	0.88	0.86	0.91	0.88	0.86	0.91
R2 (lnEmp)	0.9	0.9	0.89	0.9	0.9	0.89

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Industry, country and time dummies included in all specifications, 3SLS regressions. Other independent variables: $\ln\text{Prod}_{ij,t-1}$, $\ln w_{ij,t-1}$ or $\ln\text{Emp}_{ij,t-1}$ included as in eq. (5) and (6), not reported.
Source: own compilation

Appendix

Table A.1 Sector classification as in WIOD, release 2016 (according to ISIC Rev. 4)

1 A01 Crop and animal production, hunting and related service activities
2 A02 Forestry and logging
3 A03 Fishing and aquaculture
4 B Mining and quarrying
5 C10-C12 Manufacture of food products, beverages and tobacco products
6 C13-C15 Manufacture of textiles, wearing apparel and leather products
7 C16 Manufacture of wood and of products of wood and cork, except furniture; etc.
8 C17 Manufacture of paper and paper products
9 C18 Printing and reproduction of recorded media
10 C19 Manufacture of coke and refined petroleum products
11 C20 Manufacture of chemicals and chemical products
12 C21 Manufacture of basic pharmaceutical products and pharmaceutical preparations
13 C22 Manufacture of rubber and plastic products
14 C23 Manufacture of other non-metallic mineral products
15 C24 Manufacture of basic metals
16 C25 Manufacture of fabricated metal products, except machinery and equipment
17 C26 Manufacture of computer, electronic and optical products
18 C27 Manufacture of electrical equipment
19 C28 Manufacture of machinery and equipment n.e.c.
20 C29 Manufacture of motor vehicles, trailers and semi-trailers
21 C30 Manufacture of other transport equipment
22 C31_C32 Manufacture of furniture; other manufacturing
23 C33 Repair and installation of machinery and equipment
24 D Electricity, gas, steam and air conditioning supply
25 E36 Water collection, treatment and supply
26 E37-E39 Sewerage; waste collection, treatment and disposal activities; materials recovery; etc.
27 F Construction
28 G45 Wholesale and retail trade and repair of motor vehicles and motorcycles
29 G46 Wholesale trade, except of motor vehicles and motorcycles
30 G47 Retail trade, except of motor vehicles and motorcycles
31 H49 Land transport and transport via pipelines
32 H50 Water transport
33 H51 Air transport
34 H52 Warehousing and support activities for transportation
35 H53 Postal and courier activities
36 I Accommodation and food service activities
37 J58 Publishing activities
38 J59_J60 Motion picture, video and television programme production, sound recording and music publishing activities; etc.
39 J61 Telecommunications
40 J62_J63 Computer programming, consultancy and related activities; information service activities
41 K64 Financial service activities, except insurance and pension funding
42 K65 Insurance, reinsurance and pension funding, except compulsory social security
43 K66 Activities auxiliary to financial services and insurance activities
44 L Real estate activities
45 M69_M70 Legal and accounting activities; activities of head offices; management consultancy activities
46 M71 Architectural and engineering activities; technical testing and analysis
47 M72 Scientific research and development
48 M73 Advertising and market research
49 M74_M75 Other professional, scientific and technical activities; veterinary activities
50 N Rental and leasing activities, Employment activities, Travel services, security and services to buildings
51 O Public administration and defence; compulsory social security
52 P Education
53 Q Human health and social work activities
54 R-S Creative, Arts, Sports, Recreation and entertainment activities and all other personal service activities

55 T Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
56 U Activities of extra-territorial organisations and bodies
Source: WIOD (2016)

Table A2. Estimation of wage and employment regressions – 3SLS: different country and sectors grouping

	Backward linkages				Forward linkages			
	Middle income countries	Middle income countries	High income countries	High income countries	Middle income countries	Middle income countries	High income countries	High income countries
	manuf	service	manuf	service	manuf	service	manuf	service
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable: lnw								
Trade _{ij,t-1}	-0.093 [0.057]	-0.141 [0.099]	0.006 [0.022]	0.032 [0.022]	0.014 [0.069]	-0.183 [0.235]	-0.031 [0.025]	0.001 [0.055]
GVC _{partij,t}	-0.302*** [0.101]	1.365*** [0.225]	0.179*** [0.039]	0.137*** [0.040]	-0.205*** [0.065]	-0.396*** [0.122]	0.096*** [0.024]	0.089*** [0.034]
GVC _{posij,t}	-0.023 [0.073]	-0.361*** [0.082]	-0.157*** [0.034]	-0.023 [0.025]	-0.141* [0.074]	-0.369*** [0.080]	-0.099*** [0.034]	0.009 [0.025]
Dependent variable: lnEmp								
Trade _{ij,t-1}	0.724*** [0.099]	0.904*** [0.146]	-0.101* [0.059]	0.285*** [0.038]	0.530*** [0.123]	-0.694* [0.355]	0.128* [0.066]	0.418*** [0.098]
GVC _{partij,t}	-1.465*** [0.173]	0.698** [0.339]	0.561*** [0.105]	0.439*** [0.071]	0.018 [0.115]	0.345* [0.185]	0.381*** [0.064]	0.685*** [0.059]
GVC _{posij,t}	-0.671*** [0.127]	-0.540*** [0.123]	-0.710*** [0.090]	-0.362*** [0.045]	-1.060*** [0.130]	-0.690*** [0.120]	-0.464*** [0.089]	-0.182*** [0.045]
N	2128	2893	8206	13770	2194	3083	8594	14018
R2 (lnw)	0.89	0.66	0.9	0.84	0.89	0.66	0.9	0.84
R2 (lnEmp)	0.94	0.91	0.89	0.93	0.93	0.9	0.89	0.93

Notes: * p<0.10, ** p<0.05, *** p<0.01. Industry, country and time dummies included in all specifications, 3SLS regressions. Other independent variables: lnProd_{ij,t-1}, lnw_{ij,t-1} or lnEmp_{ij,t-1} included as in eq. (5) and (6), not reported.
Source: own compilation

Supplementary materials to the paper:

“Global value chains and labour markets – wages, employment or both: input-output approach” authored by Szymczak S., Wolszczak-Derlacz J.

Not to be included in the main text

**Code in R to calculate GVC measures used in the paper – file
“WP_GUTFME_A_59_code_accompanyingWP59_WWYZ_measures.r”**

Table S1. Estimation of wage and employment regressions – full sample of sectors and countries, additional variable: human capital (HC)

	Backward linkages					Forward linkages		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable: lnw								
HC _{j,t}	0.08 [0.055]	0.087 [0.055]	0.082 [0.055]	0.081 [0.055]	0.085 [0.055]	0.085 [0.055]	0.082 [0.055]	0.086 [0.055]
Trade _{ij,t-1}	-0.029* [0.016]			-0.051*** [0.017]	-0.003 [0.024]			-0.018 [0.024]
GVC_partij,t-1		-0.104*** [0.029]		-0.097*** [0.031]		-0.044** [0.018]		-0.058*** [0.019]
GVC_posij,t-1			-0.069*** [0.019]	-0.082*** [0.021]			-0.069*** [0.019]	-0.106*** [0.021]
Dependent variable: lnEmp								
HC _{j,t}	0.288*** [0.110]	0.319*** [0.112]	0.302*** [0.111]	0.297*** [0.110]	0.287*** [0.110]	0.287*** [0.111]	0.302*** [0.111]	0.271** [0.109]
Trade _{ij,t-1}	0.348*** [0.032]			0.198*** [0.033]	0.381*** [0.048]			0.180*** [0.048]
GVC_partij,t-1		-0.320*** [0.060]		-0.361*** [0.061]		0.506*** [0.036]		0.409*** [0.039]
GVC_posij,t-1			-0.799*** [0.039]	-0.612*** [0.041]			-0.799*** [0.039]	-0.633*** [0.041]
N	29764	31316	31280	29735	30954	31254	31280	30925
R2 (lnw)	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
R2 (lnEmp)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Notes: * p<0.10, ** p<0.05, *** p<0.01. Industry, country and time dummies included in all specifications, 3SLS regressions. Other independent variables: lnProd_{ij,t-1}, lnw_{ij,t-1} or lnEmp_{ij,t-1} included as in eq. (5) and (6), not reported.

Source: own compilation

Table S2. Estimation of wage and employment regressions – full sample of sectors and countries, additional variable: GDP per capita (lnGDPpc)

	Backward linkages				Forward linkages			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable: lnw								
lnGDPpc _{j,t}	0.377*** [0.021]	0.376*** [0.020]	0.377*** [0.020]	0.375*** [0.021]	0.382*** [0.020]	0.380*** [0.020]	0.377*** [0.020]	0.380*** [0.020]
Trade _{ij,t-1}	-0.032** [0.016]			-0.055*** [0.017]	-0.008 [0.024]			-0.024 [0.024]
GVC_partij,t-1		-0.084*** [0.029]		-0.076** [0.030]		-0.035** [0.018]		-0.049** [0.019]
GVC_posij,t-1			-0.070*** [0.019]	-0.086*** [0.021]			-0.070*** [0.019]	-0.105*** [0.020]
Dependent variable: lnEmp								
lnGDPpc _{j,t}	0.731*** [0.041]	0.769*** [0.042]	0.766*** [0.041]	0.720*** [0.041]	0.773*** [0.041]	0.780*** [0.041]	0.766*** [0.041]	0.770*** [0.041]
Trade _{ij,t-1}	0.335*** [0.032]			0.186*** [0.033]	0.364*** [0.048]			0.164*** [0.048]
GVC_partij,t-1		-0.275*** [0.060]		-0.317*** [0.061]		0.514*** [0.036]		0.419*** [0.039]
GVC_posij,t-1			-0.790*** [0.039]	-0.612*** [0.041]			-0.790*** [0.039]	-0.623*** [0.041]
N	29764	31316	31280	29735	30954	31254	31280	30925
R2 (lnw)	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
R2 (lnEmp)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Notes: * p<0.10, ** p<0.05, *** p<0.01. Industry, country and time dummies included in all specifications, 3SLS regressions. Other independent variables: lnProd_{ij,t-1}, lnw_{ij,t-1} or lnEmp_{ij,t-1} included as in eq. (5) and (6), not reported.
Source: own compilation

Table S3. Estimation of wage and employment regressions – full sample of sectors and countries, additional variable: export to GDP (EXP)

	Backward linkages				Forward linkages			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable: lnw								
EX _{j,t}	-0.094*** [0.034]	-0.107*** [0.033]	-0.107*** [0.033]	-0.089*** [0.034]	-0.104*** [0.034]	-0.098*** [0.033]	-0.107*** [0.033]	-0.094*** [0.034]
Trade _{ij,t-1}	-0.028* [0.016]			-0.050*** [0.017]	0.001 [0.024]			-0.014 [0.024]
GVC_partij,t-1		-0.102*** [0.029]		-0.095*** [0.031]		-0.041** [0.018]		-0.055*** [0.019]
GVC_posij,t-1			-0.068*** [0.019]	-0.081*** [0.021]			-0.068*** [0.019]	-0.104*** [0.021]
Dependent variable: lnEmp								
EX _{j,t}	-0.01 [0.068]	0.027 [0.068]	0.034 [0.068]	0.015 [0.068]	0.004 [0.068]	-0.01 [0.068]	0.034 [0.068]	-0.015 [0.068]
Trade _{ij,t-1}	0.349*** [0.032]			0.198*** [0.033]	0.382*** [0.048]			0.182*** [0.049]
GVC_partij,t-1		-0.319*** [0.060]		-0.361*** [0.061]		0.507*** [0.036]		0.411*** [0.039]

GVC_posij,t-1			-0.799*** [0.039]	-0.612*** [0.041]			-0.799*** [0.039]	-0.632*** [0.041]
N	29764	31316	31280	29735	30954	31254	31280	30925
R2 (lnw)	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
R2 (lnEmp)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Notes: * p<0.10, ** p<0.05, *** p<0.01. Industry, country and time dummies included in all specifications, 3SLS regressions. Other independent variables: lnProdij,t-1, lnwij,t-1 or lnEmpij,t-1 included as in eq. (5) and (6), not reported.

Source: own compilation

Table S4. Estimation of wage and employment regressions – full sample of sectors and countries, additional variable: import to GDP (IMP)

	Backward linkages				Forward linkages			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable: lnw								
IMPj,t	0.007 [0.033]	-0.005 [0.032]	-0.012 [0.032]	0.014 [0.033]	-0.004 [0.032]	-0.003 [0.032]	-0.012 [0.032]	0.002 [0.032]
Trade ij,t-1	-0.029* [0.016]			-0.051*** [0.017]	-0.003 [0.024]			-0.018 [0.024]
GVC_partij,t-1		-0.104*** [0.029]		-0.097*** [0.031]		-0.044** [0.018]		-0.058*** [0.019]
GVC_posij,t-1			-0.069*** [0.019]	-0.082*** [0.021]			-0.069*** [0.019]	-0.106*** [0.021]
Dependent variable: lnEmp								
IMPj,t	0.096 [0.065]	0.143** [0.065]	0.127** [0.065]	0.129** [0.065]	0.097 [0.065]	0.08 [0.065]	0.127** [0.065]	0.077 [0.065]
Trade ij,t-1	0.348*** [0.032]			0.197*** [0.033]	0.378*** [0.048]			0.178*** [0.049]
GVC_partij,t-1		-0.326*** [0.060]		-0.367*** [0.061]		0.505*** [0.036]		0.407*** [0.039]
GVC_posij,t-1			-0.799*** [0.039]	-0.612*** [0.041]			-0.799*** [0.039]	-0.634*** [0.041]
N	29764	31316	31280	29735	30954	31254	31280	30925
R2 (lnw)	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
R2 (lnEmp)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Notes: * p<0.10, ** p<0.05, *** p<0.01. Industry, country and time dummies included in all specifications, 3SLS regressions. Other independent variables: lnProdij,t-1, lnwij,t-1 or lnEmpij,t-1 included as in eq. (5) and (6), not reported.

Source: own compilation

Table S5. Estimation of wage and employment regressions – full sample of sectors and countries, wages measured by PPP exchange rate

	Backward linkages				Forward linkages			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable: lnw								
Trade _{ij,t-1}	-0.073*** [0.015]			-0.098*** [0.016]	-0.066*** [0.023]			-0.080*** [0.023]
GVC_partij,t-1		-0.02 [0.028]		-0.014 [0.029]		-0.063*** [0.017]		-0.077*** [0.018]
GVC_posij,t-1			-0.066*** [0.018]	-0.100*** [0.020]			-0.066*** [0.018]	-0.117*** [0.020]
Dependent variable: lnEmp								
Trade _{ij,t-1}	0.373*** [0.032]			0.224*** [0.034]	0.403*** [0.048]			0.201*** [0.049]
GVC_partij,t-1		-0.340*** [0.061]		-0.382*** [0.062]		0.524*** [0.036]		0.427*** [0.039]
GVC_posij,t-1			-0.792*** [0.039]	-0.600*** [0.042]			-0.792*** [0.039]	-0.611*** [0.042]
N	29068	30560	30527	29040	30201	30498	30527	30173
R2 (lnw)	0.81	0.81	0.81	0.82	0.81	0.81	0.81	0.81
R2 (lnEmp)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Notes: * p<0.10, ** p<0.05, *** p<0.01. Industry, country and time dummies included in all specifications, 3SLS regressions. Other independent variables: lnProd_{ij,t-1}, lnw_{ij,t-1} or lnEmp_{ij,t-1} included as in eq. (5) and (6), not reported.
Source: own compilation

Table S6. Estimation of wage and employment regressions – full sample of sectors and countries, among independent variables: capital per hours worked: K_HEMPE (instead of value added per hours worked)

	Backward linkages				Forward linkages			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable: lnw								
lnK_HEMPE _{ij,t-1}	0.108*** [0.003]	0.110*** [0.003]	0.112*** [0.003]	0.107*** [0.003]	0.108*** [0.003]	0.110*** [0.003]	0.112*** [0.003]	0.108*** [0.003]
lnEmp _{ij,t-1}	-0.272*** [0.003]	-0.257*** [0.003]	-0.256*** [0.003]	-0.271*** [0.003]	-0.267*** [0.003]	-0.260*** [0.003]	-0.256*** [0.003]	-0.267*** [0.003]
Trade _{ij,t-1}	0.101*** [0.019]			0.081*** [0.019]	0.107*** [0.028]			0.077*** [0.028]
GVC_partij,t-1		-0.496*** [0.034]		-0.506*** [0.035]		0.060*** [0.020]		0.069*** [0.022]
GVC_posij,t-1			-0.096*** [0.022]	-0.038 [0.024]			-0.096*** [0.022]	-0.077*** [0.024]
Dependent variable: lnEmp								
lnK_HEMPE _{ij,t-1}	-0.096*** [0.005]	-0.090*** [0.005]	-0.092*** [0.005]	-0.097*** [0.005]	-0.093*** [0.005]	-0.093*** [0.005]	-0.092*** [0.005]	-0.097*** [0.005]
lnw _{ij,t-1}	-0.770*** [0.009]	-0.772*** [0.009]	-0.754*** [0.009]	-0.766*** [0.009]	-0.782*** [0.009]	-0.767*** [0.009]	-0.754*** [0.009]	-0.768*** [0.009]
Trade _{ij,t-1}	0.337*** [0.032]			0.188*** [0.033]	0.377*** [0.048]			0.180*** [0.048]

GVC_partij,t-1	-0.441***		-0.385***		0.485***		0.393***	
	[0.059]		[0.060]		[0.036]		[0.038]	
GVC_posij,t-1		-0.800***	-0.605***			-0.800***	-0.627***	
		[0.038]	[0.041]			[0.038]	[0.041]	
N	29756	31294	31263	29728	30925	31245	31263	30897
R2 (lnw)	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
R2 (lnEmp)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Notes: * p<0.10, ** p<0.05, *** p<0.01. Industry, country and time dummies included in all specifications, 3SLS regressions.

Source: own compilation

Table S7. Estimation of wage and employment regressions – full sample of sectors and countries, wages expressed as labor compensation per person engaged, employment as number of persons engaged

Number of persons engaged								
Backward linkages					Forward linkages			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable: lnw								
Trade ij,t-1	-0.003			-0.028*	0.033			0.012
	[0.014]			[0.015]	[0.021]			[0.022]
GVC_partij,t-1		-0.045*		-0.03		-0.007		-0.023
		[0.026]		[0.027]		[0.016]		[0.017]
GVC_posij,t-1			-0.088***	-0.098***			-0.088***	-0.108***
			[0.017]	[0.018]			[0.017]	[0.018]
Dependent variable: lnEmp								
Trade ij,t-1	0.353***			0.212***	0.382***			0.189***
	[0.032]			[0.033]	[0.048]			[0.049]
GVC_partij,t-1		-0.398***		-0.463***		0.497***		0.410***
		[0.060]		[0.061]		[0.036]		[0.039]
GVC_posij,t-1			-0.758***	-0.567***			-0.758***	-0.594***
			[0.039]	[0.041]			[0.039]	[0.041]
N	29762	31313	31277	29733	30952	31251	31277	30923
R2 (lnw)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
R2 (lnEmp)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Notes: * p<0.10, ** p<0.05, *** p<0.01. Industry, country and time dummies included in all specifications, 3SLS regressions. Other independent variables: lnProdij,t-1, lnwij,t-1 or lnEmpij,t-1 included as in eq. (5) and (6), not reported.

Source: own compilation

Table S8. Estimation of wage and employment regressions, robustness: elimination country by country

	Backward linkages			Forward linkages		
	Mean coefficient	Min coefficient	Max coefficient	Mean coefficient	Min coefficient	Max coefficient
	(1)	(3)	(3)	(4)	(5)	(6)
Dependent variable: lnw						
Trade $ij,t-1$	-0.051	-0.098	-0.029	-0.018	-0.080	0.022
GVC_partij,t-1	-0.097	-0.157	-0.014	-0.058	-0.102	-0.022
GVC_posij,t-1	-0.082	-0.114	-0.052	-0.106	-0.134	-0.079
Dependent variable: lnEmp						
Trade $ij,t-1$	0.198	0.158	0.231	0.181	0.084	0.330
GVC_partij,t-1	-0.362	-0.630	-0.135	0.410	0.293	0.491
GVC_posij,t-1	-0.611	-0.754	-0.565	-0.632	-0.728	-0.557
N	29043	28979	29275	30205.81	30169	30463
R2 (lnw)	0.88	0.87	0.90	0.88	0.87	0.90
R2 (lnEmp)	0.90	0.89	0.90	0.90	0.89	0.90

Notes: as under Table 3. Mean/Min/Max coefficients – average/min/max values of coefficients of specifications in which one by one country are excluded. R2, N, also reported as mean/min and maximum value of the statistics.

Source: own compilation

Table S9. Estimation of wage and employment regressions, robustness: elimination industry by industry

	Backward linkages			Forward linkages		
	Mean coefficient	Min coefficient	Max coefficient	Mean coefficient	Min coefficient	Max coefficient
	(1)	(3)	(3)	(4)	(5)	(6)
Dependent variable: lnw						
Trade $ij,t-1$	-0.051	-0.077	-0.020	-0.018	-0.077	0.020
GVC_partij,t-1	-0.097	-0.134	-0.065	-0.058	-0.086	-0.012
GVC_posij,t-1	-0.082	-0.110	-0.051	-0.106	-0.129	-0.069
Dependent variable: lnEmp						
Trade $ij,t-1$	0.198	0.155	0.262	0.181	0.101	0.264
GVC_partij,t-1	-0.361	-0.567	-0.236	0.410	0.343	0.497
GVC_posij,t-1	-0.612	-0.659	-0.546	-0.632	-0.686	-0.534
N	29184	29133	29293	30352	30323	30463
R2 (lnw)	0.88	0.88	0.89	0.88	0.88	0.89
R2 (lnEmp)	0.90	0.90	0.90	0.90	0.90	0.90

Notes: as under Table 3. Mean/Min/Max coefficients – average/min/max values of coefficients of specifications in which one by one industry are excluded. R2, N, also reported as mean/min and maximum value of the statistics.

Source: own compilation

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