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Global value chains and labour markets – simultaneous analysis of wages and employment

Sabina Szymczak  and Joanna Wolszczak-Derlacz 

Faculty of Management and Economics, Gdańsk University of Technology, Gdańsk, Poland

ABSTRACT

This study examines the overall effect of global value chains (GVCs) on wages and labour demand. It exploits the World Input–Output Database to measure GVC involvement via recently developed participation indices (using both backward and forward linkages) and the relative GVC position using three-stage least squares regression. We find that the relative GVC position is negatively correlated with wages and employment and that the GVC participation effect depends on whether backward or forward linkages are considered. Moreover, we find heterogeneity across both countries (middle- vs high-income) and sectors (manufacturing versus services). Notably, the effect of GVC involvement on the labour market differs from that produced by traditional domestic trade.

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1. Introduction

This study addresses the link between global value chains (GVC) and labour markets.¹ In particular we conduct a simultaneous analysis of wages and employment effects of both GVC participation (backward and forward linkages) and the relative GVC position. It applies new and comprehensive GVC measures obtained by value-added or production decomposition (Wang et al., 2017a, 2017b).

In traditional theory, trade is a simple mechanism that explains downward pressure on employment and domestic worker wages due to a decrease in demand for work due to, for instance, increased import and substitution effects. On the other hand, an increase in jobs and wages for workers who produce export goods and services is known as the scale effect. These simple mechanisms have been substantially reconsidered due to the increasing complexity of production fragmentation along global value chains (Taglioni & Winkler, 2016; World Bank & World Trade Organization, 2019). Thus, it is prudent to look beyond the traditional textbook trade models to explain trade patterns and their labour market effects

CONTACT Sabina Szymczak  sabina.szymczak@pg.edu.pl  Faculty of Management and Economics, Gdańsk University of Technology, Narutowicza 11/12, Gdańsk 80-233, Poland

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¹ Value chain is ‘the sequence of productive (i.e. value-added) activities leading to and supporting end use’ (Sturgeon, 2001, p. 11). Such activities within the context of multiple firms and geographic locations on a global scale refers to the global value chain (The Global Value Chains Initiative, 2016).

as well as Stolper-Samuelson mechanism as the theoretical base of trade-wages analysis.² Grossman and Rossi-Hansberg (2008) described this wave of new models as a paradigm shift within the international trade literature. Different theoretical models focus on different aspects of international production fragmentation, often using different terms for the same phenomenon for the different channels and forces responsible for production fragmentation. International production fragmentation has been analysed from the perspective of trade in intermediates (Feenstra & Hanson, 1996; Yeats, 2001), foreign direct investment (Brainard, 1997; Ethier & Markusen, 1996), production fragmentation (Arndt & Kierzkowski, 2001; Jones & Kierzkowski, 2018), globalisation's second unbundling (in which Baldwin, 2006, notes the role of the ICT revolution), trade in tasks (Grossman & Rossi-Hansberg, 2008), and models of sequential production (Escaith, 2014), among others. Franssen (2019) correctly suggests the theoretical literature on the distributional effects of GVCs is abundant but ambiguous. He shows diverse predictions from alternative theoretical models that consider the effect of demand for unskilled labour to be influenced by offshoring of low-skill tasks. This situation is also confirmed by Hummels et al. (2018, p. 1021) in a survey of the offshoring literature in which they describe a variety of theoretical mechanisms through which offshoring could affect labour demand and wages, where 'the effects for workers depend on the model at hand'. This ambiguity also holds for the canonical trade-in-tasks model, in which the ultimate labour outcome results from three forces: productivity, relative price, and labour-supply effects (Grossman & Rossi-Hansberg, 2008). Indeed, the average productivity of domestic workers whose tasks are relocated can increase (since the tasks offshored are the least productive), thereby putting upward pressure on wages and, through industry expansion, the demand for labour. But relative price and the labour-supply effects work in the opposite direction, exerting negative pressure on offshored labour wages as supply increases (displaced by the relocation of tasks abroad). This negative effect on wages could stem from domestic workers' fears of losing their jobs, inducing them to accept a lower remuneration (Jeon & Kwon, 2021). It could also stem from labour relocation to lower-productivity firms not involved in international production fragmentation (Egger et al., 2015). The net outcome for wages or employment depends on which of these effects dominates. Thus, the problem remains open to new empirical evidence.

Empirical analysis generally seeks to gauge the impact of international production fragmentation on domestic workers regarding employment (i.e. job creation or job destruction) (Acemoglu et al., 2016; Harrison & McMillan, 2011; Michel & Rycx, 2012) or wages (Baumgarten et al., 2013; Ebenstein et al., 2014; Geishecker & Görg, 2013; Hummels et al., 2014; Wolszczak-Derlacz & Parteka, 2018). Wages and employment are not only tied naturally together but also simultaneously affected by GVC intensification through various channels per the theory cited above (Egger et al., 2015; Grossman & Rossi-Hansberg, 2008;

² For example, Hummels et al. (2018, pp. 989–990) notes 'Historically, the primary theoretical tool for the study of how trade affects wages has been Stolper and Samuelson [...]. [... empirical evidence] produces several puzzles that simple versions of Stolper–Samuelson cannot handle'. Another weakness pertains to the inability of traditional trade models based on factor-based comparative advantage to explain the trends observed in labour markets (e.g. the development of a skill premium). Our intention here is not to describe traditional trade models and their mechanism in details, but only indicate that GVC cannot be understood fully by their perspectives. See also Amador and Cabral (2016, p. 278) who note that 'GVCs cannot be perfectly understood with the traditional concepts of comparative advantage applied to countries and broad sectors'.

Jeon & Kwon, 2021). Hence, these labour market outcomes should be examined simultaneously, a gap that this study aims to bridge. Therefore, in this study we adopt three-stage least squares (3SLS) regression to simultaneously model the effect of GVCs on wages and employment (treated as endogenous variables),³ which corresponds to the complexity of the impact of GVCs on both the aspects of the labour market.

Additionally, what cannot be neglected in the production fragmentation analysis are backward and forward linkages. The former is usually emphasised more heavily in offshoring studies (see, e.g. Cardoso et al., 2021; Hummels et al., 2018). But domestic production can be linked with foreign markets through forward linkages as well (production embodied in exports of final or intermediate products). This market-access effect can either share the positive effect on domestic jobs or wages (as in the case of traditional trade) or enable downward pressure on labour market outcomes to meet foreign competition (Feenstra & Sasahara, 2018; Jiang, 2015). The picture becomes even more complex when we consider that the channels from foreign to domestic markets (and vice versa) can also act indirectly through global value chains. For instance, intermediate inputs imported by an industry for further production can expand the labour demand in downstream industries (Wang et al., 2018). Hence, it is essential to consider both forward and backward linkages in GVC participation, which this study addresses.⁴

Recent literature shows the relevance of not just the intensity of GVC involvement but also of the position within the GVC (World Bank & World Trade Organization, 2019). The effect of greater production fragmentation may differ depending on how far the country-sector is from the final or initial production stage. It can be explained via the uneven transmission of demand shocks into employment shocks. Thus, our study contributes to the literature by employing not just the measures of GVC participation but also a measure of a country-sector's relative position within the value chain. Additionally, it elaborates on a nonlinear specification with backward or forward linkage-based GVC production length.

We obtained data 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 via the recently developed GVC participation (using backward and forward linkages) and relative GVC position indices (Wang et al., 2017b, 2017a). Such measures differ from the first- and second-generation proxies for production fragmentation – they are based on the decomposition of production, not trade. Thus, they include important channels neglected by earlier indices (see Section 3). Additionally, the GVC position index is a relative measure that overcomes the limits of metrics such as ‘upstreamness’ and ‘downstreamness’, with a perspective from one end of the chain only (distance to final use, or from the initial production stage, as in Antràs et al., 2012). As a result, a final contribution is disentangling the GVC effects from those of traditional trade. The analysis takes a global view; basic specifications pool all sectors and countries (with appropriate dummies). However, extensions examine sector and country heterogeneity, comparing high- and low-income countries, and manufacturing and service industries. Further, to examine

³ As a robustness check we also employ the instrumental variables with generalized method of moments (IV-GMM) approach.

⁴ Although the measures regarding backward and forward linkages carry different information, they are correlated strongly enough to be included in separate models in order to avoid the multicollinearity problem. See further discussion together with robustness analysis in Section 4.

the distribution of losses and gains among different types of labour, extensions include estimates for workers with different skill levels.

2. The empirical literature and research problems

Empirical studies on global value chains differ in their findings on the nexus between labour outcome and GVC involvement.⁵ Production fragmentation has usually been seen as a threat to workers in developed countries (lost jobs and lower wages). The most widely studied case is undeniably that of the U.S. its trade relations with China and Mexico. For instance, Autor et al. (2013) and Pierce and Schott (2016) find that employment declines in the U.S. industries that are most exposed to Chinese competition.

Feenstra and Sasahara (2018) use global input–output (IO) analysis to quantify the employment effects of U.S. imports and exports. They find an increase in the total net labour demand, due to the significant growth in service exports outweighing the adverse impact of imports. Antràs et al. (2017) examine the issue at the firm level and find that domestic employment may increase, given the production expansion driven by imports, which would be a channel for the ‘productivity effect’. 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 and via input cost savings, imports of intermediates benefit sectors that come later in the value chain (even if they are not importers themselves), which imply potential employment gains. Their overall conclusion is that net employment and real wages increased due to trade with China, but with heterogeneity per educational attainment, since the less educated suffered wage declines.

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 education. For developed countries, well-educated workers bear the most severe negative impact. In their study period (1995–2009), the offshoring effect is stronger in manufacturing than services and stronger for broad than 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) in export firms. Despite the generally positive employment effect of being an exporter, Chinese competition in the European export market was responsible for the decline in this case. Jiang (2015), decomposing international trade into five components based on WIOD data for the 1995–2009 period, observes an increase in trade-generated employment for each one 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 the WIOD 2013 release data for five European countries, Japan, the U.S., and China, analyses several international trade effects on domestic employment, concluding that the restructuring of intermediate product value chains diminished domestic

⁵ The empirical literature on the trade-offshoring-GVC nexus and labour markets is voluminous and therefore, not reviewed here in depth. Rather, we want to note the main aspects and limits of previous empirical analyses, which will be further elaborated in this analysis. For an extensive review of the literature, see Hummels et al. (2018) or Cardoso et al. (2021).



employment in most of these economies. Fritsch and Matthes (2020) calculate the employment effects of intra-European intermediate consumption networks, defined as the derived labour demand based on exports of intermediate goods to other EU countries. They obtain much larger shares of this employment effect (in total employment) for Eastern European countries than major Western European economies, which means greater labour dependency on the Factory Europe observed in the East.

As far as wages are concerned, Ebenstein et al. (2014, 2017) find U.S. wages negatively responding to globalisation. Specifically, by assessing occupational exposure to trade and offshoring, these studies 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, although the authors further observe that technological change played a significant role. Polgár and Wörz (2010, 2011), analysing the relationship between openness to trade and wages at the industry level in 25 EU countries between 1995 and 2005, show that wages in Eastern Europe generally benefit from trade with the West, while the West-East trade has a negative but less significant effect.

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. Geishecker and Görg (2008, 2013) and Geishecker et al. (2010) present evidence of wage losses for the less skilled and gains for the highly skilled due to offshoring for Germany, the U.K. and Denmark. A modest decline in the wages of low- and medium-skilled workers due 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. These studies corroborate the trade-in-tasks (Grossman & Rossi-Hansberg, 2008) and 'offshorability' (Blinder, 2009) theories. Finally, Cardoso et al. (2021) perform a meta-analysis of empirical studies on offshoring and wages. After surveying 30 studies, the average effect is not significantly different from zero in either the origin or destination countries.

Hence, there are some obvious limits to most prior studies, which usually consider a single perspective (i.e. one aspect of the labour market – either earnings or labour demand). Moreover, existing studies are performed mostly from the perspective of backward linkages, with rare exceptions such as Pan (2020b) and Farole et al. (2018) that consider forward linkages as well. In the study based on the WIOD data, Pan (2020b) finds only a small positive impact of GVC participation (both linkages considered together) for the group of high-productivity economies. Using more traditional measures (from the World Bank's Export of Value Added dataset), Farole et al. (2018) obtain an overall positive employment effect of trade (the result of a negative effect of GVC integration and a positive impact of total exports). Our analysis considers the wage and employment effects of GVC simultaneously. We argue that GVC involvement may have different effects on wages and employment. Furthermore, we want to determine whether backward and forward linkages can have different effects on labour market outcomes and, if so, what these effects are.

Since it is well known that the labour market outcome of trade can be affected by the nature of the trade (final vs intermediate goods), it is surprising that this division has been rarely considered (Farole et al., 2018; Jiang, 2015; Pan, 2020a, 2020b). Therefore, to bridge this gap in the literature, we check whether the association between labour market outcomes and trade depends on if the trade involves final or intermediate products.

As noted in the introduction, the position along the value chain might be just as important as the magnitude of involvement in GVC. The literature on the impact of GVC position on labour market outcomes remains rather scant. 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, explained as a consequence of uneven transmission of demand shocks to employment shocks. Shen and Silva (2018) examine the effects of value-added trade with China on labour market outcomes in the U.S., and find that job losses are more pronounced in the sectors closer to final demand, where the demand shocks are relatively stronger. Szymczak et al. (2019) investigate differences in the wage response to GVCs, controlling for sectors' position in the value chain. The CEEC they study shows a smile curve in wages: higher in the sectors closer to either end of the chain and lower in the middle, confirming the U-shaped job polarisation for developing countries (Breemersch et al., 2017). Gagliardi et al. (2021), using employer-employee data for Belgian manufacturing, find a positive correlation between a firm's degree of 'upstreamness' and wages. Wages are generally higher for workers employed in more upstream firms, but with substantial heterogeneity in the gains per gender and earnings level. Mahy et al. (2019), from similar data, confirm the positive impact of upstreamness on wages, driven by the productivity channel. Hence, this study employs a recently proposed measure of position within the GVC (Wang et al., 2017a) to determine whether and how the labour market GVC effects depend on the position of a given country-sector along the chain.

The literature shows the importance of distinguishing the effects of production fragmentation on labour markets in developed economies from those in developing economies (Bontadini et al., 2019; Fritsch & Matthes, 2020; Taglioni & Winkler, 2016). Moreover, not all sectors are affected similarly given that the impact on services is negligible relative to manufacturing (Blinder, 2009; Crinò, 2010). But more recent studies find a bigger effect on services (Liu & Trefler, 2019; Taglioni & Winkler, 2016; World Bank Group et al., 2017). Another aspect is the 'servicification' of manufacturing, that is, the growing importance of services as inputs for manufacturing, activities within firms, or output bundled with goods (Fuster et al., 2020; Miroudot, 2017). Thus, this study considers the heterogeneity of national income levels. From prior findings, we hypothesise that low- and medium-skilled labour is affected adversely by involvement in GVCs, while skilled employees may benefit. We expect a relatively smaller impact of GVC in services than in manufacturing.

3. Data

3.1. Measures of global value chains based on input-output tables

We employed the IO tables from the latest 2016 release of the WIOD, which offers data for 43 countries and 56 industries. The GVC measures follow Wang et al. (2017a, 2017b), who determine GVC participation indices based on forward (GVC_part_f) or backward (GVC_part_b) industrial linkages, expressed by the formulas:

$$GVC_part_f = \frac{V_GVC}{V_a}, GVC_part_b = \frac{Y_GVC}{Y}, \quad (1)$$



where V_a is value-added, Y is final production, and V_GVC and Y_GVC correspond to the GVC-related components of each.⁶ Thus, 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? What percentage of final products produced by a country-sector comes from GVC activities?*’ (Wang et al., 2017b, p. 13). The former (latter) corresponds to the forward linkage-based (backward linkage-based) index and reflects the producers’ (users’) perspective. These indices describe GVC participation more completely than measures such as vertical specialisation (VS, VS1), employed in earlier works (Hummels et al., 2001; Koopman et al., 2014). Wang’s approach does not overlook such significant channels of country-sector involvement in GVCs as exports of domestic value-added embodied in intermediate exports used by the destination country to produce final products consumed domestically. The approach also doesn’t overlook the foreign value-added used for products consumed domestically. The GVC participation indices embrace production and trade, including the involvement of domestic factors in the GVC activities of a particular industry, which earlier works have not considered. Wang et al. (2017b) show that the previous measures may overestimate the real extent of participation for sectors with only limited direct exports. As it corrects for this bias, the new approach is relatively more accurate. It singles out GVC activity as a production process involving border-crossing. The two different calculation methods (from the user and producer perspectives) help determine the nature of a sector’s participation in production fragmentation (i.e. whether it is more downstream or upstream).

Another important notion considered by Wang et al. (2017a) is the relative position of a sector in a GVC, based on the ratio of forward to backward GVC production length:

$$GVC_pos = \frac{PLv_GVC}{PLy_GVC} \quad (2)$$

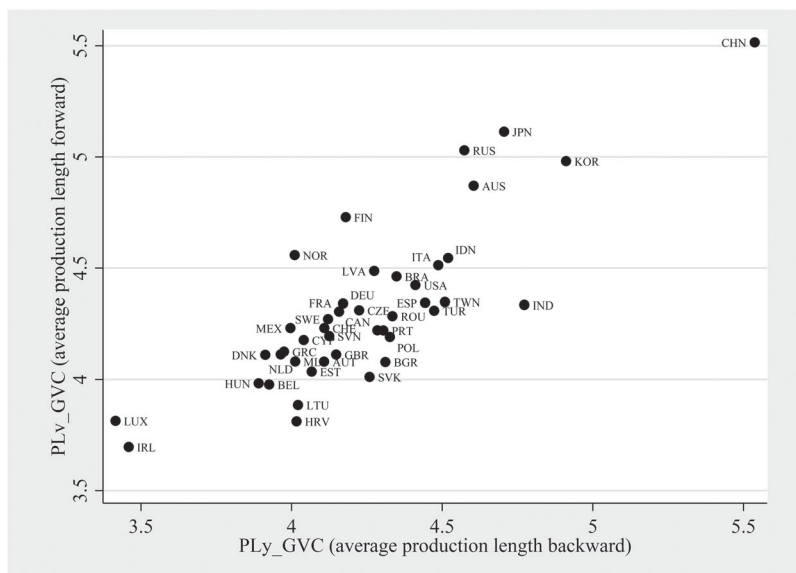
PLv_GVC (PLy_GVC) is the average production length forward (backward), calculated as a ratio of GVC-related domestic (foreign) value-added and its induced gross output (Wang et al., 2017a, pp. 23–24). The greater the value of PLv_GVC , the longer the production chain forward, hence the farther upstream the industry. The greater the value of PLy_GVC , the more production stages there are to the start of the chain, and the farther downstream is the industry.⁷

This interpretation of the relative position of a sector in a GVC is accordingly simple: the higher the GVC_pos , the more upstream the country-sector. This formula overcomes possible inconsistencies in measures based on forward or backward linkages only, insofar as it considers the distance to both ends of the chain. The measure is also robust to different aggregations of industries.

Figure 1 shows the average GVC production chain length (forward and backward) for various countries in 2014. High values of both indices for countries like China, Japan, and

⁶ For details on the methodology and formulas, see Wang et al. (2017a, 2017b). We calculate selected measures of GVC using R code included in online supplementary materials.

⁷ Wang et al. (2017a) highlight two important ways in which average production length differs from the gauge proposed by Dietzenbacher and Romero (2007); that is, average propagation length (APL). Apart from the difference in computation (to keep track of the actual start of the production line, hence the primary inputs), the average GVC production length has a different economic interpretation. That is, it represents the average number of times that value added associated with certain primary factors in a country-sector is counted as gross output along a production chain until it is embodied in final products. APL, however, measures the average number of stages of exogenous shock transmission between two industries (Wang et al., 2017a, pp. 4–5).

Figure 1. Average GVC production length (forward and backward) – means by country, 2014.

Notes: averages weighted by total hours worked in industry.

Source: own elaboration based on Wang et al. (2017a) methodology, using WIOD 2016.

South Korea imply that they participate in long value chains, with many stages both backward and forward. By contrast, whether backward or forward linkages are considered, the length for countries such as Luxembourg or Ireland is relatively short. Some countries exhibit differences between the two indices; thus, on average, they are farther upstream (e.g. Finland and Norway) or downstream (e.g. India). It is crucial to recall that the new measures of Wang et al. (2017a) consider only the portion of production that is an element of GVCs.

3.2. Wages and employment in the GVC context

Based on WIOD's Socio-Economic Accounts, we calculate wages as total labour compensation over the total number of hours worked. The original data are in nominal terms. The real values, at 2010 USD exchange rates and 2010 constant prices, are obtained by dividing the nominal values by the household consumption deflator and converting them into USD at the 2010 exchange rate.⁸ In the study analysis, we keep data for 43 countries and 54 sectors (we exclude 'Activities of households as employers; undifferentiated goods- and

⁸ 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's 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 PPP as conversion factor. For China, the WIOD 2016 release 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 the Chinese economy, we employ data from Penn World Table on average annual hours worked (avh) by persons engaged, multiplied by the number of persons engaged. This is a satisfactory proxy in that the correlation between avh from WIOD and avh from Penn World Table is, on average, .83 for other countries.



Table 1. Real hourly wages (in USD), GVC participation indices (backward and forward) and GVC position, for 2000 and 2014.

		Middle-income countries		High-income countries	
		Manufacturing	Services	Manufacturing	Services
Real hourly wages in USD	2000	1.749	2.003	27.805	30.330
	2014	2.897	3.329	32.579	33.228
GVC_part_b	2000	0.152	0.080	0.194	0.062
	2014	0.161	0.063	0.262	0.081
GVC_part_f	2000	0.123	0.073	0.215	0.065
	2014	0.145	0.069	0.291	0.085
GVC_pos	2000	0.912	0.987	0.916	1.080
	2014	0.868	1.012	0.897	1.029

Notes: Real hourly wages expressed as means and weighted by total hours worked in industry.

Source: own elaboration based on methodology of Wang et al. (2017a), using WIOD 2016, R-codes on GVC measures provided in supplementary materials.

services-producing activities of households for own use' and 'Activities of extraterritorial organisations and bodies').⁹

The study employs statistics and figures to address the labour market and GVC ties. Table 1 provides the mean values of real hourly wages, GVC participation indices, and GVC position. In all the groups, wages rose between 2000 and 2014. GVC participation also increased across the board, except for the services sector in middle-income countries, where both backward- and forward-linkage indices showed a decline.

Figure 2 presents the disaggregated data on wages and GVC position in 2000 and 2014 (for five main sectors). Middle-income country sectors are placed above the line, indicating a shift towards relatively more upstream positions, while high-income countries are below it (a shift towards more downstream positions). The evidence suggests that the gap between the positions taken in the chain by the two groups widened in our period. All the data reinforces the hypothesis of the differential response of sectors and country groups to GVC. The greatest difference in *GVC_pos* between those two groups of countries is in the construction sector (probably because high-income countries specialise in R&D activities, which are close to the upstream end).

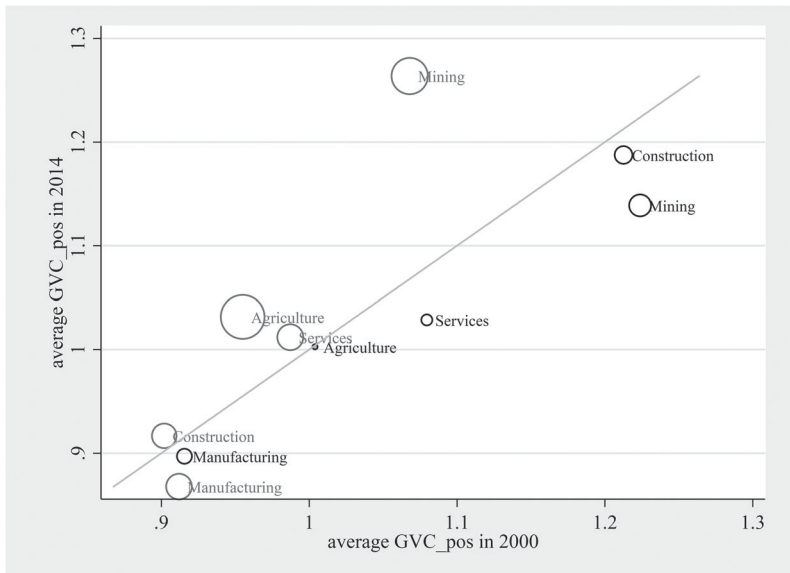
Figure 3 shows how the employment levels, GVC participation indices, and their components changed after the base year of 2000. For the whole period, employment grew faster in services than in manufacturing, while GVC participation shows growth, with fairly similar patterns (backward and forward) in the two sectors. In the last years of the period, GVC participation and employment stabilised, especially for manufacturing. Only service employment continued to increase and was not majorly impeded by the global crisis. For manufacturing, after the crisis, the return to expansion came first in GVC participation and, after a delay, in employment. It is also worth noting that the growth of both total value added as well as final production were lower than the growth in corresponding GVC components used to calculate the GVC indices.¹⁰

⁹ For the full list of sectors, see Timmer et al. (2015).

¹⁰ GVC participation indices are expressed as the ratio of GVC-related components (backward or forward) to gross output/value added. We also checked separately for the growth of nominators and denominators; see Table S15 in the supplementary materials to note that the trends in indices are in line with trends in absolute values of GVC components. Theoretically, more exports of intermediate products do not necessarily increase GVC participation index. The reason is that the denominator could increase even further, for example, because the same country-sector generates additional value added to meet a rising domestic final demand. We thank a referee for pointing this out.



Figure 2. Average GVC position in 2000 and 2014 and relative change in wages – means by sector for different country groups: middle and high income.



Notes: GVC_pos averages weighted by total hours worked in industry. Bubble size represents relative change in wage (2000–14), weighted by total hours worked. For Agriculture in high income countries the change had a negative sign.

Source: own elaboration based on Wang et al. (2017a) methodology, using WIOD 2016.

4. Empirical analysis

4.1. Empirical specification and estimation method

As noted, the prior studies have examined the impact of GVC either on the employment or wages of domestic workers. This study employs 3SLS to estimate a system of structural equations:

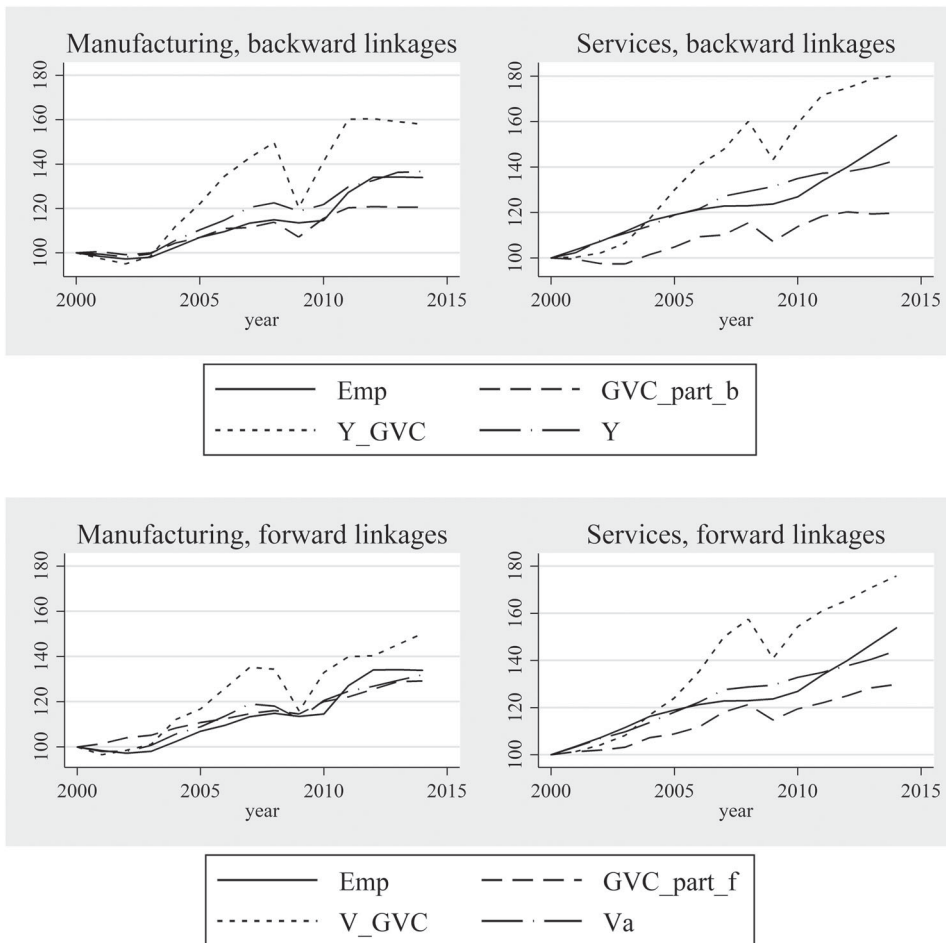
$$\ln w_{ij,t} = \alpha + \beta_1 \ln \text{Prod}_{ij,t-1} + \beta_2 \ln \text{Emp}_{ij,t-1} + \beta_3 \text{Trade}_{ij,t-1} + \beta_4 \text{GVC_part}_{ij,t-1} + \beta_5 \text{GVC_pos}_{ij,t-1} + \gamma_i + \delta_j + \theta_t + \epsilon_{ij,t}, \quad (3)$$

$$\ln \text{Emp}_{ij,t} = \alpha + \beta_1 \ln \text{Prod}_{ij,t-1} + \beta_2 \ln w_{ij,t-1} + \beta_3 \text{Trade}_{ij,t-1} + \beta_4 \text{GVC_part}_{ij,t-1} + \beta_5 \text{GVC_pos}_{ij,t-1} + \gamma_i + \delta_j + \theta_t + \epsilon_{ij,t}, \quad (4)$$

where i denotes sector, j country, and t time. Equation (3) is a wage regression where the log of the real hourly wage (in 2010 USD exchange rates at constant 2010 prices) is regressed on the number of variables. Productivity ($Prod$) is measured as a real value-added over the total number of hours worked, and employment (Emp) is measured as a total number of hours (in millions) worked in the sector. $Trade$ denotes the traditional (Ricardian) trade component (Wang et al., 2017a, 2017b). The involvement in GVC, gauged by GVC_part , refers to the participation index in Equation (1). GVC_pos refers to the production chain position index in Equation (2).



Figure 3. Changes in employment (number of total hours worked), GVC participation indices and their components (2000 = 100).



Source: Own elaboration based on Wang et al. (2017a) methodology, using socioeconomic accounts data from WIOD 2016. (in real terms).

Note that GVC_part can be measured via forward or backward industrial linkages. Similarly, traditional trade components may come from the decomposition of value-added (forward linkage-based approach) or the decomposition of final production (backward linkages).¹¹ All regressors are expressed as lags, given that the wage and employment adjustments to GVC participation are not instantaneous. A similar approach is taken by Ebenstein et al. (2017). Equation (4) represents the labour demand function, measured by employment (Emp).

¹¹ We include separately forward and backward linkages-based measures (regarding either GVC or Trade) because they are highly correlated (correlation coefficient for $Trade_b$ and $Trade_f$ equals .78 and for GVC_part_b and GVC_part_f it is .58; both correlations highly statistically significant). Including both types of indices in one regression could lead to the biased caused by the multicollinearity problem. In robustness checks, we repeat the analysis taking into account both forward and backward linkages based GVC indices simultaneously in one regression.

In both specifications, we include industry (γ_i), country (δ_j), and time (θ_t) fixed effects. The inclusion of fixed effects should solve several problems, such as GVC possibly being more intensive in certain industries, including those with lower wages. Another possible problem is that GVC, wages, and employment can be affected by time-varying shocks. Moreover, some countries may be characterised by greater or lesser openness, hence the variable intensity of involvement in GVC. We adopt the 3SLS method proposed by Zellner and Theil (1962), in which $\ln w$ and $\ln Emp$ are correlated with the disturbances in the system's equations and treated as endogenous to the system.¹² It accounts for the interconnection between wages and labour demand, in accordance with Hicks-Marshall.

4.2. The results and interpretation

Table 2 presents the overall results for all countries and sectors. The GVC variables are lagged to address endogeneity in Granger style, and there is a full set of individual effects that should control for sector, country, and time trends.

The wage regression (upper panel) shows a positive and statistically significant coefficient for productivity, per microeconomic theory (Meager & Speckesser, 2011), and a negative coefficient for employment. Traditional trade in final goods is negatively correlated with wages only in the case of backward linkages. For forward linkages, the coefficient is not statistically significant. In all specifications, the GVC participation coefficient is negative and statistically significant: wages are lower in countries and sectors more heavily involved in GVCs. Further, the negative coefficient for the GVC position means that wages are lower in countries and sectors further from final production.

The employment regression yields negative coefficients for productivity and wages and positive coefficients for traditional trade. 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. For forward linkages, however, the correlation becomes positive – the greater the participation, the higher the labour demand.

This initial general specification suggests some interesting conclusions. First, the association between international trade linkages and labour market outcomes can differ between wages and labour demand. For example, trade in final goods (analysed from the backward perspective) is related negatively (positively) to labour compensation (labour demand). That is, domestic workers must accept lower wages but the domestic value added in final exports increases labour demand. As a result, there is no threat to domestic employment.

Second, traditional trade and GVC can have different impacts on labour market outcomes depending on whether trade involves final or intermediate products, which is expected by the 'new' new trade theory (Feenstra & Hanson, 1996; Melitz, 2003; Shiozawa, 2007). For example, in the case of employment and backward linkages, the (positive) effect of traditional trade is counteracted by the (negative) effect of trade in intermediate goods.

¹² In our view, ordinary least squares (OLS) and seemingly unrelated regression (SUR) equations yield biased and inconsistent estimates, since the endogeneity of the dependent variables (wages and labour demand) is not accounted for. The superiority of 3SLS over OLS is confirmed by statistical tests (see statistics under Table 2). This study presents several tests and statistics to check the accuracy of the model employed: Breusch-Pagan Lagrange Multiplier Diagonal Covariance Matrix Test, mean arctangent absolute percentage error (MAAPE), and system-adjusted R^2 . In the robustness section we also check the estimations on the bases of IV-GMM for the separate wage and employment regressions.

Table 2. 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: lnw								
lnProd _{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]
lnEmp _{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]
Trade _{ij,t-1}	-0.029* [0.016]			-0.051*** [0.017]	-0.003 [0.024]			-0.018 [0.024]
GVC_part _{ij,t-1}		-0.104*** [0.029]		-0.097*** [0.031]		-0.044** [0.018]		-0.058*** [0.019]
GVC_pos _{ij,t-1}			-0.069*** [0.019]	-0.082*** [0.021]			-0.069*** [0.019]	-0.106*** [0.021]
Dependent variable: lnEmp								
lnProd _{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]
lnw _{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]
Trade _{ij,t-1}	0.349*** [0.032]			0.198*** [0.033]	0.382*** [0.048]			0.181*** [0.048]
GVC_part _{ij,t-1}		-0.318*** [0.060]		-0.361*** [0.061]		0.507*** [0.036]		0.410*** [0.039]
GVC_pos _{ij,t-1}			-0.799*** [0.039]	-0.612*** [0.041]			-0.799*** [0.039]	-0.633*** [0.041]
N	29,764	31,316	31,280	29,735	30,954	31,254	31,280	30,925
R2 (lnw)	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
R2 (lnEmp)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
System Adj R2	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
MAAPE (lnw)	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
MAAPE (lnEmp)	0.16	0.17	0.17	0.16	0.16	0.17	0.17	0.16
OLS-3SLS test	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Industry, country and time dummies included in all specifications, 3SLS regressions. System identification (Baum, 2007) checked (positively) for each specification. System Adj R2 refers to McElroy (1977) adjusted R-squared. MAAPE – mean arc tangent absolute percentage error (Kim & Kim, 2016). OLS-3SLS test is the Breusch-Pagan Lagrange Multiplier Diagonal Covariance Matrix Test (Shehata, 2014); p -value reported in the table.

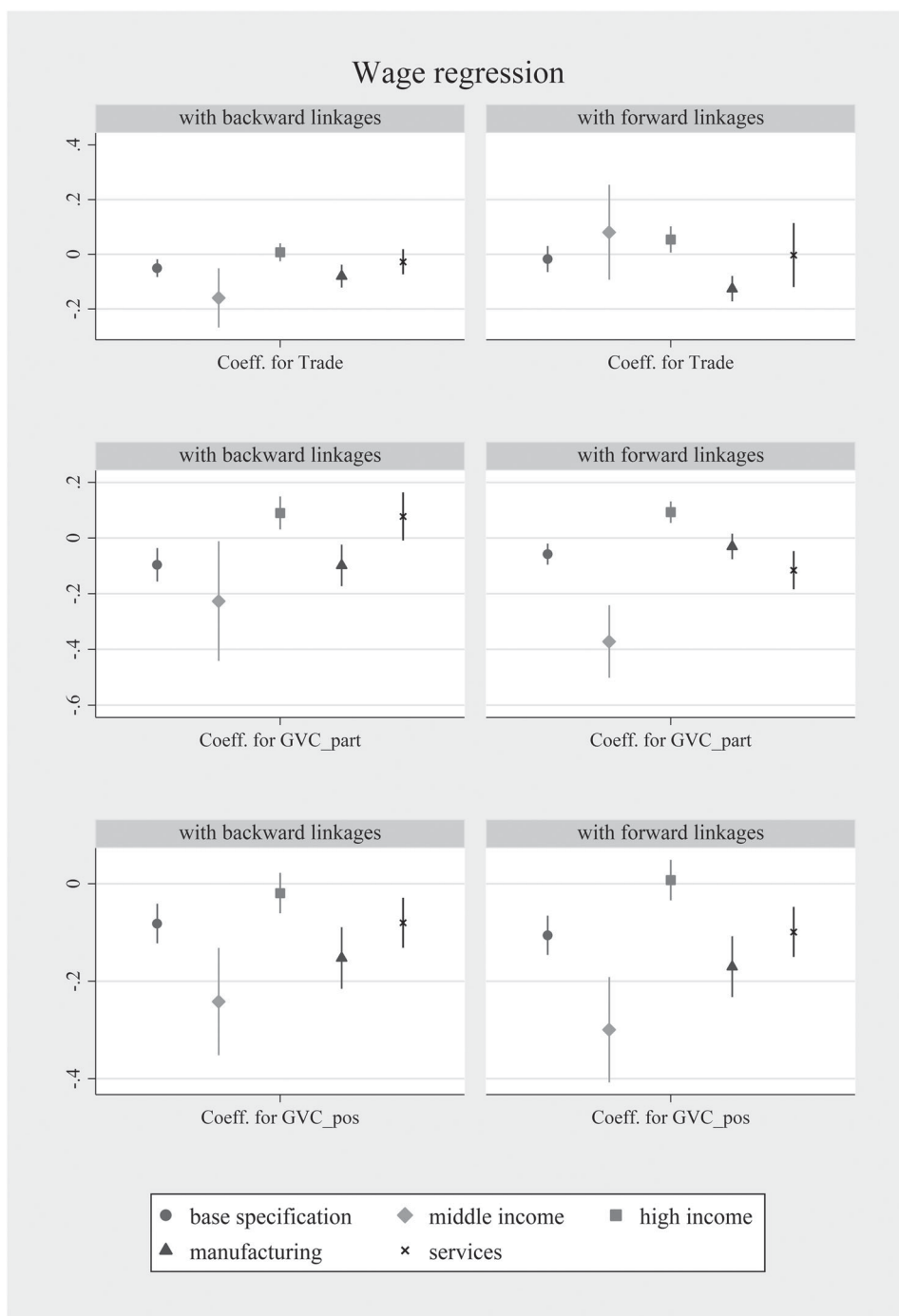
Source: Own compilation.

Third, the differences between backward and forward linkages within the labour market are not surprising; they can be viewed as analogous to the effects of imports and exports of final goods. In traditional trade theory, we expect imports (exports) to undermine (bolster) domestic employment. In our case, this difference is found for trade in intermediates, depending on whether the linkage is backward or forward. In other words, employment is correlated inversely with backward and directly with forward GVC participation. This result is in accordance with the concept of GVC participants facing different consequences of involvement in GVC when they decide to assume the role of buyers or sellers (Tagliani & Winkler, 2016).

Finally, the results indicate the importance not only of GVC participation, but of position along the chain as well; generally, country-sector pairs farther from final consumption have lower wages and employment. This observation will be examined in the extension analysis when we introduce the nonlinear relationship.

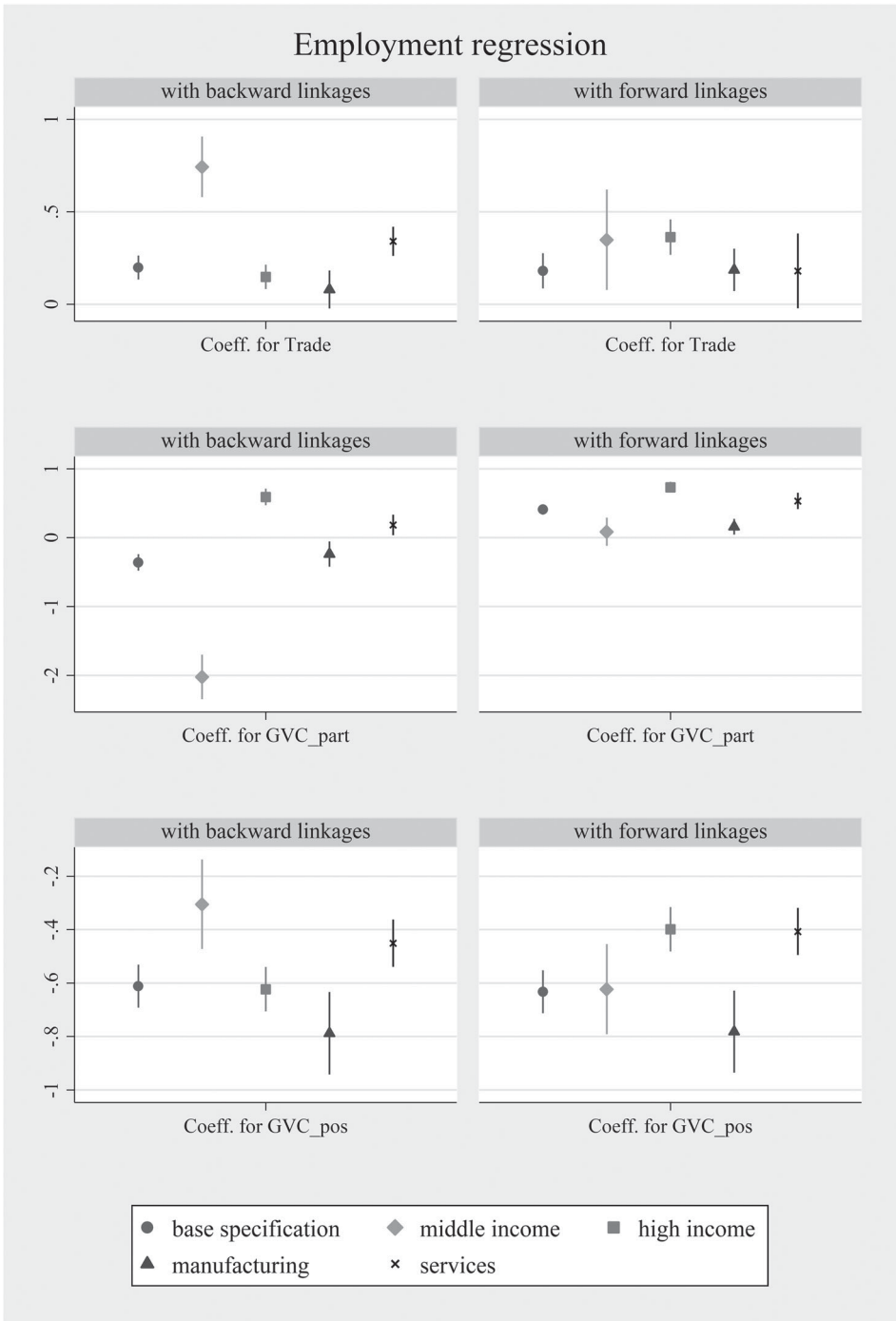
Moreover, country and sector heterogeneity is examined more thoroughly below. We distinguish between middle- and high-income countries, drawing from the North-South

Figure 4. Estimation results – coefficients for *Trade*, *GVC_part* and *GVC_pos* for the wage regression, base specification and different country and sector groups.



Notes: Base specifications (all countries and sectors pooled) – specifications (4) and (8) from Table 2. Analogous specifications for different country and sectors groups including other independent variables: $\ln\text{Prod}_{i,t-1}$, $\ln\text{Inw}_{i,t-1}$, $\ln\text{Emp}_{i,t-1}$ as well industry, country and time dummies. Middle income countries: BGR, BRA, CHN, IDN, IND, MEX, ROU, RUS, TUR.
Source: own compilation.

Figure 5. Estimation results – coefficients for *Trade*, *GVC_part* and *GVC_pos* for the employment regression, base specification and different country and sector groups.



Notes: as under Figure 4.

Source: own compilation.



trade models (e.g. Feenstra & Hanson, 1996) and following the World Bank classification. Given the trade-in-task framework (Grossman & Rossi-Hansberg, 2008), we also distinguish between two groups of sectors: manufacturing and services. We estimate the analogous regressions as in specifications (3) and (4) reported in Table 2 (our base specifications), including all covariates as well as country, industry, and time dummies. Figures 4 and 5 only present the results for the coefficients of interest (*Trade*, *GVC_part* and *GVC_pos*) to facilitate the cross-country and cross-sector comparison. Each dot represents the parameters obtained for a regression for a given country or sector group, where the dependent variable is log wage or employment in the 3SLS specification.¹³

Generally, the results confirm that the labour markets of middle-income (not high-income) countries are affected adversely by globalisation. Specifically, in the wage regression, traditional trade measured by backward linkages is correlated negatively with wages in the middle-income countries and positively in the high-income countries when measured by forward linkages. Further, GVC participation correlates positively (negatively) with wages in the high-income (low-income) countries, regardless of linkage type. Finally, the coefficient for the GVC position index is negative for middle-income countries and statistically insignificant for high-income countries. This result might indicate that the competitiveness of less developed countries takes the form of downward pressure on the prices of productive factors. In other words, they are specialised in relatively low-value-added production segments (Antràs, 2020a).

Regarding employment, the correlation with traditional trade does not differ by country type. However, in high-income countries, greater GVC participation is correlated positively with employment. Imported intermediates, used for further production, encourage industry expansion, prompting an increase in labour demand (Grossman & Rossi-Hansberg, 2008; Pan, 2020a, 2020b). On the other hand, greater GVC participation is correlated negatively with employment in middle-income countries when measured by backward linkages, which suggests the presence of the simple substitution effect. GVC position is negatively correlated with labour demand in both country types.

To interpret whether the effect is major or minor, as well as whether it is counteracted or sustained by other effects, we perform a counterfactual experiment. We take point estimates from Table 2 and actual changes in factors of interest in the analysed period. On average, *GVC_part_b* rose from about 0.188 in 2000 to 0.227 in 2013; hence the change in *GVC_part_b* was equal to 0.039. For *GVC_part_f*, the change was equal to 0.063. Similarly, the average change in Trade factor in that period was equal to 0.021 for backward linkages and 0.012 for forward linkages. The average real hourly wage was USD 26.44 in 2001 and USD 30.69 in 2014. For employment the total number of hours (in millions) worked in industry was, on average, 1330 in 2001 and 1669 in 2014. Using values of estimated coefficients from Table 2, we calculate the contribution of each factor to the change in wage and employment (the detailed results are presented in the supplementary materials in Table S16).

For instance, the expected hourly wage could have been USD 0.10 higher if the GVC participation (measured either through backward or forward linkages) had not progressed. On the other hand, the positive effect on wages driven by upgrade of the GVC position is about

¹³ Detailed estimations of wage and employment regressions for different country and sector groups are available in the online supplementary materials.

USD 0.05 or USD 0.07 for the models employing backward or forward linkages, respectively. The effect of traditional trade is even smaller. Bearing in mind the average values of real hourly wage in USD, we interpret these effects as minor. A greater impact of GVC related factors is visible for employment than for wages; over 2.6% growth in employment is due to the increased forward GVC participation, which corresponds to, on average, almost 35 million hours worked. Regardless of the selected model, GVC position contributes to a little above 1.5% growth in employment.

Specifically, we must stress that the effect of traditional trade is generally lower than the effect of GVC participation. In case of employment and backward linkages, the (positive) effect of traditional trade is counteracted by the (negative) effect of trade in intermediate goods.

Our sample of countries is quite diverse: the levels of wages and employment differ between different income groups of countries, as presented in the Table 1. Therefore, an analysis of the economic significance of further estimates (high- versus middle- income) brings more specific insights. The actual changes due to the main factors of interest are presented in the Table S17 in supplementary materials. The response of wages remains economically modest, confirming empirical findings of Cardoso et al. (2021), among others, in this combined wages-employment model. The most noticeable impact of GVC is found for employment; around 5.15% growth in employment in high-income countries is due to forward participation, while a 3.75% drop in middle-income countries is due to backward participation. In this case the negative effect is once again mitigated by the positive impact of traditional trade (almost 2%).

Regarding sectoral heterogeneity, except for GVC position, which is negatively correlated with wages and employment in manufacturing and services, other globalisation measures show stronger correlations in manufacturing. Traditional trade and GVC participation are both negatively correlated with manufacturing wages. 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, manufacturing with backward linkage exhibits a negative effect. The forward-linkage index shows a positive correlation with employment in manufacturing and services. When it comes to the economic significance of these results (for the details, see online Table S18), we also observe higher economic significance for employment, for both sectors and linkages. This suggests that the globalisation effects emerge mostly through the changes in employment levels as compared to changes in wages.

The results indicate that the effects of globalisation (i.e. GVC involvement) on labour markets can differ between developed and developing countries and between manufacturing and services. These potentially dichotomous results for countries at different levels of development were illustrated in studies on the possible threat where the labour markets of advanced countries engage in global production sharing with developing countries. (On the U.S.-China relationship, see Autor et al., 2013; Lin et al., 2018; and Meng et al., 2020. On U.S.-Mexico, see Sethupathy, 2013. And on Western Europe-CEECs, see Polgár & Wörz, 2011).

Yet, these fears have not materialised. For instance, Wolszczak-Derlacz and Parteka (2018) find that the downward pressure on domestic wages due to offshoring to low-wage countries is quite modest, as confirmed in the meta-analysis by Cardoso et al. (2021).

Similarly, the employment effects are mixed. The threat of displacement of domestic workers in advanced countries by cheap foreign labour is not significant, despite some effects on specific skills, as analysed below. The positive association between GVC participation and labour market outcomes in high-income countries corroborates the finding of Pan (2020a) that by combining backward and forward linkages, GVC activities have a significant positive effect on total U.S. employment.

Even though services are drawing increasing attention in studies of production fragmentation and labour market outcomes (see, e.g. Crinò, 2010; Geishecker & Görg, 2013), our results suggest that manufacturing remains the hardest hit sector, especially from the perspective of backward linkages.

4.3. Extensions and robustness

We ran¹⁴ several robustness checks. First, the regression was augmented with additional country-specific variables; human capital index, GDP per capita, and openness measured via exports or imports over GDP, and additional data from the Penn World Table (Feenstra et al., 2015). The inclusion of the country-level variables tested the stability of GVC-wage-employment relationship, in addition to country-sector and time-fixed effects. This augmented specification confirmed the relationship between the various GVC measures and labour market outcomes.

Second, we checked the robustness of our sectoral variables, calculating real hourly wages at purchasing power parity (PPP), employing the ratio of capital to hours worked (a good proxy for value-added per hours worked, with a correlation coefficient of 0.85), and gauging labour compensation per person engaged (not total hours worked). None of these adjustments altered the conclusions substantively.¹⁵

Third, we checked country and sector heterogeneity more thoroughly by excluding one country or one sector at a time to see whether particular countries or sectors drive the results. The resulting mean coefficients were very close to baseline estimates.

Moreover, we estimated the wage and employment regressions not simultaneously by 3SLS but separately by GMM techniques to address the endogeneity problems. Specifically, we employed IV-GMM with alternative endogenous variables. The results¹⁶ corroborated the general conclusion.

In our baseline specification, we included country-sector productivity as an important determinant of wages and labour-demand. (For a literature review of theories on the wages, employment, and productivity nexus, see, e.g. Meager & Speckesser, 2011; or Sharpe et al., 2008.) Specifically, we derived the labour demand function from the cost function (see, e.g. Hijzen & Swaim, 2007). In this way, we cleaned out the potential effect of GVC participation on labour markets (wages and labour demand) through the productivity channel.¹⁷ As a robustness check, we ran an alternative model with a third equation, productivity explained by *Trade* and *GVC* related measures, to capture the potential effect of GVC participation on labour markets through the productivity channel thoroughly (see Table S13

¹⁴ Detailed results for this section are available as online supplementary materials.

¹⁵ The only 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.

¹⁶ See Table S12 in the online supplementary materials.

¹⁷ We thank a referee for pointing this out.



in the supplementary materials). The signs and significance of GVC impact on wages and employment remain very similar to our baseline results. Therefore, we believe that the inclusion of productivity does not indicate a bias in the results presented in the paper.

Additionally, we also repeat the analysis taking into account both forward and backward linkages-based GVC indices simultaneously in one regression. The results look similar to our baseline results (see Table S14).

Next, we run the estimations for workers in different skill categories – high, medium, and low, defined via the education level – to test the model in the presence of workers' heterogeneity (see, e.g. the skill-specific model of wage determination of Acemoglu & Autor, 2011). To calculate the wages and employment of high-, medium-, and low-skilled workers, we use the information on their shares in labour compensation and total hours worked from the WIOD 2013 release, which unfortunately provides data for only 35 industries for the 1995–2009 period. Accordingly, we limit the analysis to the 2000–2009 period (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 to map 54 sectors in the WIOD 2016 release.¹⁸ We conduct an analogous analysis with structural equations for wages and labour demand separately for high-, medium- and low-skilled workers. Table 3 presents the results. The figures illustrating the main coefficients are included in the supplementary materials.

For wages, the negative effect of traditional trade and GVC participation, gauged by backward linkages, is found only for the medium-skilled. For the others, the effect is not statistically significant. Regarding employment, backward GVC participation shows a negative correlation only for low-skilled workers, while forward participation is positively correlated with employment for all three skill groups. This highlights the importance of employing the analysis of both characterisations of GVC; intensity of participation and the position of an industry. It seems the distribution of skills needed along the production line and the corresponding distribution of created value-added (Shih, 1996) is much more significant for the wage-setting than the GVC participation.

For all specifications (wages, employment, and linkage type), GVC position is correlated inversely with outcome variables regardless of skill category. These results are in accordance with previous studies (Ebenstein et al., 2017; Geishecker & Görg, 2008; Wang et al., 2018; Wolszczak-Derlacz & Parteka, 2018), which make it clear that the costs and benefits of production fragmentation are not distributed evenly per skill level. Note that our analysis is for employed workers only. Thus, no conclusions can be drawn about how production fragmentation affects the displacement of workers or the earnings of those displaced.

Finally, to check for nonlinearities between the position along the chain and labour outcomes, we augment Equations (3) and (4) with backward or forward linkage-based production length of GVC activities inputted as a polynomial. We base our approach on the centrality-upstreamness nexus (Antràs & de Gortari, 2020), together with the theory behind the unequal distribution of the value-added along the production chain (Shih, 1996). Note that we do not use GVC_pos , which is the relative measure (ratio of

¹⁸ The WIOD 2016 release has 56 industries according to the International Standard Industrial Classification Revision 4, whereas the WIOD 2013 release has 35 industries according to NACE Revision 1. Mapping the industries, we have a higher level of aggregation in WIOD 2013, such as AtB (agriculture, hunting, forestry, and fishing). We then apply the labour shares of specific workers to all the disaggregated industries in the WIOD 2016 release; in this case, we apply it to A01, A02, and A03.



Table 3. Estimation of wage and employment regressions – selected worker groups: high (HS), medium (MS) and low skill (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_part _{ij,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_pos _{ij,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_part _{ij,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_pos _{ij,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	17,874	17,874	17,874	18,505	18,505	18,505
R2 (lnw)	0.88	0.86	0.91	0.88	0.86	0.91
R2 (lnEmp)	0.90	0.90	0.89	0.90	0.90	0.89
System Adj R2	0.89	0.89	0.90	0.89	0.89	0.90
MAAPE (lnw)	0.12	0.11	0.12	0.12	0.12	0.12
MAAPE (lnEmp)	0.17	0.17	0.18			
OLS-3SLS test	0.00	0.00	0.00	0.00	0.00	0.00

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. (3) and (4), not reported. Details of the statistics tests as under Table 2.

Source: Own compilation.

backward and forward linkage-based GVC production length). Instead, we use the production lengths (i.e. the average distance from the given end of the chain), following specifications similar to Szymczak et al. (2019). Results in Table 4 confirm that compensation is higher at the beginning and end of the chain, as per the so-called smile-curve hypothesis (World Bank & World Trade Organization, 2019). For labour demand, the shape of the curve depends on whether the backward or forward approach is taken. The forward-linkage approach shows an inverted U-shape relationship; higher employment in the sectors located in the middle of the chain. It may be a sign that production embodied in intermediate product exports prompts greater demand for workers employed in tasks like assembly, relative to those at the ends of the chain, such as R&D and marketing.

5. Conclusion

We have examined the nexus between sector-country participation in global value chains (GVCs) and labour market outcomes in a global context, using recent input–output-based measures of GVC ties. Global production links are measured via comprehensive GVC measures: GVC participation, GVC position, and GVC length, as recently developed by Wang et al. (2017a, 2017b). Our study



- i. addresses the relationship between involvement in GVC and labour markets with simultaneous consideration of labour compensation and labour demand;
- ii. distinguishes between traditional trade and trade in intermediate goods and services based on comprehensive decomposition of value-added and production;
- iii. considers backward and forward linkages in globally integrated production structures;
- iv. examines labour outcomes along the chain, considering country-sector position regarding the final demand;
- v. re-analyses country, sector, and labour heterogeneity;
- vi. provides a counterfactual exercise that assesses the economic significance of the results; and
- vii. includes R code to help other calculate selected GVC measures (see online supplementary materials).

Since our analysis assesses many aspects of GVC ties, it should be no surprise that the overall picture appears quite complex at first sight. The results differ with the dependent variable (wages or labour demand) and, importantly, with whether trade or GVC involvement is measured via backward or forward linkages. Essentially, the data indicate that relative GVC position is correlated negatively with wages and employment, while the effect

Table 4. Estimation of wage and employment regressions with additional GVC length measures: $GVC_length_{ij,t-1}$ and $GVC_length^2_{ij,t-1}$.

	Backward linkages		Forward linkages	
	(1)	(2)	(3)	(4)
Dependent variable: $\ln w$				
$Trade_{ij,t-1}$		-0.033** [0.016]		-0.039 [0.025]
$GVC_part_{ij,t-1}$		-0.119*** [0.033]		-0.069*** [0.020]
$GVC_length_{ij,t-1}$	-0.160* [0.087]	-0.138 [0.092]	-0.141*** [0.036]	-0.175*** [0.039]
$GVC_length^2_{ij,t-1}$	0.019* [0.011]	0.016 [0.011]	0.015*** [0.004]	0.018*** [0.004]
Dependent variable: $\ln Emp$				
$Trade_{ij,t-1}$		0.346*** [0.032]		0.282*** [0.050]
$GVC_part_{ij,t-1}$		-0.404*** [0.067]		0.505*** [0.041]
$GVC_length_{ij,t-1}$	-0.823*** [0.178]	-0.465** [0.183]	0.240*** [0.073]	0.650*** [0.077]
$GVC_length^2_{ij,t-1}$	0.108*** [0.022]	0.064*** [0.022]	-0.050*** [0.008]	-0.088*** [0.009]
N	31,297	29,746	31,285	30,930
R^2 ($\ln w$)	0.88	0.88	0.88	0.88
R^2 ($\ln Emp$)	0.90	0.90	0.90	0.90
System Adj R^2	0.90	0.90	0.90	0.90
MAAPE ($\ln w$)	0.11	0.11	0.11	0.11
MAAPE ($\ln Emp$)	0.17	0.16	0.17	0.16
OLS-3SLS test	0.00	0.00	0.00	0.00

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Industry, country and time dummies included in all specifications, 3SLS regressions. Other independent variables: $\ln Prod_{ij,t-1}$, $\ln w_{ij,t-1}$ or $\ln Emp_{ij,t-1}$ included as in eq. (3) and (4), not reported. Details of the statistics tests as under Table 2.

Source: Own compilation.



of GVC participation depends on whether the gauge is backward or forward linkage. Backward linkages are inversely correlated with both wages and employment. We find some heterogeneity between countries (middle- vs 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 confirms that the costs and benefits of involvement in GVCs tend to be unevenly distributed per workers' skill levels.

Looking more closely at some specific results, we can draw some broad conclusions and see how they relate to previous studies. First, our empirical analysis shows the negative correlation between GVC participation and labour compensation; that is, there is indeed a downward pressure on the wages of domestic workers in the sectors more involved in GVCs. This observation may indicate that among the forces at work in task relocations (Grossman & Rossi-Hansberg, 2008), the relative price effect and labour-supply effect dominate productivity gains. This explanation accords with the hypothesised 'threat effect', which forces domestic workers to accept lower wages for fear of job losses (even where production relocation is only potential, not actual, as shown by Jeon & Kwon, 2021). Our results confirm some of the earlier findings of negative correlation between international production fragmentation (usually measured by offshoring indices—backward linkages) and domestic wages (Parteka & Wolszczak-Derlacz, 2015; Szymczak et al., 2019; Wolszczak-Derlacz & Parteka, 2018; Zierahn et al., 2015). Further, the inverse correlation between labour compensation and GVC mainly holds for middle-income countries and medium-skilled workers (Wolszczak-Derlacz & Parteka, 2018), which may signal that less-developed countries tend to compete more on the price of production.

Regarding the relationship between globalisation ties and labour demand, we find that unlike international trade in final goods, backward GVC participation is associated with lower labour demand (probably through a substitution effect). Similar results are obtained by Foster-McGregor et al. (2016), with sector-level data on offshoring, and Farole et al. (2018), with a simple measure of 'GVC integration as a buyer'. But the negative association is restricted to middle-income countries and low-skilled labour only. The reverse relation is found for high-income countries, where greater backward GVC participation results in increased labour demand. This is in accord with the evidence produced by Pan (2020a) in a study of the U.S. and can be explained by the fact that imported intermediates used for further production may lead to industry expansion and therefore an increase in labour demand (Grossman & Rossi-Hansberg, 2008; Pan, 2020a). Further, both exports of final manufactured goods or services and exports of intermediate goods or services are positively related to sectoral employment, confirming the employment-inducing effect of exports (Farole et al., 2018).

Additionally, we note the relationship between GVC position and labour market outcomes. The negative and significant correlation between GVC position and wages in middle-income countries, as against a statistically insignificant correlation in high-income countries, may suggest that the more upstream position of less developed countries in the value chain does not work in their favour. Upgrading their position by specialising in more downstream production stages is a possible way of increasing wages. GVC position turns out to be negatively correlated with labour demand in both country sets. Hence, improving the country's position in the value chain is beneficial for not only wages but also labour demand. Such an improvement could be achieved via successful innovation (Meng et al., 2020).



Finally, based on the economic significance of the results, we conclude that the response of wages to GVC related factors remains economically modest, which confirms results from previous empirical findings (Cardoso et al., 2021). The effect is more visible for employment.

Against the above, we cannot neglect one major limitation of our study, namely its adoption of sectoral analysis rather than micro-level data that can consider workers' actual occupations. Ebenstein et al. (2017), for example, find no effect of trade on wages at the sectoral level. But they find an effect when the individual occupational variable is included. Furthermore, our analysis establishes broad empirical facts rather than causal interpretation. Causality must be explored more thoroughly in further studies.

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

Finally, the COVID-19 pandemic has surely affected global value chains. At the moment, we can only guess whether global chains will be translate into regional ones (Xiao et al., 2020) or the extent to which and for how long international trade will be hampered by protectionism (Antràs, 2020b). Moreover, we cannot know in advance which sectors or countries will react to the COVID-19 outbreak by 'reshoring' previously relocated tasks or production or how quickly the global links will be reconstructed. Even so, we can be certain that this extraordinary new situation will not diminish the research interest in international trade, global value chains, and their impact on labour markets.

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ORCID

Sabina Szymczak  <http://orcid.org/0000-0001-8690-0891>

Joanna Wolszczak-Derlacz  <http://orcid.org/0000-0002-3392-5267>



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