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Abstract

This paper provides empirical evidence on the relationship between patterns of integration in global value chains (GVCs), the ‘quality’ of such integration in terms of technological capabilities and the structure of employment in European countries and sectors. We study employment shares in fabrication and headquarter occupations in terms of functional specialisation and employment upgrading, making two specific contributions. First, we explicitly account for pre-existing asymmetries in employment structure. Second, we account for the complex role of technology both in terms of country-industries’ own initial technological intensity and that of their GVC partners. To achieve this we blend data on employment, trade in value added, patents and intangible asset stocks, for the period 2000-2014. We find that such pre-existing asymmetries are highly persistent over time with little sign of convergence in employment structure over our observed period. Furthermore GVC participation is not related, in and of itself, to changes in employment structure. However, this relationship appears to be mediated by country-industries’ initial technological position. Technological leaders exhibit greater shares of employment in headquarter functions as they increase their integration in GVCs; in contrast country-industries that start off as technological laggards see further integration in GVCs alongside an increase in the share of employment in fabrication functions.

Keywords:

Global Value Chains; Technology; Intangible assets; Employment

JEL codes:

F14, F15, O33

1. Introduction

Global value chains (GVCs) are forms of international production which involve growing trade in intermediates and international fragmentation of the production process (Antràs 2020). GVCs have reshaped the international division of labour and led to the emergence of headquarter and factory economies (Timmer *et al.* 2019; Baldwin and López-Gonzalez 2015; López Gonzalez *et al.* 2019). In the case of Europe, for instance, Germany is a headquarter economy while factory economies in Eastern Europe integrate in GVCs providing low technology intermediates and remaining on the periphery of production networks (Milberg and Winkler 2011; Cirillo and Guarascio 2015; Garbellini *et al.* 2014; Celi *et al.* 2018).

Against this backdrop, the flourishing literature on GVCs has extended the Heckscher-Ohlin models by considering new forms of trade specialisation in intermediates and tasks (Grossman and Rossi-Hansberg 2008, 2012; Antràs 2020). Timmer *et al.* (2019) (see also de Vries *et al.* 2021) have coined the term functional specialisation in trade and argue that this is the third generation of ways to conceptualise and measure GVCs. The first was traditional trade specialisation, measured in terms of the gross export of (finished) products, while the second was vertical trade specialisation, measured in terms of the value added embodied in exports. This captures the international fragmentation of production and gives a more accurate picture of trade specialisation. The novel, third-generation conceptualisation and measurement of GVCs builds on the second by adding the characteristics of the functions associated with the trade specialisation which, in turn, refer to its task and labour dimensions. Functional specialisation, it is argued (Timmer *et al.* 2019), is more informative than sectoral or vertical specialisation in trade particularly in the context of trade in value added as it (loosely) considers the factors (tangible and intangible capital and labour) and the functions/activities ('fabrication' and 'R&D and managerial activities') that contribute to the particular specialisation of a country.

The concept and measurement of functional specialisation in trade bridges neatly with (and might add to) a whole strand of literature that has looked at the employment and skills impact of offshoring, a subset of the whole possibilities of GVC integration – that is, the effects of the import of foreign value added on the relocation of jobs abroad (Autor *et al.* 2016). This large body of evidence has not yielded unequivocal results but a key insight emerging from the literature is the skill bias of offshoring, suggesting that it is mostly low-skilled and highly routinised jobs that are likely to be offshored, driven by cost-reducing strategies (Becker *et al.* 2013; Timmer *et al.* 2013; Bramucci *et al.* 2017).

More recently a (very few) number of contributions to the literature on offshoring and employment have attempted to incorporate the role of technology (Reijnders and de Vries 2018), albeit limited to ICT (Marcolin *et al.* 2016), in the growth and composition of routinised and non-routinised tasks. Reijnders and de Vries (2018) consider technological change in this context as limited to automation and representing an alternative cost-cutting strategy to the offshoring one, i.e. firms would decide either to automate and therefore replace routinised tasks, saving on costs, or to offshore and therefore access cheaper routinised occupations abroad.

However, technological change has a more complex nature and impact than the strategies of automation and replacement of routinised tasks which have dominated the most recent literature on the effects of technology on occupations, tasks and skills (Acemoglu and Restrepo 2017; Autor *et al.* 2015). Technical change is associated with investments in tangible and intangible capital that might be complementary to, rather than substitutive of, certain occupations and which, at the same time, affect strategies of insertion in GVCs (Alsawami *et al.* 2020). Also, in a trade context, it is not only firms' strategies that affect automation, offshoring and jobs replacement. These decisions depend on structural differences in countries' technological development and asymmetries in technological specialisation¹ that, in turn, affect how countries, sectors and firms position themselves along GVCs (Simonazzi *et al.* 2013; Altzinger and Landesmann 2008). These factors affect employment directly and via countries' trade specialisation and performance.

The aim of this paper is to analyse the effects of GVC insertion on the opportunities for employment upgrading by taking into account the effects of country-sector technological asymmetries on the quality of such insertion. We therefore add to the concept of the functional specialisation of trade in a twofold way.

First, we explicitly consider the dynamics of the functional specialisation of GVCs as a process of employment upgrading – that is, a shift in countries' and industries' employment structure from fabrication activities (intensive in manual workers) to R&D and headquarter activities (intensive in managerial occupations) that might (or might not) be due to the process of insertion in GVCs. In studying this process, we focus on countries' initial employment structures which constrain their opportunities to gainfully insert in GVCs.

Second, we account for the complexity of the role of technology in terms of its effects both on the quality of insertion in GVCs and the potential for employment upgrading mentioned above. We do so by studying the relationship between GVC integration and employment composition, taking into account both the initial positioning of countries and industries in terms of their technological intensities and the technological intensity of their GVC partners.

1. Accounting for these structural conditions is at the centre of the technology-gap approach to trade (Dosi *et al.*, 1990, 2015).

We focus on a sample of 21 European countries and 49 industries over the period 2000-14. The EU has experienced several interesting dynamics that have reinforced the north-south and east-west divides, including the integration of Eastern European countries and the long-term industrial leadership of core EU countries. These phenomena have led to the concentration of the highest value added segments of GVCs in continental Europe – namely Germany – and the emergence of new peripheries (Wirkierman *et al.* 2021). We analyse these dynamics by building on the concept of functional specialisation in GVCs and offering evidence on the technology and employment upgrading opportunities (or lack thereof) linked to insertion in GVCs.

From a methodological perspective this paper contributes to the literature by complementing the existing measures of GVC integration with measures of the patent and intangible asset intensity of partner countries and industries. In doing so, we provide a novel and rich empirical mapping that allows a characterisation of the quality of country-industries' participation in GVCs.

In order to draw this multifaceted picture of trends in GVC participation, technology and employment in European countries, we combine several sources: the World Input-Output Database (WIOD) for standard GVC participation measures; OECD-REGPAT and INTAN-Invest for patent and intangible asset intensities, respectively; and the EU Labour Force Survey (LFS) for employment across occupations and sectors. We then use GVC participation measures to weight the average patent and intangible asset intensity of each country-industry's partners, providing new insights on the technological quality of GVC participation.

We explore how these measures relate to the distribution of jobs across different occupational categories, focusing mainly on headquarter and fabrication functions as defined in Timmer *et al.* (2019).² Drawing on these different sources, our empirical analysis provides new descriptive evidence on the trends of GVC integration, its quality and the changes in employment structure in Europe over the 2000-14 period. We then test the structural relations among these variables, focusing in particular on how country-industries' initial features mediate the relationship between GVC integration and employment structure, through regression analysis.

Our analysis yields three key results. First, despite a sustained process of economic integration and increasing GVC participation, functional specialisation is highly persistent over time with no sign of convergence in employment upgrading over time.

2. We should point out that, while we use the same classification of occupations into functions as Timmer *et al.* (2019), we do not use indexes of functional specialisation computed in the same way as the authors. This is because we look at employment shares rather than Balassa indexes based on wage bills. This being said, we are confident that employment shares are still an effective proxy for the functions being carried out and the type of activities available to workers within each country-industry and therefore of that country-industry's position in GVCs.

Second, rather than the intensity of GVC participation, it is its quality, and specifically the intangible asset intensity of GVC partners, that is relevant for country-sector employment structures. We find that, in the manufacturing sector, countries that import value added from intangible intensive partners also tend to employ higher shares of managers and lower shares of manual workers – i.e. a specialisation in headquarter functions and away from fabrication ones.

Third, the initial conditions in terms of technological positioning matter as they affect how GVC participation and its quality are related to country-industries' employment upgrading trajectories. In particular, countries that start off with an advantage in patent intensity are more likely to see their share of employment in headquarter functions increase as they further integrate in GVCs. The opposite occurs for country-industries that were lagging behind in patent intensity at the beginning of our observed period.

These findings are of great relevance to policy. The current economic crisis triggered by the pandemic has laid bare the importance of the European Union in the coordination of policy efforts for economic recovery. Further economic integration – that might exacerbate existing asymmetries – needs to be accompanied by appropriate policies to foster economic cohesion and mitigate these effects.

2. Literature review

2.1 Asymmetries in the new international division of labour and GVCs

The increasing fragmentation of production within and across national borders over the last decades has drawn growing attention from scholarship and policy-makers alike. This phenomenon has brought about a spatial concentration of ‘factory economies’ that specialise in the low-tech phases of production chains around ‘headquarter’ centres that have retained higher value added activities such as R&D and managerial functions (Baldwin and López-Gonzalez 2015). Importantly, closeness to ‘headquarters’ matters particularly as it favours the industrialisation of developing countries in the form of participation in existing GVCs (rather than ‘building (GVCs) from scratch’) (Baldwin and López-Gonzalez 2015: 4). For the specific case of Europe, Germany has been identified as leading the GVC network, surrounded by ‘factories’ such as Poland and Czech Republic (Grodzicki and Geodecki 2016; Stöllinger 2016; Celi *et al.* 2018).

The narrative around ‘headquarters and factory economies’ is reminiscent, in the context of GVCs, of ‘core-periphery’ models (Prebisch 1950; Fujita *et al.* 1999) to the (loose) extent that countries’ initial conditions, in terms of location, sectoral structure and technological capabilities, will affect their insertion in GVCs (see also Baldwin *et al.* 2005).

Different streams of literature have indeed been cautious in foreseeing the automatic positive effects deriving from joining a GVC, especially as the distribution of such gains might be unequal along the GVC.³ A growing body of literature takes a political economy lens to look at asymmetries in GVC integration in Europe, which is very relevant to the purpose of the present paper. Milberg and Winkler (2011) link the bargaining power of countries joining GVCs to the quality of their institutions which, they argue, play a significant role in shaping how the gains associated with GVC participation are distributed. Similarly Simonazzi *et al.* (2013) and Celi *et al.* (2018) take a structural approach to international production based on a geo-political economic framework. This literature understands phenomena such as the offshoring and restructuring of GVCs as the outcome of changes in the hierarchical organisation of value chains. These are, in turn, the result of changes in relationships between firms, sectors and, crucially, geographically identifiable

3. Among the first contributions to highlight asymmetries in power and their relationship with the distribution of gains along GVCs we find Gereffi (1994) and Gereffi *et al.* (2005).

locations. Concerning Europe's specific case, these authors recognise that the core of the European economy – i.e. the manufacturing network in which Germany is at the centre – has deployed a geo-economic strategy to strengthen its productive and technological capabilities and, therefore, solidify its market share. This strategy relies both on the offshoring of the production phases of intermediate products that can be purchased at cheap prices from Eastern European countries and the core's technological advantage that has been strengthened over time.

In line with this evidence, Grodzicki and Geodecki (2016) use World Input-Output tables to show 'Central and Eastern Europe's successful integration into the global value chains as well as its significantly larger dependence on global production networks, as opposed to Southern and North-Western Europe' (Grodzicki and Geodecki 2016: 377). Stöllinger (2016) has confirmed these changes in the European production landscape, highlighting the emergence of a new 'manufacturing divide': 'members of the manufacturing core benefit from participation in GVCs in terms of structural change towards manufacturing, whereas in other EU Member States GVC participation, if anything, accelerates the deindustrialisation process' (Stöllinger 2016: 801). While the contributions above discuss geo-political asymmetries at length, they rarely explicitly consider the role that technology has in furthering these asymmetries.

2.2 GVCs, technology and intangible assets

Over the last decades, a set of key issues within trade and GVC theories has emerged, namely: a) whether and under which conditions factory economies (and, more broadly, firms and industries) could benefit from becoming integrated within GVCs (OECD 2013); b) if and how they could upgrade their specialisation by moving towards the higher value added segments of those value chains (Taglioni and Winkler 2016; WIPO 2017); and c) the role played by the quality of the science, technology and innovation system in determining the different possible outcomes deriving from participation in GVCs (Pietrobelli and Rabellotti 2011; Lema *et al.* 2019).

Several contributions have highlighted the importance played by technology and knowledge assets in affecting the potential benefit stemming from participation in GVCs, translating the main insights of the technology-gap approach to trade (Dosi *et al.* 1988, 1990, 2015; Fagerberg 1994; Cohen 2010; Laursen and Meliciani 2010; Maggi 2017) to the new context of international production and GVCs. Jona-Lasinio and Meliciani (2018) show that knowledge-based or intangible capital (including not only R&D but also design, training, organisational capital and brand) affect countries' ability to appropriate gains from GVC participation. Moreover, these intangible assets are usually highly scalable with minimal marginal costs that can quickly compensate the initial cost of investment (Durand and Milberg 2020). As a result companies that specialise in intangible-intensive segments of value chains will be in a position to appropriate a disproportionate share of the value added generated. Chen *et al.* (2017) estimate, by merging WIOD and national account statistics on capital stocks, the income generated by intangible assets in 19 global manufacturing value chains during the 2000-14 period. They find that the average

share of intangible capital income in final output has increased rapidly since 2000, albeit that it has levelled off after 2008 and with dynamic patterns that diverge across the sectors and stages of GVCs (see also WIPO 2017).

The literature on technological trajectories and GVCs has also highlighted that the specific trajectory that a country-industry takes depends to a large extent on the initial conditions of the country and the co-evolution of different factors such as the strategies and technological endowments of firms and industries and the qualitative structure of the national innovation systems in which they are embedded. Specifically, Mudambi (2008) shows that advanced countries tend to specialise in the intangible intensive stages of the GVC (with emerging countries specialising in manufacturing and assembling activities) while Lema *et al.* (2019) identify the different possible trajectories of insertion of developing countries in GVCs as well as the different possible outcomes in terms of technological upgrading/downgrading evolutionary patterns.

2.3 Offshoring, GVC integration and employment

The literature reviewed in the previous subsections has shown that the issue regarding the role of technology in shaping the structure and governance of GVCs, as well as the level and type of participation of firms and countries in GVCs, has been addressed only in recent years and by a small, albeit growing, number of contributions. The same can be said regarding the effects of participation in GVCs on employment which has seen the empirical literature on this topic grow significantly in recent years yielding, nevertheless, mixed results.

The first set of studies has focused on the relationship between offshoring, often proxied as import penetration, and employment. Amiti and Wei (2005, 2009), examining the cases of the United Kingdom and the US, find that, while offshoring leads to productivity gains, it does not have an impact on the labour demand of service offshoring. Consistent with these findings, Hijzen and Swaim (2007) look at 17 high-income OECD countries and find inter-industry offshoring does not change labour intensity but leads in contrast to an increase in overall employment. Other contributions find less encouraging results. An OECD study of 12 countries finds that material and service offshoring activities have a negative association with domestic employment (OECD 2007).

The literature has also focused on how offshoring affects the composition of employment across skill groups; the evidence is not conclusive but does point towards the existence of a skill bias, i.e. offshoring increases the share of the wage bill of high-skilled workers (Feenstra and Hanson 1996, 1999; Strauss-Kahn 2003; Hijzen *et al.* 2005; Falzoni and Tajoli 2012; Crinò 2012; Foster-McGregor *et al.* 2013). Interestingly Foster-McGregor *et al.* (2016) present evidence that partially contradicts the idea of skill biased offshoring, showing an unexpectedly larger negative effect on the employment of highly educated workers in high-income countries. The authors make sense of this result by suggesting that companies in high-income countries have also started to offshore high-tech functions.

A more recent strand of work has highlighted the role of task routinisation rather than skill requirement. In this instance theoretical predictions and empirical results are quite aligned, suggesting that routine intensive tasks are more likely to be offshored (Becker *et al.* 2013; Hogrefe 2013; Baumgarten *et al.* 2013; Ottaviano 2015). Subsequent contributions have raised the point that the relationship between offshoring/participation in GVCs and employment could also run the other way round. In fact, several studies have shown that the quality of the employment structure of a firm or a country represents a prerequisite for firms and countries to become involved in GVCs and to be positioned in the most qualitative stages of value chains. In particular Grundke *et al.* (2017a, 2017b) show that countries and firms with a labour force which is endowed with higher cognitive, ICT or science and technological skills provide more value added in their exports and tend to position themselves in production segments and functions characterised by these high-level competences.

The nexus between GVC participation, of which offshoring is a key component, the knowledge and technological endowments of countries and the ensuing occupational outcomes has so far received little attention. Marcolin *et al.* (2016) are among the first to shed light on the complexity of such linkages highlighting the existence of ‘complex interactions between the routine content of occupations, skills, technology, industry structure and trade, which do not allow for a neat identification of “winners” and “losers” in a GVC context’ (Marcolin *et al.* 2016: 3). The complexity of such interactions is further explored by the recent work of Marcolin and Squicciarini (2018) that, in line with the empirical agenda of our contribution, addresses empirically two main issues: a) how the skill composition of a country’s workforce shapes its specialisation and positioning along the global value chain; and b) the way in which GVC specialisation and positioning both determine, and are determined by, investment in selected knowledge-based capital assets and what this entails for policy. All in all, this work confirms the complexity of the interplay between GVC, technology and employment and, as a consequence, the difficulty of drawing from the evidence clear-cut policy implications and guidelines on how to get the most from participation in GVCs. Nonetheless it has the merit of defining the main issues and relationships at stake, providing relevant hints on the main channels through which technology and knowledge-based assets can shape the GVC-employment relationship. The empirical exercise proposed in this paper aims at shedding additional empirical light on some of these channels.

3. Measuring GVC integration, its technological quality and employment upgrading

In light of the literature discussed in the previous section we aim to make two key contributions exploring the nexus between GVCs, technology and employment. First, we frame employment upgrading as shifts in employment structure towards headquarter and away from fabrication functions. Second, we offer a rich empirical picture of country-industries' technological position and that of their GVC partners which we operationalise in terms of patent and intangible asset intensity.

To investigate the relationship between GVC participation, technology and employment structure, we compile a country-industry dataset combining a range of sources. This section discusses these in turn starting from traditional measures of GVC participation, then the data used to capture technological positioning and finally looking at the data on employment shares which we use as a proxy for employment upgrading.

3.1 Measures of GVC integration

In order to measure countries' participation in GVCs we rely on the 2016 release of the WIOD dataset which covers 2000-14 for 43 countries and 51 industries.⁴ The literature on Input-Output tables has developed a range of approaches to capturing industries and countries' participation in GVCs and the degree of fragmentation of production chains (for a review of the conceptual and methodological issues see Bontadini and Saha 2021; and Borin and Mancini 2020). We follow Borin and Mancini (2020) in expanding the approach of Johnson (2018) to what Koopman *et al.* (2014) refer to as foreign value added in gross exports, also known in the literature as backward GVC participation :

$$BWD_s = \sum_{r \neq s} V_r B_{r,s}^{\#} E_s \quad (1)$$

V_r is a diagonalised vector of value added as a share of total output in country-sector r . $B_{r,s}^{\#}$ is a modified version of the traditional Leontieff inverse that captures all inter-sectoral linkages among all countries and industries taking into account,

4. In our empirical analysis we aggregate some of these industries in order to make it possible to match information for NACE rev. 1 industries for 2000-07 from the EU Labour Force Survey; as a result we end up with 49 industries. Out of these we focus on manufacturing and service industries. We provide a complete list of the available industries in Appendix A.

however, that foreign intermediate demand for country-sector s is also present in the vector of gross export E_s :

$$B_{r,s}^{\$} = (I - A^{\$})^{-1} \quad (2)$$

$A^{\$}$ is a matrix of technical coefficients in which all rows corresponding to country-sectors have been turned to 0, as discussed in Borin and Mancini (2020). BWD_s informs us of how relevant foreign inputs are in the production of gross exports. As such, this can also be interpreted as a measure of offshoring, i.e. the segments of value chains that have been relocated abroad. BWD_s is expressed in absolute terms and, in order to account for size effects, we divide it by country-industry total output:

$$Bwdint_s = \frac{BWD_s}{Output_s} \quad (3)$$

We prefer to use output as the denominator rather than exports or value added. This is because, at country-industry level, value added can be very small or even negative and it would be a less stable measure of productive capabilities than gross output. Concerning exports, we prefer to use output to have a more accurate understanding of how different inputs feed into the productive process of country-industries as a whole, not just production that satisfies foreign demand.

3.2 The technological quality of GVC integration

A key contribution of this paper is to put the quality of GVC participation at the centre of our analysis. This requires having a measure of partners' knowledge and technology intensity.

In order to achieve this we turn first to patent data. Using the REGPAT dataset compiled by the OECD, we retrieve the number of patent applications filed with the European Patent Office (EPO) across technological classes identified at the 4-digit level of the international patent classification (IPC). We translate IPC classes into NACE rev.2 2-digit industries using the crosswalk developed by Lybbert and Zolas (2014). We identify the country of development of each patent based on the country of residence of the inventor, rather than the applicant, which is provided in REGPAT. This is relevant because we are interested in knowing where innovative capabilities are located rather than the location of the company that seeks market protection through patenting. We then compute patent stocks K_{ijt} with the perpetual inventory method:

$$K_{ijt} = PAT_{ijt} + (1 - \delta)K_{ijt-1} \quad (4)$$

We calculate the initial value of the stock K_{ijt_0} as follows:

$$K_{ijt_0} = \frac{PAT_{ijt_0}}{g_{ij} + \delta} \quad (5)$$

PAT_{ijt} is the total patent applications filed with the EPO in sector j from inventors in country i in year t and $\delta = 0.1$ is the depreciation rate, set at a level in line with the literature (Verdolini and Galeotti 2011; Keller 2002); and \bar{g}_{ij} is the average rate of growth of patenting in country i and industry j for the period between t_0 and $t_0 - 4$. We use $t_0 = 1995$ as the initial year for the computation of the patent stock while our analysis starts from 2000 to minimise the impact of the initial stock on the level of stock we use in the analysis.

Patents have been used extensively in the literature to capture technological capabilities and are a straightforward and intuitive measure of innovation output. However, they only capture the technological dimension of knowledge and are not relevant for all industries in the same way. This is particularly the case for services that have virtually no patenting activity and, as a result, are not included in the crosswalk from IPC classes to industries by Lybbert and Zolas (2014).

To compensate for this, we take the approach of complementing patent stocks by looking at estimates of investment in intangible capital drawn from the INTAN-Invest dataset (Corrado *et al.* 2016). These measures expand the boundaries of what we consider as technological capabilities by including knowledge that has been accumulated over time through a broader set of activities and that are therefore also relevant in services industries. Intangible capital includes several assets, ranging from those that are included in national accounts (such as R&D, software and databases) to those that are not, such as investments in brand, design, organisational capital, training and financial innovation.⁵

However, the data on intangible assets present one major limitation as they are only available at the 1-digit level of NACE rev.2 industries. This means that there is no variation across manufacturing industries within each country.⁶ Moreover, intangible assets have been computed only for a subset of high-income economies, covering most European countries, US and Japan. As a result, when we use this measure to capture the quality of a country-industry's partner this is restricted to those countries that are included in the INTAN-Invest dataset.⁷

It is also worth stressing that, while data on intangibles are of course related to innovative activity that would also be captured by patenting activity, they are not

5. The INTAN-Invest dataset contains information on investment in three broad categories of assets that can be broken down as follows: 1. Computerised information: (i) purchased and (ii) own-account software; plus (iii) databases; 2. Innovative property: (i) R&D; (ii) design; (iii) mineral exploration; (iv) financial innovation; and (v) artistic originals; 3. Economic competencies: (i) advertising; (ii) marketing research; (iii) purchased and (iv) own-account organisational capital; and (v) training.

Assets that are split between purchased and own-account refer to whether investment in these assets is achieved by purchasing services from other industries or by hiring personnel providing these services from within the sector itself. For a detailed discussion of what each of these assets represent and how it is computed we refer the interested reader to Corrado *et al.* (2016).

6. All of the manufacturing sector is lumped into division C in the NACE rev.2 classification at the 1-digit level.

7. Table A1 of Appendix A reports the list of countries we include in our final sample; it should be noted, however, that among Easter European countries we have data on intangible assets only for Hungary, Slovakia and Czech Republic.

directly comparable to our measures of patent stocks since they are computed in millions of national currency while patent stocks use the simple number of patent applications.

We are therefore faced with both conceptual and empirical trade-offs in our two sources of data. On the one hand, patent stocks are a well-known measure of technological capabilities, and are available for all countries and at the desired level of disaggregation, but are only relevant in manufacturing industries. On the other hand, intangible assets cover a broader group of knowledge-related activities, relevant for services and manufacturing alike, but the latter are only available for manufacturing as a whole.

In an effort to reconcile these issues, we resolve to use patent data for manufacturing sectors and measures of intangible assets for service industries, computing the following intensity measures:

$$Patint_{ijt} = \frac{K_{ijt}}{Output_{ijt}} \quad \text{if } j \in \text{manufacturing} \quad (6)$$

$$Intanint_{ijt} = \frac{Intan_{ijt}}{Output_{ijt}} \quad \text{if } j \in \text{services} \quad (7)$$

While this choice is certainly dictated by the data availability issues discussed above, it also makes sense conceptually. Manufacturing and services are starkly different activities whose quality can hardly be measured by a unique indicator. It seems therefore appropriate to use patents as a relatively narrowly-defined measure of technological capabilities in manufacturing while relying on intangibles with broader conceptual boundaries in assessing quality in services industries.

Now that we have derived measures of knowledge intensity for both manufacturing and service country-industries, we can combine these with the GVC participation indicators discussed above to obtain a measure of the technological quality of GVC participation. We can think of the quality of a country-sector's GVC backward participation as the quality of the partners with which the country-sector engages. To have a unique measure of this we look at the average quality of a country-industry's backward linked partners. For manufacturing partners we compute:

$$BwdPatent_s = \sum_{r \neq s} Patint_r * \frac{BWD_{r,s}}{\sum_{r \neq s} BWD_{r,s}} \quad (8)$$

while for service partners we compute:⁸

8. Two clarifications on notation are in order. First, we use subscripts r and s instead of i and j because they refer to different things. In the former case, we separate the two subscripts with a comma to indicate two separate country-sectors (r and s) with value added flowing from r to s . In the latter case, we do not use a comma as we indicate a unique country-sector identified by country i and sector j . Second, in equations 8 and 9 we use $BWD_{r,s}$ to indicate the foreign value added from r that is embodied in the exports of s ; this is a bilateral measure of backward GVC as indicated by the double subscript r and s . In contrast the denominator in equations 8 and 9 $\sum_{r \neq s} BWD_{r,s}$ refers to the total backward GVC participation of country-industry s and is therefore equal to BWD_s from equation 1.

$$BwdIntant_s = \sum_{r \neq s} Intantint_r * \frac{BWD_{r,s}}{\sum_{r \neq s} BWD_{r,s}} \quad (9)$$

In this way, we have two measures of the quality of GVC participation. For each country-industry s , we compute the average patent intensity of manufacturing backward-linked partners, weighted on the strength of the backward linkages. For service backward-linked partners we compute the same average using, however, intangible intensity as our measure of quality.

3.3 Functional specialisation and employment upgrading

Finally, we use data on employment across country-industries from the European Union Labour Force Survey (LFS). We use this source of data to compute the shares in employment of managers and manual workers which we equate to headquarter and fabrication functions respectively, following Timmer *et al.* (2019). In Table A11 in Appendix A we report what occupations have been grouped into the broader function of ‘managers’ and those we have considered as ‘manual workers’. These two terms are rather broad so some further characterisation is in order. The occupations that we label as managers identify the location of skills (hence the inclusion of ‘Professional’ occupations as well as those belonging to ‘Technicians and associate professionals’) and decision-making about how production is organised across countries and industries (hence the inclusion of ‘Legislators, senior officials and managers’). In this sense we use the general term ‘managers’ to proxy for what the literature has more broadly referred to as headquarter functions (Timmer *et al.* 2019; Baldwin and López-Gonzalez 2015). Conversely we use occupations that refer to manual work as a proxy for fabrication activities – characterising what Baldwin and López-Gonzalez (2015: 15) refer to as a ‘factory economy’ – that do not feature a high degree of decision-making with respect to the value chain to which they contribute.

We have already discussed how the notion of functional specialisation is particularly appealing for our analysis because it conceptually links occupations with business functions within GVCs. From an empirical point of view we believe this is a meaningful classification for two key reasons. First, it loosely corresponds to the distinction between skilled (white collar) and unskilled (blue collar) workers. Second, it also matches business functions that are likely to be co-located as a consequence of the new international division of labour (Lanz *et al.* 2011; Timmer *et al.* 2019). This is, in turn, informative of the position each country-sector occupies within GVCs with managerial functions appropriating a larger share of value added, determining the location of other functions and corresponding, ultimately, to GVC upgrading (Gereffi 1994; Gereffi *et al.* 2005). The result is that an increase in the share of managers can be interpreted as an increase in the capability intensity of a country-sector and as a shift in function, and therefore of position, within GVCs.

4. Descriptive evidence

By combining the different types of data sources described in the previous section, we are able to shed new light on the main trends in GVC participation, technological asymmetries and employment structure across European countries and industries.

A first key aspect of GVCs is that this phenomenon has brought about increasingly complex production networks that link countries with one another. The European Single Market has led to a very high level of integration among countries that has grown considerably over the past 20 years. Figure 1 shows how backward linkages (as measured in equation 3) have grown over time, from 2000 to 2014. There are three key features that emerge from this evidence. First, Western Europe was already a rather highly integrated region in 2000 while, at the time, Eastern and Southern European countries (Portugal and Greece in particular) were comparatively much less involved in GVCs. Second, Germany is at the centre of production networks in Europe, a centrality which has been identified in other contributions (Amador and Cabral 2017; Amador *et al.* 2018; Baldwin and López-Gonzalez 2015). Third, while Eastern Europe has significantly increased its participation in GVCs, this has not changed the structure of production networks that remain concentrated around Germany.

Building on the geographical patterns emerging from Figure 1, and in order to facilitate a discussion of the descriptive evidence in this section, we focus on regions and macro sectors in Europe. We aggregate European countries into five main macro EU regions: centre; north; south; east; and west. We do the same for sectors aggregating industries into five main groups: high-tech manufacturing (htm); low-tech manufacturing (ltm); knowledge intensive business services (kibs); knowledge intensive services (kis); and low-knowledge business services (lkbs).⁹

9. We provide details of how countries and industries are grouped into regions and macro sectors in Tables A1 to A3 of Appendix A. We have chosen to group the UK and Ireland within the 'west' group as these two economies share, along with their geographical proximity, a similar industrial structure with a strong specialisation in services. The classification of macro sectors based on knowledge and technology intensity follows the list provided by Eurostat.

Figure 1a Backward linkages network over time, 2000

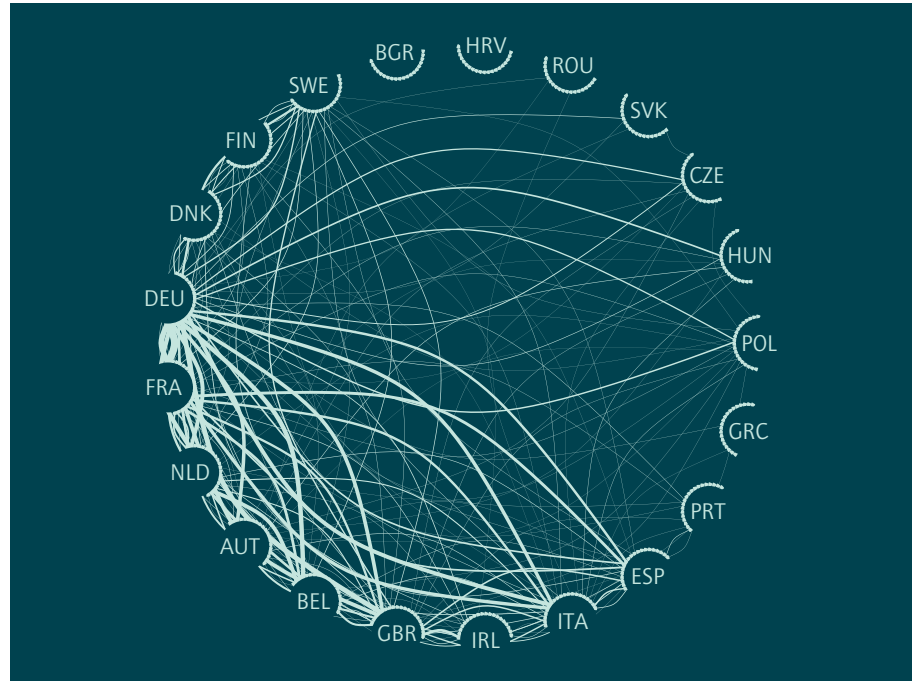
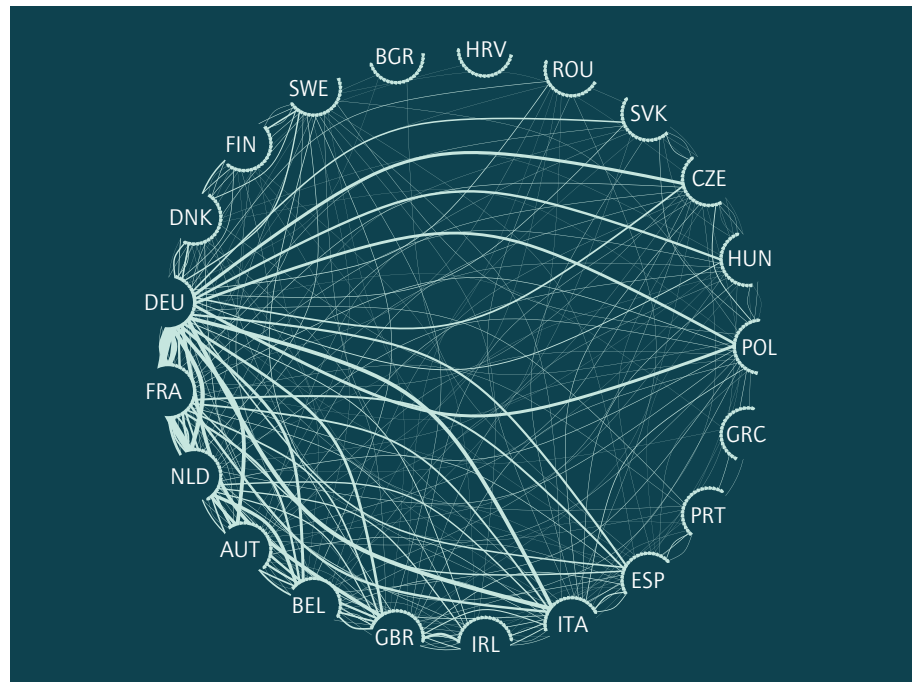


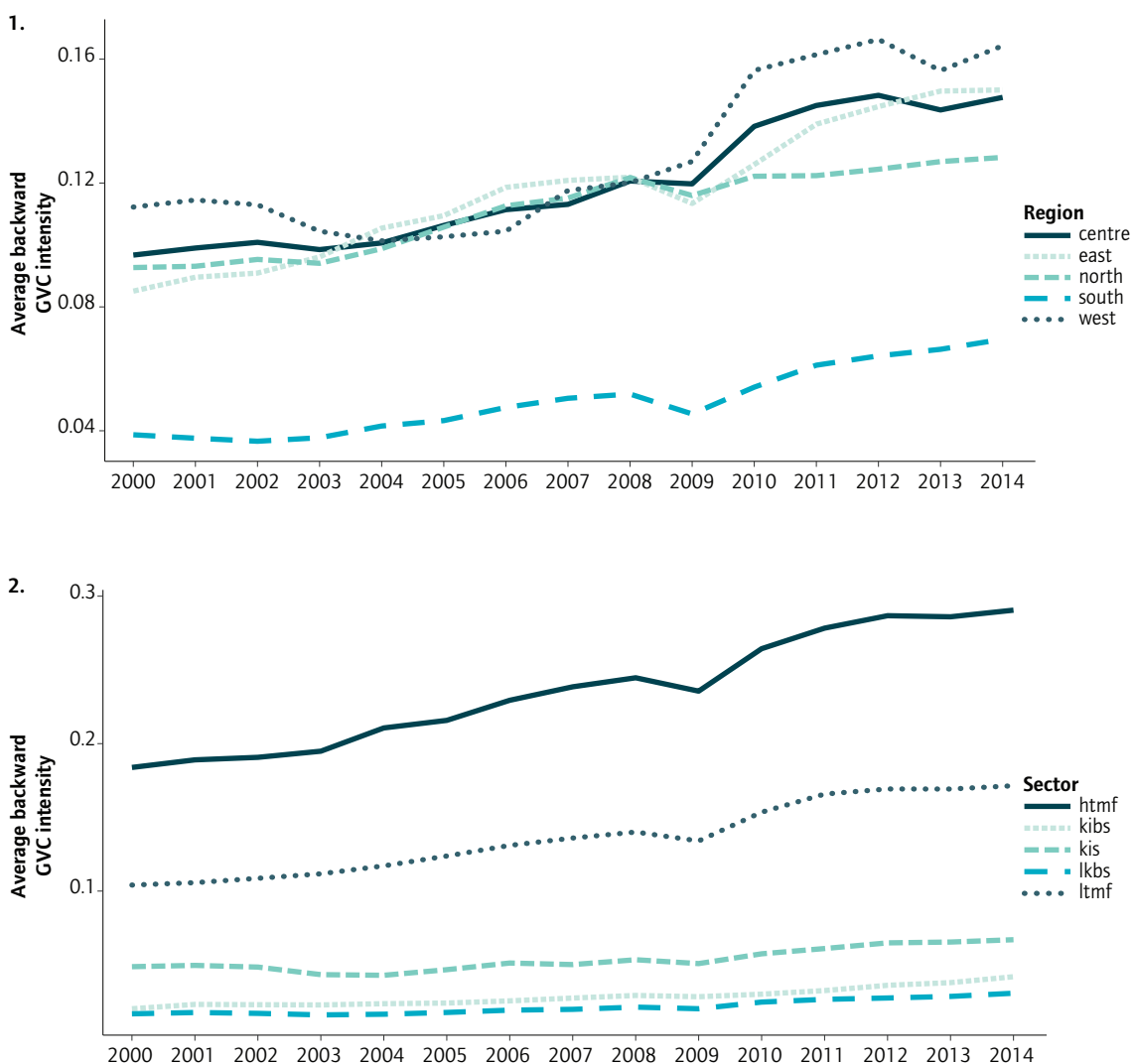
Figure 1b Backward linkages network over time, 2014



Source: authors' calculations using WIOD data

Figure 2 reports the evolution of backward GVC participation in macro regions and macro sectors.¹⁰ We find confirmation that, in 2000, Eastern and Southern Europe occupied rather peripheral, i.e. less connected, positions in Europe's GVC network. However, these two regions show starkly different evolutionary patterns. By 2014, southern Europe remained by far the region with the lowest integration across the continent, while Eastern Europe had moved up from fourth to second position.

Figure 2 Backward linkages across regions and macro sectors over time



Source: authors' calculations using WIOD data – unweighted average across macro regions and sectors for backward GVC intensity

10. In Appendix A we also report country-level evidence, looking at mean, median and long-term change across countries for all the variables in Figures 2 to 4.

Some clear sectoral patterns emerge as well, setting manufacturing and services apart from each other. The former shows a much higher level of GVC participation, with high-tech sectors participating in GVCs almost twice as much as low-tech sectors. Service industries, in contrast, show shorter value chains with much lower shares of the import of foreign value added.

All in all, Figures 1 and 2 demonstrate a general trend of growing GVC participation in Europe, particularly marked for Eastern European countries. But has this increasing integration been accompanied by a technological and functional upgrading? This can be assessed from Figure 3 which looks at the dynamics of the average patent and intangible capital intensity of macro regions and macro sectors over the 2000-14 period. Figure 3 clearly shows the persistence of wide technological and knowledge-based asymmetries across regional areas and sectors. Southern and Eastern Europe set themselves apart from the rest of the continent, with lower levels of both patent and intangible intensities both at the beginning and at the end of the examined period. Furthermore, despite Eastern Europe having significantly increased its level of participation in GVCs over our observed period (Figure 2), this process has not been paralleled by a reduction of its technological gap to the most advanced EU countries.

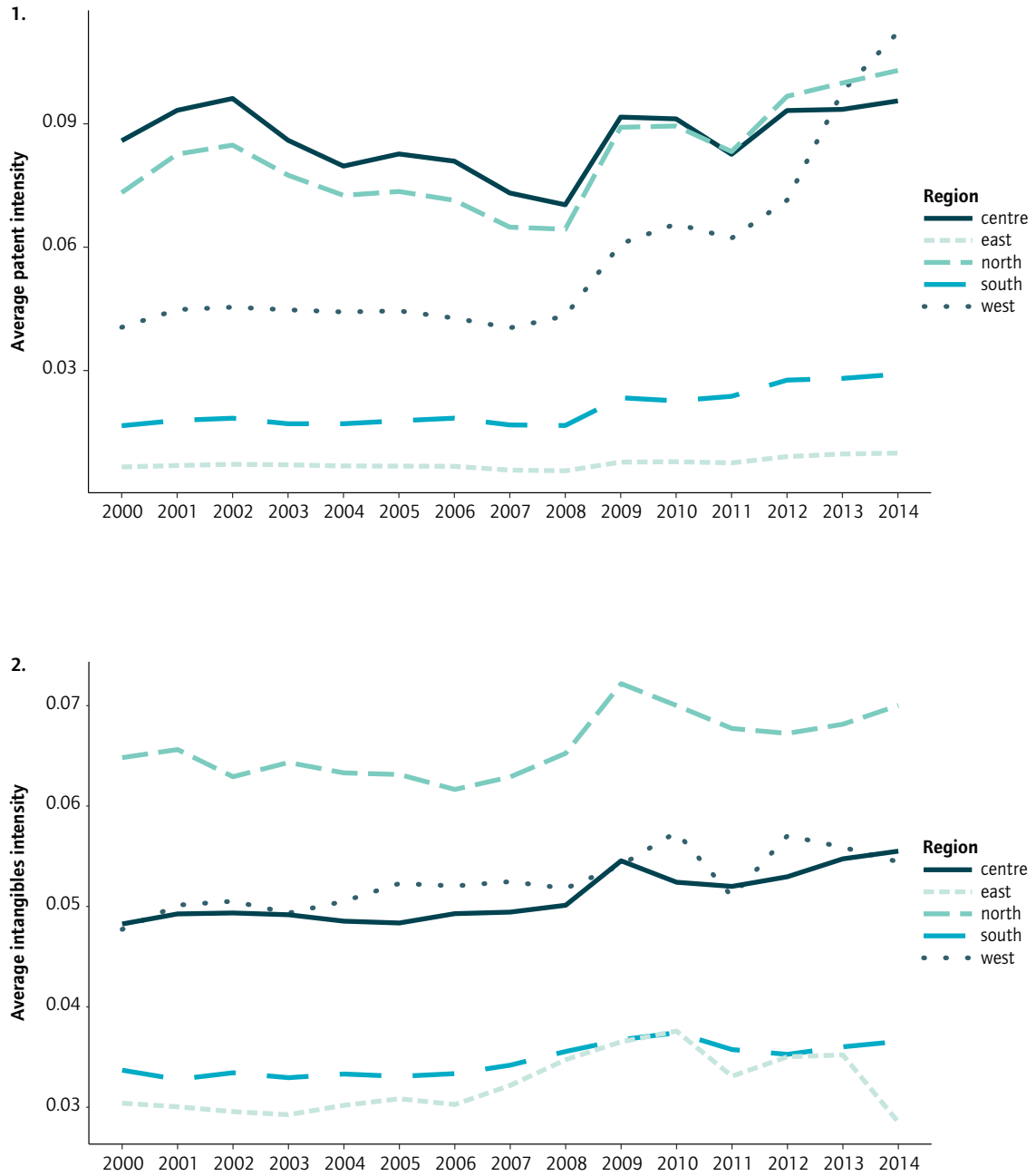
To provide a more granular example of these patterns we also present country-level evidence in Appendix A¹¹ in the effort to unveil further cross-country heterogeneity. In Figure A1, we find evidence which is consistent with Figure 3: Czechia and Italy are consistently at the bottom for patent intensity. This pattern also persists, though much less starkly, when we look at intangible asset intensity. In fact, we can see that Germany's average intensity in intangibles is just above that of Italy's and Czechia's – in contrast Sweden and France rank at the top in terms of both patent and intangible asset intensities.

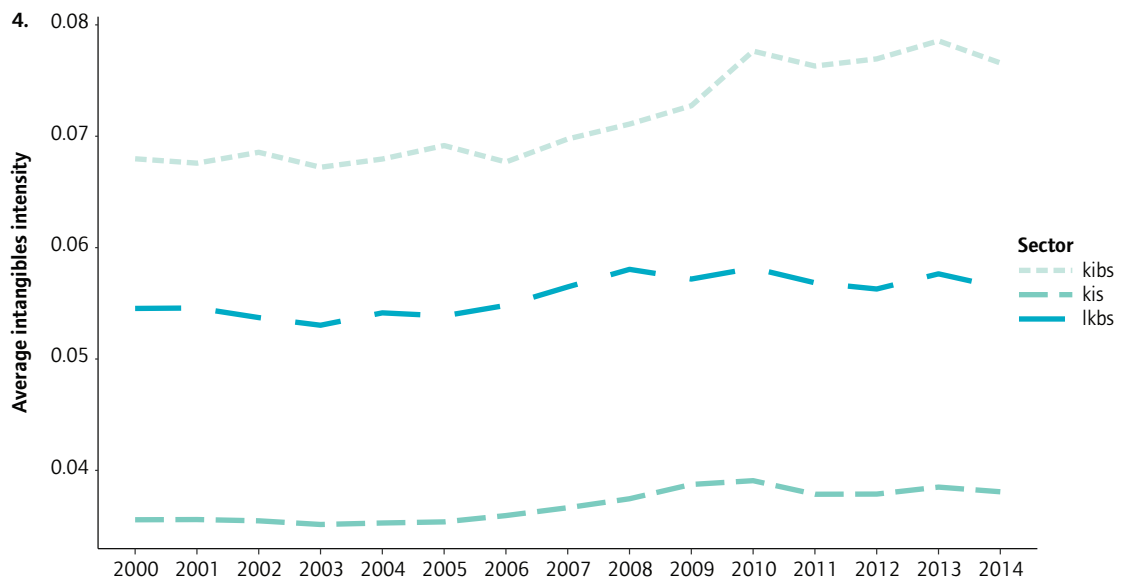
Finally, turning back to macro sectors in Figure 3 we also find rather stark and persistent differences. There is a clear, and increasing, gap between high and low-tech manufacturing in terms of patent intensity; while the same applies between knowledge intensive and other service industries, as can be seen from the indicator measuring intangible asset intensity.

Given the persistence of technological asymmetries, it is also important to assess whether these are also reflected in terms of employment structure which, as discussed in the previous section, is the key variable of interest in our analysis as it speaks to skills and business functions that take place across countries and industries.

11. See Tables A6-A10 and Figure A1 in Appendix A.

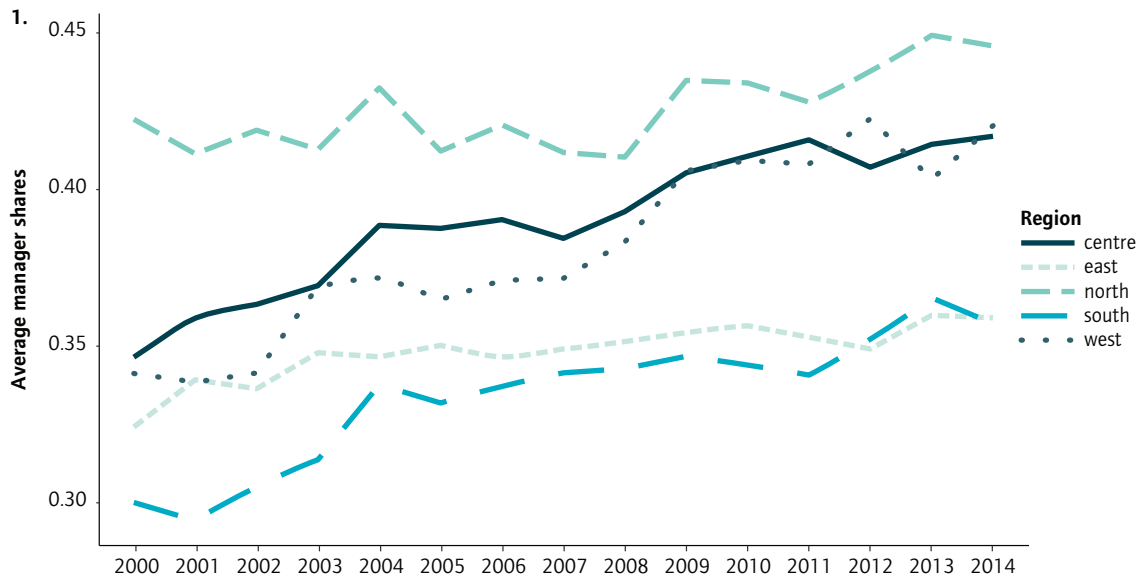
Figure 3 Patent and intangibles intensity across regions and macro sectors over time

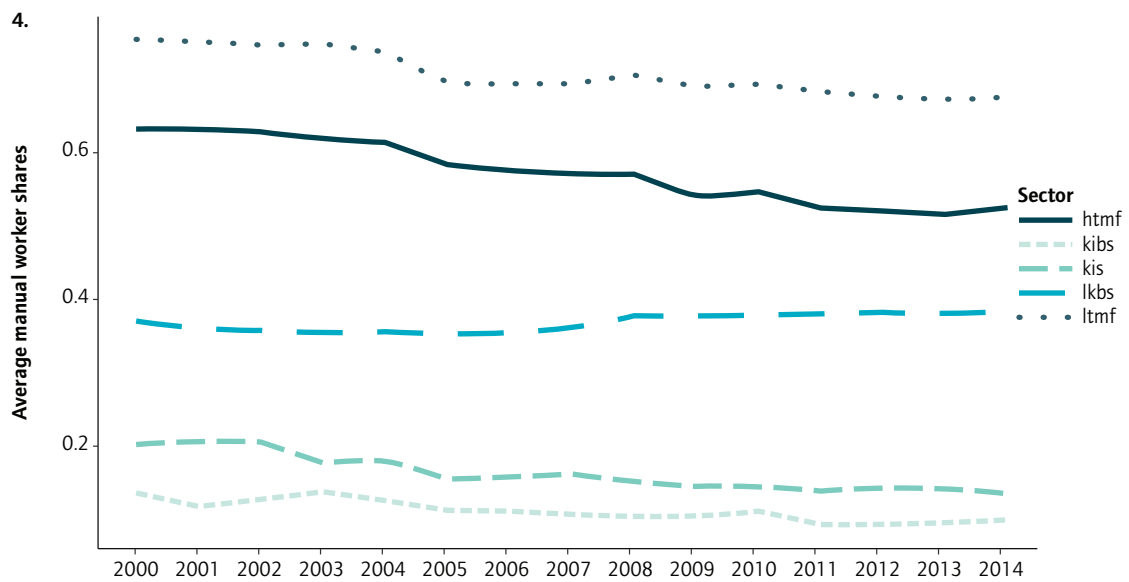
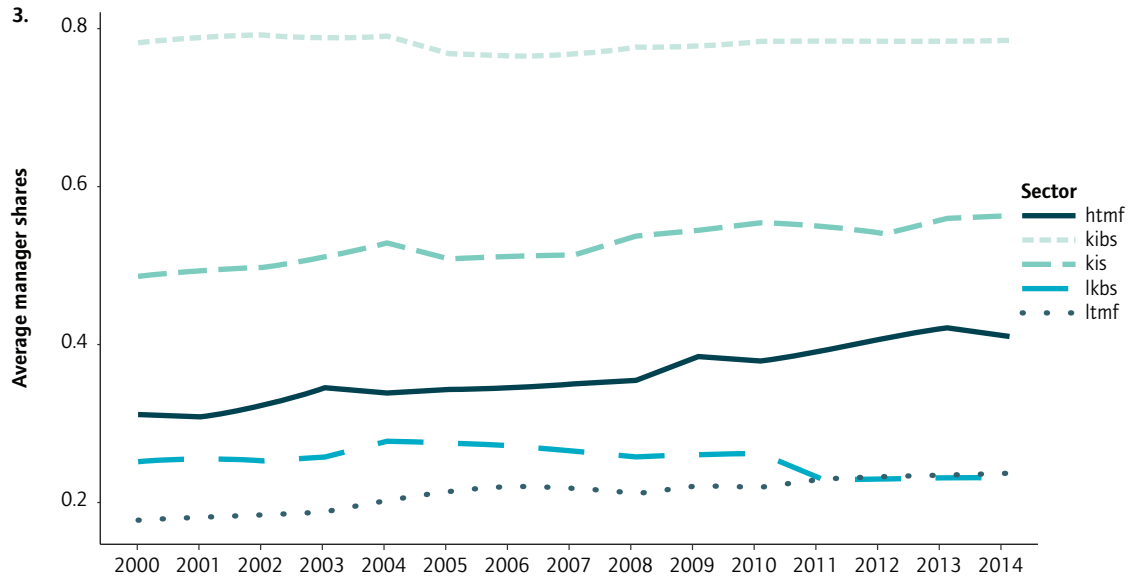




Source: authors' calculations using REGPAT and INTAN-Invest data – unweighted average across macro regions and sectors for patent and intangible asset intensity

Figure 4 Shares of managers and manual workers across regions and macro sectors over time





Source: authors' calculations using LFS data – unweighted average across macro regions and sectors for manager and manual workers employment shares.

In Figure 4 we look at the evolution of the shares of managers and manual workers across regions and macro sectors over our observed period. Concerning the former, we find common trends that maintain and, in some cases, even increase the initial differences in the employment structure. Looking at the share of managers in panel A of Figure 4 we find not only that Eastern and Southern European countries have the lowest average shares of this occupational category but that, over time, the gap to the centre and western regions has increased. Overall these core EU regions are those that have experienced the largest increase in the share of managers, suggesting that many sectors in the most advanced areas of the EU have further strengthened their specialisation in headquarter functions (Timmer *et al.* 2019).

Concerning manual workers, we find a declining share of this component of the labour force in all regions but that this trend stops in Eastern Europe from 2005. This once again suggests that, while Eastern European countries have significantly increased their participation in GVCs, this rapid integration has not been accompanied by a process of functional upgrading, i.e. a shift away from fabrication and towards headquarter functions. Southern Europe, in contrast, does experience a steady decline in its share of manual workers but the relevance of this component of the labour force remains consistently higher than in the other three macro regions, especially the west and centre of the EU.

We confirm these patterns also at country-level in Figure A1 in Appendix A. In particular, Czechia follows a similar trend to that of the Eastern Europe region with a decrease in the share of manual workers that plateaus after 2005 and even increases following the global financial crisis. Italy has a steady decrease in the share of manual workers but it always remains above the other countries from the core and northern region included in Figure A1, i.e. Germany, the Netherlands, France and Sweden.

We find some remarkable patterns when we look at the share of managers. Germany has the lowest share, comparable with that of Italy and Czechia. While this is somewhat surprising, it can be explained by looking at the sectoral composition of both Germany, Italy and Czechia, all three of which are much more concentrated around manufacturing industries than services compared to the other three countries in Figure A1.

This resonates with the observation that, when we look at employment structure by macro sector in Figure 4 (Panels 3 and 4), we find that services have much higher shares of managers than manufacturing while the opposite is true in respect of manual workers. Between the two manufacturing macro sectors, high-tech industries show higher shares of managers and lower ones for manual workers, consistent with the category of managers encompassing scientists and researchers which are occupations closely related to R&D activity.

The descriptive evidence presented in this section suggests that most countries and sectors have increased their participation in GVCs. However, both geographical and sectoral patterns persist starkly, with three key pieces of evidence emerging.

First, increased GVC participation has not altered the centre of gravity of the production network – notably Germany – and it has mostly concerned manufacturing industries. Second, cross-country and cross-sector asymmetries, both in terms of patent and intangible asset intensities, persist and there is no sign of convergence. Third, while the share of managers has increased across the board, the relative position of countries and industries has remained unchanged. Western and central regions have experienced the largest increase in manager shares, suggesting a concentration of headquarter functions in this part of the continent, while Eastern Europe has remained specialised in fabrication functions with by far the largest share of manual workers.

In sum, the descriptive evidence discussed here is in line with the literature emphasising the existence of asymmetries in the international division of labour, both across countries and industries (Chen *et al.* 2017; Stöllinger 2016; Mudambi 2007). Such asymmetries are persistent over time and concern both technological intensity and employment structure suggesting that, despite growing economic integration, the geographical and sectoral distribution of functions have remained, broadly speaking, unchanged.

In our discussion we have also looked at country-level patterns which, while consistent with the evidence for macro regions, also show a significant degree of cross-country variability as well as the importance of sectoral composition. In an effort to account for these factors in our analysis, we perform an econometric exercise to probe further the structural features that emerge from the descriptive analysis.

5. An econometric exercise to test the key structural features of GVCs in Europe

The evidence discussed in the previous section points to the existence of asymmetries both in terms of employment structure (the share of managers and manual workers) and technological intensity (patents and intangible assets). We are therefore interested in assessing the extent to which these asymmetries shape the relationship between GVC participation and employment outcomes (the shares of managers and manual workers).

To achieve this, we propose an econometric exercise focusing on the period 2006-14, using the preceding years in our sample (2000-05) to construct pre-sample means (PSM).¹² Because we have seen that GVC participation is most relevant for manufacturing industries and that these sectors also exhibit a higher variation in the shares of managers and manual workers, we focus this part of our empirical analysis only on manufacturing industries but take into account linkages with service industries.

We should point out from the outset that our econometric exercise, rather than aiming at assessing the existence of causal relationships, pursues three specific goals. First, we explicitly look at the degree of persistency of country-industries' initial positions, captured by employment structure. Second, we also investigate how employment structure correlates with GVC participation and its quality. Third, we focus on how initial technological levels mediate this relationship and whether the sign of the correlation changes based on position as leaders or laggards in technological capabilities.

As discussed in the literature review, the relationship between the technological quality of GVC participation and employment structure is a rather understudied aspect of GVC participation, so it is hard to have clear-cut *ex ante* expectations. On the one hand, integrating with high quality partners could lead to processes of employment upgrading through spillover effects; on the other, it could lead to competition/substitution effects (especially when both importer and exporter have high technological capabilities), reinforcing the initial asymmetries (especially when the importer has lower technological capabilities than the partner).

Moreover, the impact can also differ depending on whether manufacturing industries import value added from other manufacturing industries or from

¹² Information on employment for Poland is only available from 2004 onwards and, as a result, we rely only on 2004 and 2005 to compute the PSM for this specific country.

service industries. In fact, competition effects are more likely to occur in the first case, while importing value added especially from service sectors with high levels of intangible capital can be beneficial for upgrading due to knowledge and skill complementarities (Meliciani and Savona 2015).

This range of potential outcomes is also in line with the qualitative evidence put forward by the traditional literature on GVCs (Gereffi *et al.* 2005) and suggests that employment outcomes do not depend on the quality of GVC partners alone. Based on the discussion above, two issues arise for our empirical approach. First, it is important to have separate measures of technological quality for manufacturing and service GVC partners. Second, we should take into account country-industries' own technological intensity in terms of the patent stock which our descriptive evidence shows to be persistent over time. The technological level of the country-sector is likely to mediate the relationship between the level and the quality of GVC participation and the employment structure. Our econometric strategy deals with these issues explicitly as follows:

$$\begin{aligned} \ln(y_{ijt}) = & \alpha + \sum_t \beta_t \ln(\bar{y}_{ijt_0}) + \delta_1 TopDecile_{ijt_0} + \\ & \beta_1 \ln(Bwd_{ijt}) + \gamma_1 TopDecile_{ijt_0} * \ln(Bwd_{ijt}) + \\ & \beta_2 \ln(BwdPatent_{ijt}) + \gamma_2 TopDecile_{ijt_0} * \ln(BwdPatent_{ijt}) + \\ & \beta_3 \ln(BwdIntangibles_{ijt}) + \gamma_3 TopDecile_{ijt_0} * \ln(BwdIntangibles_{ijt}) + \\ & \beta_4 \ln(Patint_{ijt}) + \delta_2 \ln(Capital_{ijt_0}) + \kappa_i + \varphi_j + \tau_t \end{aligned} \quad (10)$$

Our outcome variable (y_{ijt}) is either the share of managers or that of manual workers in country-industry ij at time t (2006-14). We control for country, sector and year fixed effects (κ_i, φ_j , and τ_t , respectively) and add the pre-sample mean (2000-05) of the outcome variable. The fixed effects should net out from our correlation analysis the role of country, industry and time idiosyncrasies while the pre-sample mean takes into account time-invariant effects that shape country-industries' initial asymmetries in terms of employment structure.¹³ Furthermore, interacting the pre-sample mean with time dummies allows us to control for the persistency of initial conditions over time which is relevant in assessing whether there has been a convergence or a divergence of employment structure across country-industries over time.

Moreover, this approach is also consistent with the idea that pre-existing employment structure is relevant for the position that countries and industries will occupy when joining GVCs (Grundke *et al.* 2017a, 2017b). Finally the choice to use pre-sample means, rather than classical fixed effect estimators, to absorb country-industries' pre-existing conditions is in line with the literature dealing with highly persistent variables (Blundell *et al.* 1995, 2002).

13. We do not include in our specification a measure of relative wages as these are not readily available at this level of industrial disaggregation; however, these should be partly taken into account by our fixed effects and the inclusion of the PSM. In Tables B5 and B6 of Appendix B we also test a more demanding specification using country-year and industry-year fixed effects that account for all country and industry level time trends.

This approach, coupled with our set of fixed effects, also allows us to include in our regression dummy variables for country-sectors' initial positioning in terms of technological capabilities which traditional fixed effects would otherwise absorb. In particular, we capture country-industries' technological positioning with the dummy variable $TopDecile_{ijt_0}$ taking a value of 1 if the pre-sample mean of the country-industry's patent intensity ranks in the top decile. We also present the results using a dummy for the bottom decile, used as a proxy for technological backwardness.¹⁴ We interact this dummy with the measures of GVC participation as well as the two measures of quality for backward patent and intangible asset intensity.¹⁵ Given the persistency of initial positions in terms of patent intensity (see Figure 3), using dummies based on the pre-sample period is an appropriate strategy in studying how initial technological asymmetries affect the relationship between GVC participation and employment.

We provide a list of country-industries that rank in the two top and bottom deciles in Tables A4 and A5 of Appendix A. What is worth noting here is that this ranking seems to be driven not only by sectoral determinants but also, and crucially, by country-level characteristics suggesting that technological asymmetries also reflect differences in the strength of national innovation systems. More specifically no sector from Eastern Europe is included in the top two deciles, while this is the case for low-tech sectors from Germany, e.g. textiles manufacture (sector C13-C15). In contrast no sector from the centre region is included in the bottom two deciles, while relatively high-tech sectors such as the automotive industry (C29) from Eastern European countries – e.g. Poland, Romania and Slovakia – rank in the bottom decile for patent intensity.

Finally we add two control variables to our specification. First, we take into account that, while the initial technological position matters, as country-industries engage with GVCs their technological intensity is also likely to evolve over time and that this could, in turn, have an impact on their employment structure. For this reason we control for country-industries' own patent intensity during our period of analysis (2006-2014), as computed in equation 6 above. Second, we include a measure of capital intensity, measured for the pre-sample period, which we compute as a country-industry's total capital stock, retrieved from the EU KLEMS database and divided by total employment drawn from the EU LFS.

14. We have also tested our results by including both dummies with the respective interactions and they remained unchanged. We do not report these in the interests of space, but they are available upon request.

15. Recall from equations 8 and 9 that backward patent intensity is computed for each country-industry, based on the patent intensity of its *manufacturing* partners, while backward intangible asset intensity is based only on *service* partners. As a result, these two variables capture the quality of manufacturing and service partners, respectively, which is why we include them both in our analysis.

6. Results

The key aim of our econometric exercise is to qualify the relationship between employment structure and GVC participation, focusing in particular on the role played by the initial asymmetries, both in terms of employment structure and technological intensity, and the quality of GVC participation. We first include only the traditional measures of backward GVC participation and their interaction with the starting level of technological intensity (column 1 and 5) before progressively adding our measures of the technological quality of GVC participation both in terms of the patent intensity of foreign manufacturing suppliers and the intangible asset intensity of foreign service suppliers.

The interaction of the pre-sample mean of the outcome variable (the shares of managers and manual workers) with time trends is always positive and significant, throughout our results, which is consistent with the descriptive evidence of a strong persistence of the employment structure over time. Despite the significant changes in the share of managers and manual workers that occurred over our observed time period throughout countries and industries, the initial employment structure remains a strong predictor of future employment shares, with little evidence of convergence between countries-sectors located in the centre and at the periphery of the EU. This also confirms the descriptive evidence in Figure 4 discussed in the previous sections.

Concerning the relationship between GVC participation and employment structure, our results show that the shares of managers or manual workers are not related to the level of integration in and of itself. However, we do find evidence of a different relationship for country-industries that start off among the top decile for patent intensity. The negative and statistically significant coefficient of the interaction term (Top decile patent*Bwd GVC) in columns 5-8 of Table 1 suggests country-industries with high patent intensity do indeed see their share of manual workers decrease as they expand their backward GVC participation while we find no such evidence for the share of managers.¹⁶ This is consistent with the results of the literature on the ‘skill biased effect of offshoring’ (Strauss-Kahn 2003; Hijzen *et al.* 2005; Falzoni and Tajoli 2012; Crinò 2012; and Foster-McGregor *et al.* 2013).

16. Naturally, whether a country-sector ranks in the top decile is going to be driven by both country and sector-level features that will also have an impact on both GVC participation and employment structure. These are, however, controlled for by the inclusion of country and sector fixed effects in our specification. As a result the dummy captures the role of being among the top decile and therefore having a technological advantage, depurated from other country and sector time-invariant effects.

Table 1 GVC participation, quality and employment structure: results controlling for initial technological intensity (top decile)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Managers				Manual Workers			
2006*PSM	0.505*** (0.0387)	0.509*** (0.0391)	0.498*** (0.0385)	0.503*** (0.0389)	0.695*** (0.0428)	0.697*** (0.0424)	0.678*** (0.0426)	0.682*** (0.0423)
2007*PSM	0.535*** (0.0377)	0.537*** (0.0377)	0.529*** (0.0375)	0.531*** (0.0375)	0.706*** (0.0505)	0.708*** (0.0497)	0.689*** (0.0510)	0.692*** (0.0504)
2008*PSM	0.460*** (0.0514)	0.462*** (0.0509)	0.453*** (0.0513)	0.455*** (0.0508)	0.598*** (0.0512)	0.599*** (0.0509)	0.577*** (0.0505)	0.580*** (0.0502)
2009*PSM	0.390*** (0.0403)	0.397*** (0.0408)	0.382*** (0.0402)	0.390*** (0.0406)	0.602*** (0.0487)	0.604*** (0.0477)	0.578*** (0.0480)	0.583*** (0.0472)
2010*PSM	0.437*** (0.0385)	0.442*** (0.0387)	0.432*** (0.0386)	0.438*** (0.0387)	0.615*** (0.0524)	0.617*** (0.0518)	0.592*** (0.0506)	0.597*** (0.0503)
2011*PSM	0.444*** (0.0488)	0.448*** (0.0489)	0.438*** (0.0490)	0.443*** (0.0490)	0.673*** (0.0559)	0.674*** (0.0548)	0.648*** (0.0549)	0.652*** (0.0539)
2012*PSM	0.392*** (0.0435)	0.397*** (0.0436)	0.383*** (0.0438)	0.389*** (0.0438)	0.689*** (0.0550)	0.691*** (0.0548)	0.660*** (0.0537)	0.665*** (0.0536)
2013*PSM	0.414*** (0.0713)	0.421*** (0.0716)	0.404*** (0.0718)	0.411*** (0.0720)	0.636*** (0.0530)	0.638*** (0.0525)	0.606*** (0.0520)	0.611*** (0.0517)
2014*PSM	0.378*** (0.0551)	0.385*** (0.0560)	0.366*** (0.0549)	0.374*** (0.0556)	0.667*** (0.0536)	0.669*** (0.0534)	0.636*** (0.0523)	0.641*** (0.0525)
Bwd GVC	0.00246 (0.0127)	-0.000217 (0.0126)	0.00218 (0.0127)	-0.000438 (0.0126)	0.0146* (0.00832)	0.0146* (0.00842)	0.0134 (0.00830)	0.0135 (0.00839)
Top decile patent _{t₀}	0.0441 (0.0421)	-0.200 (0.129)	0.734* (0.424)	0.583 (0.444)	-0.110*** (0.0265)	-0.0955 (0.103)	-1.308*** (0.321)	-1.271*** (0.347)
Top decile patent _{t₀} *Bwd GVC	0.0226 (0.0224)	0.0272 (0.0225)	0.0167 (0.0222)	0.0235 (0.0222)	-0.0377*** (0.0123)	-0.0380*** (0.0122)	-0.0405*** (0.0121)	-0.0414*** (0.0119)
Bwd Patent		-0.0690 (0.0627)		-0.0640 (0.0629)		-0.00110 (0.0271)		-0.00337 (0.0267)
Top decile patent _{t₀} *Bwd Patent		-0.0972** (0.0486)		-0.119** (0.0488)		0.00561 (0.0374)		0.0167 (0.0375)
Bwd intangibles			0.644*** (0.208)	0.640*** (0.208)			-0.253** (0.115)	-0.255** (0.114)
Top decile patent _{t₀} *Bwd Intangibles			0.236* (0.141)	0.285** (0.136)			-0.401*** (0.106)	-0.403*** (0.105)
Patents	-0.0286** (0.0123)	-0.0284** (0.0122)	-0.0212* (0.0127)	-0.0210* (0.0126)	0.0104* (0.00615)	0.0104* (0.00616)	0.00744 (0.00636)	0.00737 (0.00637)
Capital _{t₀}	0.0441*** (0.0145)	0.0440*** (0.0145)	0.0443*** (0.0143)	0.0441*** (0.0143)	-0.0334*** (0.00609)	-0.0334*** (0.00609)	-0.0329*** (0.00599)	-0.0329*** (0.00599)
Constant	-0.980*** (0.107)	-1.168*** (0.210)	0.966 (0.648)	0.782 (0.685)	-0.0156 (0.0405)	-0.0182 (0.0851)	-0.801** (0.354)	-0.814** (0.353)
Observations	2,575	2,575	2,575	2,575	2,589	2,589	2,589	2,589
R-squared	0.741	0.741	0.742	0.743	0.822	0.822	0.825	0.825

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

But does the relationship between GVC integration and the structure of employment vary also according to the quality of the partner? Specifications (2), (3) and (4) look at this question for the share of managers, taking respectively into account the patent intensity of GVC (manufacturing) partners, the intangible intensity of GVC (service) partners and both of these together. The same analysis is reported for the share of manual workers in columns (6), (7) and (8).

We find that the quality of manufacturing partners, i.e. backward patent intensity, is significantly related to the share of managers only for top decile country-industries, leading to a decrease in the share of this occupational category (columns 2 and 4). It therefore appears that country-industries that are among the top technological performers (high patent intensity) see their share of managers reduce as they engage with high-technology suppliers.

While our empirical approach does not aim at gauging clear-cut causal relationships, this evidence is suggestive of a competition mechanism: as technological leaders increase their integration with other patent intensive partners, some managerial positions are offshored to these new partners. This conjecture is also in line with the evidence put forward by Foster-McGregor *et al.* (2016) as well as with micro-level evidence on the negative effect of foreign technological innovation for domestic employment (Gagliardi 2019).

When we turn to the relationship between the employment structure of manufacturing industries and the quality of imported service inputs, we find that the content of the knowledge-based intangible assets associated with these inputs has a positive relationship with the share of managers and a negative one with the share of manual workers. As manufacturing country-sectors engage with service providers with a high intangible intensity (Bwd Intangibles), they tend to have larger shares of headquarter (manager) functions and smaller shares of fabrication (manual worker) ones. The interaction terms are statistically significant both for the shares of managers (positive sign) and for manual workers (negative sign). The positive and significant interaction between the quality of partners and the dummy for the top decile (Top decile patent_{it}*Bwd Intang) suggests that technological leaders in manufacturing industries draw even larger benefits, in terms of employment structure, from the quality of their service providers.

We thus find evidence of complementarity, rather than competition, between the quality of the service inputs imported and the employment structure of manufacturing industries. This is in contrast with the results for the quality of manufacturing GVC partners, but it confirms the importance of the link between services and manufacturing industries for which a growing body of evidence is emerging in the literature (Evangelista *et al.* 2013; Meliciani and Savona 2015; López-Gonzalez *et al.* 2019).

Table 2 GVC participation, quality and employment structure: results controlling for initial technological intensity (bottom decile)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Managers				Manual Workers			
2006*PSM	0.486*** (0.0383)	0.483*** (0.0383)	0.479*** (0.0381)	0.476*** (0.0382)	0.703*** (0.0449)	0.703*** (0.0449)	0.697*** (0.0449)	0.698*** (0.0449)
2007*PSM	0.518*** (0.0370)	0.516*** (0.0368)	0.511*** (0.0368)	0.509*** (0.0366)	0.715*** (0.0525)	0.715*** (0.0524)	0.708*** (0.0529)	0.709*** (0.0529)
2008*PSM	0.443*** (0.0502)	0.441*** (0.0496)	0.436*** (0.0499)	0.434*** (0.0494)	0.607*** (0.0513)	0.608*** (0.0512)	0.600*** (0.0512)	0.601*** (0.0513)
2009*PSM	0.373*** (0.0393)	0.371*** (0.0392)	0.366*** (0.0390)	0.364*** (0.0389)	0.613*** (0.0484)	0.613*** (0.0484)	0.607*** (0.0484)	0.608*** (0.0485)
2010*PSM	0.421*** (0.0371)	0.419*** (0.0370)	0.418*** (0.0370)	0.416*** (0.0369)	0.630*** (0.0520)	0.631*** (0.0521)	0.627*** (0.0512)	0.628*** (0.0513)
2011*PSM	0.428*** (0.0474)	0.428*** (0.0472)	0.424*** (0.0473)	0.424*** (0.0472)	0.689*** (0.0542)	0.690*** (0.0542)	0.685*** (0.0537)	0.686*** (0.0537)
2012*PSM	0.378*** (0.0428)	0.376*** (0.0426)	0.371*** (0.0428)	0.369*** (0.0426)	0.707*** (0.0534)	0.708*** (0.0533)	0.701*** (0.0530)	0.702*** (0.0529)
2013*PSM	0.400*** (0.0706)	0.400*** (0.0704)	0.391*** (0.0708)	0.391*** (0.0706)	0.654*** (0.0518)	0.655*** (0.0518)	0.647*** (0.0514)	0.648*** (0.0515)
2014*PSM	0.364*** (0.0549)	0.364*** (0.0551)	0.354*** (0.0545)	0.354*** (0.0546)	0.685*** (0.0524)	0.686*** (0.0524)	0.677*** (0.0517)	0.678*** (0.0518)
Bwd GVC	0.00853 (0.0128)	0.00761 (0.0129)	0.00829 (0.0132)	0.00684 (0.0131)	0.00890 (0.00836)	0.00926 (0.00842)	0.00761 (0.00866)	0.00782 (0.00866)
Bottom decile patent _{t₀}	0.0380 (0.0566)	-0.195 (0.275)	-0.160 (0.602)	-0.169 (0.598)	-0.0520* (0.0270)	-0.100 (0.150)	0.295 (0.383)	0.288 (0.384)
Bottom decile patent _{t₀} *Bwd GVC	-0.0416** (0.0186)	-0.0471** (0.0200)	-0.0445** (0.0186)	-0.0516** (0.0204)	0.0265** (0.0110)	0.0255** (0.0121)	0.0283** (0.0111)	0.0260** (0.0120)
Bwd Patent		-0.0757 (0.0621)		-0.0690 (0.0623)		0.00686 (0.0266)		0.00375 (0.0262)
Bottom decile patent _{t₀} *Bwd Patent		-0.0743 (0.0877)		-0.104 (0.0954)		-0.0155 (0.0442)		-0.0356 (0.0471)
Bwd intangibles			0.720*** (0.184)	0.711*** (0.185)			-0.380*** (0.107)	-0.380*** (0.107)
Bottom decile patent _{t₀} *Bwd Intang.			-0.0615 (0.199)	0.0421 (0.218)			0.111 (0.123)	0.145 (0.136)
Patents	-0.0137 (0.0124)	-0.0132 (0.0123)	-0.00693 (0.0127)	-0.00628 (0.0126)	-0.00532 (0.00646)	-0.00542 (0.00650)	-0.00847 (0.00657)	-0.00848 (0.00658)
Capital _{t₀}	0.0482*** (0.0144)	0.0489*** (0.0144)	0.0486*** (0.0142)	0.0495*** (0.0141)	-0.0363*** (0.00598)	-0.0361*** (0.00595)	-0.0361*** (0.00585)	-0.0358*** (0.00582)
Constant	-0.966*** (0.106)	-1.182*** (0.209)	1.206** (0.582)	0.980 (0.623)	-0.0634 (0.0413)	-0.0445 (0.0842)	-1.222*** (0.330)	-1.212*** (0.329)
Observations	2,575	2,575	2,575	2,575	2,589	2,589	2,589	2,589
R-squared	0.744	0.745	0.746	0.746	0.828	0.828	0.830	0.830

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

In sum, three findings emerge from the evidence discussed so far. First, employment structure and therefore functional specialisation is highly persistent over time and has shown no sign of convergence despite significant increases in GVC participation throughout Europe. Second, GVC participation in and of itself does not seem to be related to countries' employment structures; in contrast, the quality of GVC participation, especially of foreign service providers, does matter in terms of shifting the employment structure towards managerial functions. Finally, country-industries' initial technological position also matters: those that start off as technological leaders are likely to have larger shares of their workforce in managerial (headquarter) functions and smaller shares in fabrication ones as they further integrate in GVCs.

We complement the evidence on the importance of being a technological leader by exploring whether having a technological disadvantage also plays a role in affecting the relationship between GVC participation and employment structure. We replace our $TopDecile_{ijt_0}$ dummy with $BottomDecile_{ijt_0}$, taking a value of 1 if a manufacturing country-sector is in the bottom decile in terms of patent intensity.

The results for this second specification are reported in Table 2 and are essentially in line with the three main results which emerge from Table 1. GVC participation alone is not significantly correlated with employment structure. However, as country-industries that, at the beginning of our observed period, were in the bottom decile for patent intensity further integrate in GVC ($Bottom\ decile\ patent_{t_0} * Bwd\ GVC$), we observe lower shares of employment in managerial functions and more in fabrication ones (see the negative and significant interaction term for the share of managers and the positive and significant interaction coefficient for the share of manual workers). This suggests that country-industries that have started to integrate in GVCs from the lower rungs of the technological ladder have mainly specialised in fabrication functions without managing to upgrade to headquarter positions.

The (average) patent intensity of foreign manufacturing suppliers does not seem to be related to employment structure and this also applies to country-industries in the bottom decile for patent intensity. In contrast the quality of services providers, i.e. backward intangible asset intensity, exhibits a positive coefficient, confirming the results in Table 1. However, the interaction term is not statistically significant, indicating that the relationship is not different for country-industries that are in the bottom decile for patent intensity.

Finally the key results are robust to a range of robustness checks which we present in Appendix B. We construct our dummy variables for being leaders or laggards in technological intensity using the two, rather than the first, top and bottom deciles (Tables B1 and B2). We also weight our results by sectors' total employment to make sure that our results are not driven by sectors that account for very small shares of total employment (Tables B3 and B4). We also test a more demanding specification using country-year and industry-year fixed effects (Tables B5 and B6). This is in the effort to control for changes in demand and/or policy, such as labour market reforms and relative wages that affect all sectors within the same country, or a change in sector technology that affects all countries, which we discuss at greater length in Appendix B.

7. Conclusion

This paper looks at the interplay between GVCs and technology and the impact this has on employment outcomes. We build on the concept of functional specialisation to look at changes in the share of employment in headquarter and fabrication occupations which we interpret in terms of employment upgrading (or lack thereof) associated with participation in GVCs.

Our empirical analysis shows that European economies increased their economic integration considerably between 2000 and 2014 but that this process has not shifted the centre of gravity of the EU production landscape in which Germany remains a pivotal player. Also, looking at intensity in technology and intangible assets, as well as employment structure, we find the persistence of stark country (and sectoral) technological asymmetries with no sign of any substantial process of convergence in employment structure.

We expand these descriptive insights by focusing on manufacturing industries and take full account of the persistence of employment structure and the role of initial technological positioning to explore how these affect the relationship between GVC participation, the technological quality of that participation and the employment structure.

In our econometric analysis, we find a confirmation of the highly inert and structural dimension of employment composition, suggesting that there is no automatic convergence across countries and industries in terms of functional specialisation. Moreover, GVC participation alone has no significant relationship with employment structure but is mediated by country-industries' initial technological strength.

Specifically, country-sectors that are leading in terms of patent intensity have lower employment shares in fabrication functions as they integrate in GVC. They also seem to experience competition from other patent-intense manufacturing partners to which they offshore managerial positions. In contrast higher intensity in intangible assets among GVC partners in services is associated with higher shares of managers and lower shares of manual workers, and these relationships are stronger for country-industries which are endowed with strong technological capabilities.

Country-sectors which are characterised by poor technological performances show an opposite specular pattern, exhibiting lower shares of employment in managerial functions and larger ones in fabrication activities. This suggests

that European countries and sectors that have joined GVCs on the basis of more limited technological capabilities have not been able to upgrade their employment structure. On the contrary they seem to have been pushed towards a specialisation in fabrication and, arguably, low value added functions.

In sum we find no evidence of convergence in employment structures across the European continent. This has important implications for policy, especially in the context in which Europe is about to deploy considerable resources to foster recovery from the pandemic. The sanitary crisis has highlighted the deep interdependencies that link European countries. Economic integration to the degree achieved in Europe is arguably irreversible and has afforded significant opportunities for development, but it has not reduced the initial technological asymmetries and gaps in the quality of employment structures of EU countries.

More specifically the policy implications deriving from this contribution can be conveyed through three key messages. First, the evidence presented seems to suggest that the significant extension and deepening of GVCs in Europe has not helped the achievement of EU cohesion targets. While peripheral regions in Europe, especially Eastern Europe, have successfully integrated in GVCs and seen their incomes increase, their occupational structures have not undergone the same sweeping changes. As a result the structure of Europe's production network has remained unchanged with Germany (and the other 'core' countries in the north-west part of the continent) at its core while peripheral regions specialise in fabrication activities offering a greater share of manual, rather than managerial, occupations. This has great policy relevance because it means that GVC integration has made different jobs available in different regions providing for different occupational opportunities. Within the current sanitary emergency, it is also important to stress that managerial positions are more likely to be carried out remotely while manual work usually requires workers to be on site. This has major implications with respect to how severely the latter occupations have been affected by the Covid-19 pandemic and by the measures countries have put in place to tackle it.

Second, and in relation to the previous point, countries and industries' initial technological advantages influence their ability to benefit from GVC integration. Integration should, therefore, be accompanied and possibly preceded by policies favouring the upgrading of skills and technological capabilities as a means of facilitating integration processes that are less asymmetrical. By putting in place policies that will strengthen country-industries' technological capabilities, as (if not before) they integrate into GVCs, policy-makers will be able to increase the probability that GVC integration is also accompanied by a change in the employment structure with a shift towards managerial occupations and headquarter functions. As considerable resources are put in place to mount a sustained recovery from the pandemic, policy-makers should therefore bear in mind that building technological advantages in key sectors will also allow countries and sectors to benefit from further integration in the global economy.

Finally the evidence put forward in this paper calls for the adoption of a more systemic approach to EU cohesion policies. This should be based on a detailed

analysis of the pattern and effects of the ongoing changes in the geography of production in Europe and should include the possibility of putting in place pan-European policies to govern such processes, ensuring that the benefits of economic integration are distributed more evenly across European countries and industries. Our analysis has brought additional evidence that production within Europe is highly interconnected across countries and that the persisting asymmetries along GVCs can be hard to address at national level alone and therefore warrant a broader approach.

References

- Acemoglu D. and Restrepo P. (2017) Robots and jobs: evidence from US labor markets, *Journal of Political Economy*, 128 (6), 2188–2244.
- Akcomak S., Kok S. and Rojas-Romagosa H. (2013) The effects of technology and offshoring on changes in employment and task-content of occupations, CPB Discussion Paper 233, The Hague, CPB Netherlands Bureau for Economic Policy Analysis.
- Alsamawi A., Cadestin C., Jaax A., Martins Guilhoto J., Miroudot S. and Zürcher C. (2020) Returns to intangible capital in global value chains: new evidence on trends and policy determinants, OECD Trade Policy Papers 240, Paris, OECD Publishing.
- Altzinger W. and Landesmann M. A. (2008) Special issue: relocation of production and jobs to Central and Eastern Europe – who gains and who loses?, *Structural Change and Economic Dynamics*, 19 (1), 1–3.
- Amador J. and Cabral S. (2017) Networks of value-added trade, *The World Economy*, 40 (7), 1291–1313. <https://doi.org/10.1111/twec.12469>
- Amador J., Cabral S., Mastrandrea R. and Ruzzenenti F. (2018) Who's who in global value chains? A weighted network approach, *Open Economies Review*, 29 (5), 1039–1059. <https://doi.org/10.1007/s11079-018-9499-7>
- Amiti M. and Wei S. J. (2005) Fear of service outsourcing: is it justified?, *Economic Policy*, 20 (42), 308–347.
- Amiti M. and Wei S. J. (2009) Service offshoring, productivity and employment: evidence from the United States, *The World Economy*, 32 (2), 203–220.
- Anderton R. and Brenton P. (1999) Outsourcing and low-skilled workers in the UK, *Bulletin of Economic Research*, 51 (4), 267–285.
- Antràs P. (2020) Conceptual aspects of global value chains, Policy Research Working Paper 9114, Washington, DC, The World Bank.
- Autor D. H., Dorn D. and Hanson G. H. (2016) The China shock: learning from labor market adjustment to large changes in trade, *Annual Review of Economics*, 8, 205–240.
- Baldwin R., Forslid R., Martin P., Ottaviano G. and Robert-Nicoud F. (2005) *Economic geography and public policy*, Princeton University Press.
- Baldwin R. (2011) Trade and industrialization after globalization's second unbundling: how building and joining a supply chain are different and why it matters, in Feenstra R. C. and Taylor A. M. (eds.) *Globalization in an age of crisis: multilateral economic cooperation in the twenty-first century*, Chicago, The University of Chicago Press.
- Baldwin R. and López-Gonzalez J. (2015) Supply-chain trade: a portrait of global patterns and several testable hypotheses, *The World Economy*, 38 (11), 1682–1721. <https://doi.org/10.1111/twec.12189>
- Baumgarten D., Geishecker I. and Görg H. (2013) Offshoring, tasks, and the skill-wage pattern, *European Economic Review*, 61, 132–152.
- Becker S. O., Ekholm K. and Muendler M. A. (2013) Offshoring and the onshore composition of tasks and skills, *Journal of International Economics*, 90 (1), 91–106.
- Belderbos R., Sleuwaegen L., Somers D. and De Backer K. (2016) Where to locate innovative activities in global value chains: does co-location matter?, OECD Science, Technology and Industry Policy Papers 30, Paris, OECD Publishing.
- Blundell R., Griffith R. and van Reenen J. (1995) Dynamic count data model of technological innovation, *The Economic Journal*, 105 (429), 333–344.

- Blundell R., Griffith R. and Windmeijer F. (2002) Individual effects and dynamics in count data models, *Journal of Econometrics*, 108 (1), 113–131.
- Bontadini F., Evangelista R., Meliciani V. and Savona M. (2019) Integration in global value chains and employment in Europe, SPRU Working Paper Series 2019-16, Brighton, Science Policy Research Unit, University of Sussex Business School.
- Bontadini F. and Saha A. (2021) How do we understand participation in global value chains? A structured review of the literature, Sciences Po OFCE Working Paper 01/2021, Paris, Observatoire français des conjonctures économiques.
- Borin A. and Mancini M. (2020) Measuring what matters in global value chains and value-added trade, Policy research Working Paper 8804, Washington, DC, The World Bank.
- Bramucci A., Cirillo V., Evangelista R. and Guarascio D. (2017) Offshoring, industry heterogeneity and employment, *Structural change and economic dynamics*, 56, 400–411.
- Castellani D., Meliciani V. and Mirra L. (2016) The determinants of inward foreign direct investment in business services across European regions, *Regional Studies*, 50 (4), 671–691.
- Chen W., Los B. and Timmer M. P. (2017) Factor incomes in global value chains: the role of intangibles, NBER Working Paper 25242, Cambridge, MA, National Bureau of Economic Research.
- Celi G., Ginzburg A., Guarascio D. and Simonazzi A. (2018) Northern and Southern Europe in the long European crisis: a core-periphery perspective, London, Routledge.
- Cirillo V. and Guarascio D. (2015) Jobs and competitiveness in a polarised Europe, *Intereconomics*, 50 (3), 156–160.
- Cirillo V., Pianta M. and Nascia L. (2018) Technology and occupations in business cycles, *Sustainability*, 10 (2), 463.
- Cirera X. and Maloney W.F. (2017) The innovation paradox: developing-country capabilities and the unrealized promise of technological catch-up, Washington, DC, The World Bank.
- Cohen W.M. (2010) Fifty years of empirical studies of innovative activity and performance, in Hall B. H. and Rosenberg N. (eds.) *Handbook of the economics of innovation*, Amsterdam, Elsevier, 129-213.
- Corrado C., Haskel J., Jona-Lasinio C. and Iommi M. (2016) Intangible investment in the EU and US before and since the Great Recession and its contribution to productivity growth, EIB Working Papers 2016/08, Luxembourg, European Investment Bank.
- Crinò R. (2009) Offshoring, multinationals and labour market: a review of the empirical literature, *Journal of Economic Surveys*, 23 (2), 197–249.
- Crinò R. (2012) Service offshoring and the skill composition of labour demand, *Oxford Bulletin of Economics and Statistics*, 74 (1), 20–57.
- Dedrick J., Kraemer K. L. and Linden G. (2010) Who profits from innovation in global value chains? A study of the iPod and notebook PCs, *Industrial and Corporate Change*, 19 (1), 81-116.
- Dosi G., Freeman C., Nelson R., Silverberg G. and Soete L. (eds.) (1988) *Technical change and economic theory*, London, Pinter Publisher.
- Dosi G., Pavitt K. and Soete L. (1990) *The economics of technical change and international trade*, New York, New York University Press.
- Dosi G., Grazzi M. and Moschella D. (2015) Technology and costs in international competitiveness: from countries and sectors to firms, *Research Policy*, 44 (10), 1795-1814.
- Durand C. and Milberg W. (2020) Intellectual monopoly in global value chains, *Review of International Political Economy*, 27 (2), 404-429.

- Evangelista R., Lucchese M. and Meliciani V. (2013) Business services, innovation and sectoral growth, *Structural Change and Economic Dynamics*, 25 (1), 119-132.
- Everatt D., Tsai T. and Chang B. (1999) The Acer Group's China manufacturing decision, Richard Ivey School of Business Case Series #9A99M009, London, Ontario, Ivey Publishing.
- Fagerberg J. (1994) Technology and international differences in growth rates, *Journal of Economic Literature*, 32 (3), 1147-1175.
- Falzoni A. M. and Tajoli L. (2012) The effects of offshoring on the composition of employment in Italy, in Stern R. (ed.) *Quantitative analysis of newly evolving patterns of international trade fragmentation, offshoring of activities, and vertical intra-industry trade*, London, World Scientific Publishing, 195-236.
- Farole T. and Winkler D. (eds.) (2014) *Making foreign direct investment work for Sub-Saharan Africa: local spillovers and competitiveness in global value chains*, Washington, DC, The World Bank.
- Feenstra R. C. and Hanson G.H. (1996) Globalization, outsourcing, and wage inequality, *The American Economic Review*, 86 (2), 240-245.
- Feenstra R. C. and Hanson G. H. (1999) The impact of outsourcing and high-technology capital on wages: estimates for the United States, 1979-1990, *Quarterly Journal of Economics*, 114 (3), 907-940.
- Foster-McGregor N., Stehrer R. and De Vries G. J. (2013) Offshoring and the skill structure of labour demand, *Review of World Economics*, 149 (4), 631-662.
- Foster-McGregor N., Pöschl J. and Stehrer R. (2016) Offshoring and the elasticity of labour demand, *Open Economies Review*, 27 (3), 515-540.
- Fujita M., Krugman P. and Venables A. (1999) *The spatial economy. Cities, regions and international trade*, Cambridge, MA, MIT Press.
- Gagliardi L. (2019) The impact of foreign technological innovation on domestic employment via the industry mix, *Research Policy*, 48 (6), 1523-1533.
- Garbellini N., Marelli E. and Wirkierman A. L. (2014) Domestic demand and global production in the eurozone: a multi-regional input-output assessment of the global crisis, *International Review of Applied Economics*, 28 (3), 336-364.
- Gereffi G. (1994) The organization of buyer-driven global commodity chains: how U.S. retailers shape overseas production networks, in Gereffi G. and Korzeniewicz M. (eds.) *Commodity chains and global capitalism*, Westport, CT, Praeger, 95-122.
- Gereffi G., Humphrey J. and Sturgeon T. (2005) The governance of global value chains, *Review of International Political Economy*, 12 (1), 78-104.
<https://doi.org/10.1080/09692290500049805>
- Grodzicki M.J. and Geodecki T. (2016) New dimensions of core-periphery relations in an economically integrated Europe: the role of global value chains, *Eastern European Economics*, 54 (5), 377-404.
- Grossman G. and Rossi-Hansberg H. (2008) Trading tasks: a simple theory of offshoring, *American Economic Review*, 98 (5), 1978-1997.
- Grossman G. and Rossi-Hansberg H. (2012) Task trade between similar countries, *Econometrica*, 80 (2), 593-629.
- Grundke R., Kalamova M., Keslair F., Jamet S. and Squicciarini M. (2017a) Skills and global value chains: a characterisation, *OECD Science, Technology and Industry Working Papers 2017/05*, Paris, OECD Publishing.
- Grundke R., Kalamova M., Jamet, S. and Squicciarini M. (2017b) Having the right mix: the role of skill bundles for comparative advantage and industry performance in GVCs, *OECD Science, Technology and Industry Working Papers 2017/03*, Paris, OECD Publishing.

- Hijzen A. and Swaim P. (2007) Does offshoring reduce industry employment?, *National Institute Economic Review*, 201 (1), 86–96.
- Hijzen A., Görg H. and Hine R. C. (2005) International outsourcing and the skill structure of labour demand in the United Kingdom, *The Economic Journal*, 115 (506), 860–878.
- Hogrefe J. (2013) Offshoring and relative labour demand from a task perspective, ZEW Discussion Paper 13–067, Leibniz, Centre for European Economic Research.
- Jaax A. and Miroudot S. (2021) Capturing value in GVCs through intangible assets: the role of the trade–investment–intellectual property nexus, *Journal of International Business Policy*, 4, 433–452.
- Johnson R. C. (2018) Measuring global value chains, *Annual Review of Economics*, 10, 207–236.
- Jona-Lasinio C. and Meliciani V. (2018) Productivity growth and international competitiveness: does intangible capital matter?, *Intereconomics*, 53 (2), 58–62.
- Keller W. (2002) Geographic localization of international technology diffusion, *American Economic Review*, 92 (1), 120–142.
- Koopman R., Wang Z. and Wei S. (2014) Tracing value-added and double counting in gross exports, *American Economic Review*, 104 (2), 459–494.
- Lanz R., Miroudot S. and Nordås H. K. (2011) Trade in tasks, OECD Trade Policy Working Papers 2011/117, Paris, OECD Publishing.
- Landesmann M. A. and Stehrer R. (2000) Industrial specialization, catching-up and labour market dynamics, *Metroeconomica*, 51 (1), 67–101.
- Laurson K. and Meliciani V. (2010) The role of ICT knowledge flows for international market share dynamics, *Research Policy*, 39 (5), 687–697.
- Lema R., Pietrobelli C. and Rabellotti R. (2019) Innovation in global value chains, in Ponte S., Gereffi G. and Raj-Reichert G. (eds.) *Handbook on global value chains*, Cheltenham, Edward Elgar, 370–384.
- López-Gonzalez J., Meliciani V. and Savona M. (2019) When Linder meets Hirschman: inter-industry linkages and global value chains in business services, *Industrial and Corporate Change*, 28 (6), 1555–1586.
- Lybbert T. J. and Zolas N. J. (2014) Getting patents and economic data to speak to each other: an “algorithmic links with probabilities” approach for joint analyses of patenting and economic activity, *Research Policy*, 43 (3), 530–542.
- Maggi B. (2017) A technology-based countries-interaction dynamic model for the study of European growth and stability: were there the conditions for convergence?, *Technological Forecasting and Social Change*, 125, 275–288.
- Marcolin L., Miroudot S. and Squicciarini M. (2016) Routine jobs, employment and technological innovation in global value chains, OECD Science, Technology and Industry Working Papers, 2016/01, Paris, OECD Publishing.
- Marcolin L. and Squicciarini M. (2018) Investing in innovation and skills: thriving through global value chains, *Review of Economics and Institutions*, 9 (1), 1–33.
- Meliciani V. and Savona M. (2015) The determinants of regional specialisation in business services: agglomeration economies, vertical linkages and innovation, *Journal of Economic Geography*, 15 (2), 387–416.
- Milberg W. and Winkler D. (2011) Economic and social upgrading in global production networks: Problems of theory and measurement, *International Labour Review*, 150 (3–4), 341–365.
- Milberg W. and Winkler D. (2013) *Outsourcing economics. Global value chains in capitalist development*, New York, Cambridge University Press.

- Mudambi R. (2007) Offshoring: economic geography and the multinational firm, *Journal of International Business Studies*, 38 (1), 206-210.
- Mudambi R. (2008) Location, control and innovation in knowledge-intensive industries, *Journal of Economic Geography*, 8 (5), 699-725.
- OECD (2007) *Offshoring and employment: trends and impact*, Paris, OECD Publishing.
- OECD (2013) *Interconnected economies: benefiting from global value chains*, Paris, OECD Publishing.
- Ottaviano G. (2015) *Offshoring and the migration of jobs*, IZA World of Labor.
- Pietrobelli C. and Rabellotti R. (2011) Global value chains meet innovation systems: are there learning opportunities for developing countries?, *World Development*, 39 (7), 1261–1269.
- Prebisch R. (1950) *The economic development of Latin America and its principal problems*, New York, United Nations Department of Economic Affairs, Economic Commission for Latin America.
- Reijnders L. S. M. and de Vries G. J. (2018) Technology, offshoring and the rise of non-routine jobs, *Journal of Development Economics*, 135, 412–432.
- Shin N., Kraemer K. L. and Dedrick J. (2009) R&D, value chain location and firm performance in the global electronics industry, *Industry and Innovation*, 16 (3), 315–330.
- Shin N., Kraemer K. L. and Dedrick J. (2012) Value capture in the global electronics industry: empirical evidence for the 'smiling curve' concept, *Industry and Innovation*, 19 (2), 89-107.
- Simonazzi A., Ginzburg A. and Nocella G. (2013) Economic relations between Germany and Southern Europe, *Cambridge Journal of Economics*, 37 (3), 653–675.
- Stöllinger R. (2016) Structural change and global value chains in the EU, *Empirica*, 43, 801–829.
- Strauss-Kahn V. (2003) The role of globalization in the within-industry shift away from unskilled workers in France, in Baldwin R. and Winters A. (eds.) *Challenges to globalization: analyzing the economics*, Chicago, University of Chicago Press, 209-234.
- Taglioni D. and Winkler D. E. (2016) *Making global value chains work for development*, Trade and Development, Washington, DC, The World Bank.
- Timmer M. P., Los B., Stehrer R. and de Vries G. J. (2013) Fragmentation, incomes and jobs: an analysis of European competitiveness, *Economic Policy*, 28 (76), 613–661.
- Timmer M. P., Miroudot S. and de Vries G. J. (2019) Functional specialisation in trade, *Journal of Economic Geography*, 19 (1), 1–30. <https://doi.org/10.1093/jeg/lby056>
- Verdolini E. and Galeotti M. (2011) At home and abroad: an empirical analysis of innovation and diffusion in energy technologies, *Journal of Environmental Economics and Management*, 61 (2), 119-134.
- de Vries G. J., Jiang A., Lemmers O. and Wei S. J. (2020) Firm productivity and functional specialisation, *The World Economy*, 44 (5), 1232-1260.
- Wang Z., Wei S., Yu X. and Zhu K. (2017) *Measures of participation in global value chains and global business cycles*, NBER Working Paper 23222, Cambridge, MA, National Bureau of Economic Research.
- WIPO (2017) *Intangible capital in global value chains, Report 2017*, Geneva, World Intellectual Property Organization.
- Wirkierman A., Ciarli T. and Savona M. (2021) *A taxonomy of European innovation clubs*, Working paper 9/2021, Rome, LUISS School of European Political Economy.

Appendix A

Grouping of countries, industries and occupations

This section of the Appendix reports the grouping of countries into regions (Table A1) and industries into macro sectors (Tables A2 and A3) that we use to present the descriptive evidence in section 4. We also show which country-industries rank in the top and bottom two deciles of the distribution of patent intensity among manufacturing industries (Tables A4 and A5, respectively). This ranking is used to construct our dummy variables $TopDecile_{ijt_0}$ and $BottomDecile_{ijt_0}$ which we use in our econometric analysis as discussed in section 5.

We also report some key descriptive evidence on the distribution and evolution of the variables used in Figures 2 to 4, this time at country level. These can be found in Tables A6 to A10.

Table A1 Countries and regions

Region	Centre	East	North	South	West
Country	Austria Belgium Germany France Netherlands	Bulgaria Czech Republic Croatia Hungary Poland Romania Slovakia	Denmark Finland Sweden	Spain Greece Italy Portugal	United Kingdom Ireland

Table A2 Manufacturing industries

NACE	Description	Macro sector
C10-C12	Manufacture of food products, beverages and tobacco products	ltmf
C13-C15	Manufacture of textiles, wearing apparel and leather products	ltmf
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	ltmf
C17	Manufacture of paper and paper products	ltmf
C18	Printing and reproduction of recorded media	ltmf
C20-C21	Manufacture of chemicals and pharmaceutical products	htmf
C22	Manufacture of rubber and plastic products	ltmf
C23	Manufacture of other non-metallic mineral products	ltmf
C24	Manufacture of basic metals	ltmf
C25	Manufacture of fabricated metal products, except machinery and equipment	ltmf
C26	Manufacture of computer, electronic and optical products	htmf
C27	Manufacture of electrical equipment	htmf
C28	Manufacture of machinery and equipment n.e.c.	htmf
C29	Manufacture of motor vehicles, trailers and semi-trailers	htmf
C30	Manufacture of other transport equipment	htmf
C31-C32	Manufacture of furniture; other manufacturing	ltmf

Table A3 Service industries

NACE	Description	Macro sector
G45	Wholesale and retail trade and repair of motor vehicles and motorcycles	lkbs
G46	Wholesale trade, except of motor vehicles and motorcycles	lkbs
G47	Retail trade, except of motor vehicles and motorcycles	lkbs
H49	Land transport and transport via pipelines	lkbs
H50	Water transport	kis
H51	Air transport	kis
H52	Warehousing and support activities for transportation	lkbs
I	Accommodation and food service activities	lkbs
J61-H53	Post and telecommunications	kis
J62-J63	Computer programming, consultancy and related activities; information service activities	kibs
K64	Financial service activities, except insurance and pension funding	kis
K65	Insurance, reinsurance and pension funding, except compulsory social security	kis
K66	Activities auxiliary to financial services and insurance activities	kis
M-N	Business services	kibs
M72	Scientific research and development	kibs
R-S	Other service activities	kis

Table A4 Manufacturing country-industries in the top 2 deciles for patent intensity

Country	NACE	Decile
AUT	C20-C21; C26; C30	Tenth decile
BEL	C26	
DEU	C13-C15; C17; C20-C21; C23; C26; C31-C32	
DNK	C20-C21; C26	
FIN	C20-C21; C23; C26	
FRA	C20-C21; C23; C26; C27; C28; C31-C32	
GBR	C20-C21; C26	
ITA	C26	
NLD	C23; C26; C27	
SWE	C13-C15; C20-C21; C22; C23; C26; C31-C32	
AUT	C22; C23; C28; C31-C32	Ninth Decile
BEL	C17; C20-C21	
DEU	C22; C24; C27; C28; C30	
DNK	C17; C23; C24; C27; C29	
FIN	C27; C29; C31-C32	
FRA	C17; C24	
GBR	C17; C23; C28	
GRC	C26	
HUN	C20-C21	
ITA	C20-C21	
NLD	C17; C20-C21; C22; C24; C28	
SWE	C27; C28	

Table A5 **Manufacturing country-industries in the bottom 2 deciles for patent intensity**

Country	NACE	Decile
BGR	C13-C15	First Decile
CZE	C16; C18	
ESP	C18	
GRC	C18	
HRV	C16	
HUN	C18	
IRL	C18	
POL	C10-C12; C16; C18; C22; C25; C29	
PRT	C10-C12; C13-C15; C16; C17; C18; C25	
ROU	C10-C12; C13-C15; C16; C17; C18; C22; C24; C25; C29; C31-C32	
SVK	C16; C18; C24; C29	
BGR	C10-C12; C18; C23; C24; C25; C29	Second Decile
CZE	C10-C12; C22; C25; C29	
FIN	C18	
GRC	C10-C12; C13-C15	
HRV	C10-C12; C13-C15; C25; C30	
HUN	C13-C15; C16; C29	
POL	C13-C15; C17; C24; C30; C31-C32	
PRT	C22; C23; C27; C29	
ROU	C30	
SVK	C10-C12; C17; C22; C25	

Table A6 Country-level descriptive evidence on GVC backward participation

Country	Mean	Median	Change	Percentage change
AUT	0.13	0.13	0.04	36.61
BEL	0.18	0.16	0.08	51.18
BGR	0.08	0.08	0.11	543.87
CZE	0.12	0.12	0.07	76.86
DEU	0.07	0.07	0.03	59.98
DNK	0.15	0.16	0.05	37.61
ESP	0.05	0.05	0.02	36.54
FIN	0.09	0.09	0.04	62.07
FRA	0.08	0.08	0.04	54.13
GBR	0.06	0.06	0.02	35.86
GRC	0.03	0.02	0.02	81.09
HRV	0.10	0.10	0.05	57.98
HUN	0.18	0.17	0.08	53.41
IRL	0.20	0.18	0.09	49.13
ITA	0.04	0.04	0.02	70.59
NLD	0.14	0.12	0.07	66.23
POL	0.09	0.09	0.04	65.32
PRT	0.08	0.08	0.06	130.75
ROU	0.07	0.07	0.01	18.93
SVK	0.18	0.18	0.09	72.19
SWE	0.10	0.10	0.02	21.61

Note: this table reports the distribution and long-term change of country-level averages over time and across industries.

Table A7 Country-level descriptive evidence on patent stock intensity

Country	Mean	Median	Change	Percentage change
AUT	0.07	0.07	-0.01	-7.02
BEL	0.07	0.06	0.04	73.78
BGR	0.01	0.01	0.01	80.91
CZE	0.01	0.01	0.00	58.35
DEU	0.11	0.11	-0.01	-12.45
DNK	0.09	0.08	0.05	75.41
ESP	0.02	0.02	0.02	113.31
FIN	0.06	0.06	0.02	35.96
FRA	0.09	0.09	0.02	25.03
GBR	0.07	0.07	0.01	14.53
GRC	0.02	0.02	0.02	176.09
HRV	0.01	0.01	0.01	83.30
HUN	0.01	0.01	0.00	-13.31
IRL	0.04	0.02	0.13	681.82
ITA	0.04	0.04	0.00	9.46
NLD	0.09	0.10	0.01	11.69
POL	0.00	0.00	0.01	350.83
PRT	0.01	0.01	0.01	417.46
ROU	0.00	0.00	0.00	257.37
SVK	0.00	0.00	0.00	-1.73
SWE	0.09	0.09	0.01	15.85

Note: this table reports the distribution and long-term change of country-level averages over time and across industries.

Table A8 Country-level descriptive evidence on intangible asset intensity

Country	Mean	Median	Change	Percentage change
AUT	0.052	0.050	0.012	25.15
BEL	0.045	0.044	0.011	27.95
BGR				
CZE	0.034	0.035	0.003	8.74
DEU	0.043	0.042	-0.003	-6.11
DNK	0.058	0.056	0.006	11.75
ESP	0.031	0.029	0.006	19.47
FIN	0.062	0.061	0.005	8.47
FRA	0.064	0.064	0.014	23.69
GBR	0.059	0.059	-0.008	-12.84
GRC	0.033	0.033	-0.005	-13.04
HRV				
HUN	0.035	0.033	-0.010	-31.00
IRL	0.046	0.045	0.022	69.27
ITA	0.036	0.036	0.001	3.46
NLD	0.051	0.051	0.002	4.80
POL				
PRT	0.039	0.039	0.009	27.12
ROU				
SVK	0.028	0.027	0.002	7.06
SWE	0.078	0.078	0.004	5.17

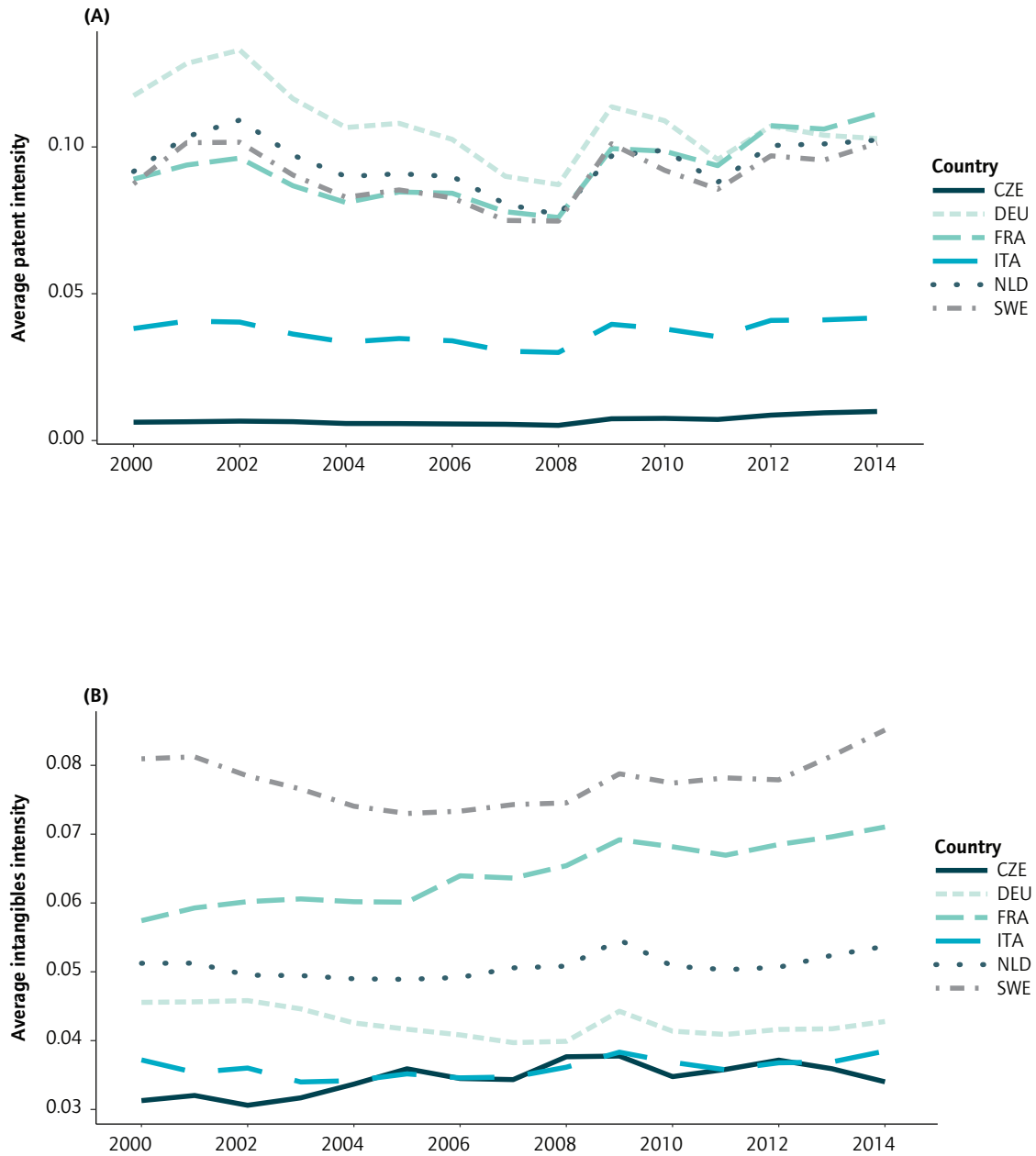
Note: this table reports the distribution and long-term change of country-level averages over time and across industries. Poland, Romania, Croatia and Bulgaria are missing from the INTAN-Invest dataset.

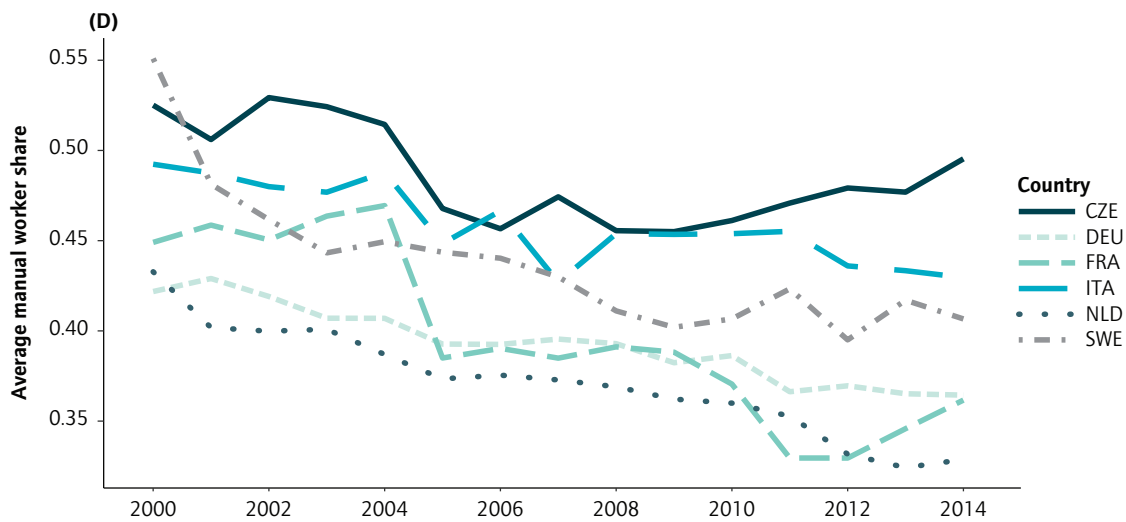
Table A9 Country-level descriptive evidence on the share of managers

Country	Mean	Median	Change	Percentage change
AUT	0.36	0.38	0.17	73.87
BEL	0.39	0.39	0.05	13.64
BGR	0.34	0.34	-0.01	-3.22
CZE	0.38	0.38	0.03	8.22
DEU	0.36	0.36	-0.01	-1.75
DNK	0.44	0.44	-0.01	-2.71
ESP	0.35	0.35	0.05	15.04
FIN	0.42	0.41	0.04	9.42
FRA	0.43	0.42	0.10	26.55
GBR	0.41	0.41	0.07	18.93
GRC	0.33	0.32	0.02	7.21
HRV	0.36	0.35	0.05	13.13
HUN	0.33	0.33	0.03	9.93
IRL	0.35	0.35	0.08	27.84
ITA	0.34	0.35	0.09	32.15
NLD	0.41	0.41	0.04	9.79
POL	0.38	0.38	0.04	11.49
PRT	0.32	0.31	0.07	21.93
ROU	0.32	0.32	0.04	12.92
SVK	0.35	0.35	0.01	2.75
SWE	0.43	0.42	0.04	9.30

Note: this table reports the distribution and long-term change of country-level averages over time and across industries. Information on employment in Poland is only available from 2004 onwards; therefore, long-term changes for this country refer to the period 2004-14.

Figure A1 Patent, intangible asset intensity and shares of managers and manual workers across selected countries and over time





Source: authors' calculations using REGPAT, INTAN-Invest and LFS data – unweighted average across macro regions and sectors for patent and intangible asset intensity.

Table A10 Country-level descriptive evidence on the share of manual workers

Country	Mean	Median	Change	Percentage change
AUT	0.43	0.41	-0.13	-25.41
BEL	0.46	0.44	-0.12	-22.20
BGR	0.54	0.54	-0.07	-11.28
CZE	0.49	0.48	-0.03	-5.66
DEU	0.39	0.39	-0.06	-13.61
DNK	0.49	0.45	-0.18	-28.38
ESP	0.47	0.45	-0.09	-16.85
FIN	0.47	0.46	-0.07	-13.56
FRA	0.40	0.39	-0.09	-19.46
GBR	0.39	0.39	-0.05	-12.78
GRC	0.49	0.46	-0.11	-18.87
HRV	0.51	0.51	-0.01	-2.08
HUN	0.52	0.51	-0.02	-2.80
IRL	0.45	0.45	-0.03	-6.92
ITA	0.46	0.45	-0.06	-12.76
NLD	0.37	0.37	-0.10	-24.05
POL	0.50	0.50	-0.11	-18.79
PRT	0.54	0.54	-0.10	-17.54
ROU	0.56	0.55	-0.09	-13.87
SVK	0.53	0.51	-0.07	-11.83
SWE	0.44	0.43	-0.14	-26.20

Note: this table reports the distribution and long-term change of country-level averages over time and across industries. Information on employment in Poland is only available from 2004 onwards; therefore, long-term changes for this country refer to the period 2004-14.

Table A11 Occupations and functions

ISCO label	ISCO88	Function
Legislators, senior officials and managers	01	Managers
Professionals	02	Managers
Technicians and associate professionals	03	Managers
Craft and related trades workers	07	Manual workers
Plant and machine operators and assemblers	08	Manual workers
Elementary occupations	09	Manual workers

Appendix B

Robustness checks

This section reports and briefly discusses some of the robustness checks of our results from the econometric analysis presented in section 5 and discussed in section 6 in the main text.

Naturally, the choice of using a dummy taking a value of 1 when a country-industry ranks in the top (or bottom) decile, while appropriate for identifying leaders and laggards in patent intensity, is somewhat arbitrary. We therefore replicate our results, setting the threshold to identify country-industries at the top and bottom for patent intensity encompassing also the second and ninth (rather than just the first and tenth) deciles.

Table B1 reports our results looking at the interaction between a dummy taking a value of 1 if a country-industry is in the top 20 per cent for patent intensity. As we enlarge the group of country-industries we consider as leaders in patent intensity, the interaction term loses statistical significance, suggesting that the relationship between GVC backward participation and the share of managers is no longer different for this larger group of technological leaders than from the rest of the country-industries in our sample.

Interestingly we also find a change in significance for the interaction of our dummy variable with backward patent intensity, capturing the technological quality of backward linked GVC partners. In our main model we find a negative sign, suggesting a competition/substitution effect that leads technological leaders to offshore managerial occupations to other technologically intensive GVC partners. Now we find no evidence of this effect but, in contrast, we find that country-industries in the top 20 per cent for patent intensity that import value added from other patent intensive partners tend to have lower shares of manual workers. This evidence hints at the possible spillover effect that we discussed in section 4: as country-industries with a solid technological base engage in GVC participation with other technological intensive partners, they also shift their employment structure away from fabrication activities.

Concerning the relationship between intangible asset intensity of backward linked GVC partners and employment structure, we find results that are, overall, consistent with our preferred specification with the exception of the loss of significance of the interaction term for the share of managers (columns 3 and 4).

Table B2 replicates the results for Table 2 in the main text, focusing thus on country-industries in the bottom 20 per cent (rather than 10 per cent) for patent intensity. We find our main results to be robust and that there are two additional features at play. First, country-industries in the bottom 20 per cent see their share of managers decrease as they import value added from high patent intensity partners (columns 2 and 4), as well as higher shares of manual workers as they integrate with service GVC partners that are intangibles intensive. Overall, this confirms the idea that country-industries that are lagging in technological intensity stand to reap smaller benefits, in terms of employment structure, from integrating in GVCs with partners of high technological quality.

Table B1 GVC participation, quality and employment structure in the top 2 deciles

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Managers				Manual Workers			
2006*PSM	0.507*** (0.0387)	0.504*** (0.0390)	0.500*** (0.0385)	0.497*** (0.0389)	0.718*** (0.0413)	0.689*** (0.0436)	0.699*** (0.0413)	0.671*** (0.0437)
2007*PSM	0.538*** (0.0375)	0.535*** (0.0375)	0.531*** (0.0374)	0.529*** (0.0373)	0.729*** (0.0489)	0.706*** (0.0499)	0.709*** (0.0496)	0.688*** (0.0507)
2008*PSM	0.463*** (0.0513)	0.461*** (0.0508)	0.456*** (0.0512)	0.454*** (0.0507)	0.622*** (0.0497)	0.600*** (0.0509)	0.599*** (0.0494)	0.579*** (0.0506)
2009*PSM	0.392*** (0.0401)	0.389*** (0.0406)	0.384*** (0.0401)	0.382*** (0.0405)	0.624*** (0.0461)	0.589*** (0.0484)	0.599*** (0.0459)	0.566*** (0.0486)
2010*PSM	0.439*** (0.0382)	0.437*** (0.0386)	0.435*** (0.0384)	0.433*** (0.0387)	0.641*** (0.0498)	0.610*** (0.0519)	0.618*** (0.0486)	0.588*** (0.0511)
2011*PSM	0.447*** (0.0487)	0.446*** (0.0489)	0.441*** (0.0490)	0.441*** (0.0491)	0.700*** (0.0520)	0.674*** (0.0528)	0.675*** (0.0510)	0.650*** (0.0521)
2012*PSM	0.395*** (0.0434)	0.393*** (0.0435)	0.387*** (0.0438)	0.385*** (0.0438)	0.716*** (0.0520)	0.686*** (0.0526)	0.688*** (0.0508)	0.659*** (0.0517)
2013*PSM	0.417*** (0.0713)	0.416*** (0.0714)	0.407*** (0.0719)	0.406*** (0.0720)	0.662*** (0.0501)	0.631*** (0.0522)	0.632*** (0.0496)	0.603*** (0.0521)
2014*PSM	0.380*** (0.0551)	0.380*** (0.0557)	0.369*** (0.0550)	0.369*** (0.0555)	0.692*** (0.0513)	0.662*** (0.0531)	0.661*** (0.0506)	0.632*** (0.0530)
Bwd GVC	0.00396 (0.0120)	0.00250 (0.0119)	0.00306 (0.0119)	0.00160 (0.0119)	0.0104 (0.00721)	0.00950 (0.00725)	0.00963 (0.00716)	0.00879 (0.00720)
Top decile patent ₁₀	0.0340 (0.0415)	0.0952 (0.105)	0.310 (0.390)	0.358 (0.400)	-0.0379 (0.0319)	-0.288*** (0.0846)	-1.003*** (0.255)	-1.231*** (0.277)
Top decile patent ₁₀ *Bwd GVC	-0.000606 (0.0236)	-0.00128 (0.0234)	-0.00105 (0.0234)	-0.00189 (0.0233)	0.00984 (0.0195)	0.00530 (0.0189)	0.00817 (0.0194)	0.00386 (0.0189)
Bwd Patent		-0.0818 (0.0629)		-0.0752 (0.0631)		0.0240 (0.0264)		0.0224 (0.0260)
Top decile patent ₁₀ *Bwd Patent		0.0233 (0.0383)		0.0137 (0.0384)		-0.0903*** (0.0296)		-0.0859*** (0.0296)
Bwd intangibles			0.675*** (0.205)	0.664*** (0.205)			-0.258** (0.114)	-0.248** (0.114)
Top decile patent ₁₀ *Bwd Intangibles			0.0933 (0.129)	0.0976 (0.128)			-0.322*** (0.0828)	-0.319*** (0.0818)
Patents	-0.0316*** (0.0120)	-0.0310*** (0.0120)	-0.0240* (0.0125)	-0.0235* (0.0124)	0.0120** (0.00604)	0.0130** (0.00608)	0.00820 (0.00624)	0.00920 (0.00628)
Capital ₁₀	0.0425*** (0.0145)	0.0428*** (0.0145)	0.0424*** (0.0144)	0.0426*** (0.0144)	-0.0314*** (0.00595)	-0.0327*** (0.00597)	-0.0293*** (0.00584)	-0.0306*** (0.00587)
Constant	-0.984*** (0.106)	-1.218*** (0.212)	1.056* (0.636)	0.808 (0.670)	-0.00968 (0.0407)	0.0547 (0.0833)	-0.817** (0.352)	-0.728** (0.349)
Observations	2,575	2,575	2,575	2,575	2,589	2,589	2,589	2,589
R-squared	0.741	0.741	0.743	0.743	0.824	0.825	0.826	0.827

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table B2 GVC participation, quality and employment structure in the bottom 2 deciles

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Managers				Manual Workers			
2006*PSM	0.492*** (0.0386)	0.486*** (0.0387)	0.485*** (0.0385)	0.479*** (0.0385)	0.687*** (0.0447)	0.684*** (0.0448)	0.683*** (0.0449)	0.682*** (0.0451)
2007*PSM	0.524*** (0.0371)	0.520*** (0.0368)	0.517*** (0.0368)	0.513*** (0.0365)	0.698*** (0.0527)	0.697*** (0.0526)	0.693*** (0.0532)	0.693*** (0.0532)
2008*PSM	0.449*** (0.0503)	0.446*** (0.0494)	0.442*** (0.0499)	0.439*** (0.0491)	0.591*** (0.0532)	0.590*** (0.0531)	0.585*** (0.0530)	0.585*** (0.0530)
2009*PSM	0.379*** (0.0397)	0.372*** (0.0393)	0.370*** (0.0394)	0.365*** (0.0390)	0.597*** (0.0503)	0.593*** (0.0503)	0.590*** (0.0502)	0.590*** (0.0504)
2010*PSM	0.426*** (0.0375)	0.421*** (0.0371)	0.422*** (0.0373)	0.418*** (0.0369)	0.614*** (0.0536)	0.611*** (0.0537)	0.610*** (0.0524)	0.610*** (0.0526)
2011*PSM	0.434*** (0.0477)	0.432*** (0.0472)	0.429*** (0.0475)	0.427*** (0.0471)	0.673*** (0.0558)	0.672*** (0.0558)	0.668*** (0.0549)	0.668*** (0.0550)
2012*PSM	0.383*** (0.0429)	0.378*** (0.0424)	0.375*** (0.0428)	0.370*** (0.0423)	0.691*** (0.0551)	0.689*** (0.0551)	0.684*** (0.0539)	0.683*** (0.0539)
2013*PSM	0.405*** (0.0704)	0.402*** (0.0698)	0.395*** (0.0706)	0.392*** (0.0700)	0.638*** (0.0531)	0.636*** (0.0531)	0.629*** (0.0522)	0.629*** (0.0524)
2014*PSM	0.369*** (0.0550)	0.366*** (0.0551)	0.357*** (0.0546)	0.355*** (0.0547)	0.669*** (0.0533)	0.667*** (0.0533)	0.659*** (0.0526)	0.659*** (0.0527)
Bwd GVC	0.0142 (0.0136)	0.0145 (0.0136)	0.0175 (0.0141)	0.0159 (0.0141)	0.00903 (0.00933)	0.00881 (0.00934)	0.00384 (0.00966)	0.00417 (0.00967)
Bottom decile patent _{t₀}	-0.0172 (0.0410)	-0.539** (0.233)	-0.866 (0.610)	-0.957 (0.601)	-0.0539*** (0.0201)	0.105 (0.0998)	1.134*** (0.423)	1.139*** (0.421)
Bottom decile patent _{t₀} *Bwd GVC	-0.0341** (0.0143)	-0.0396*** (0.0148)	-0.0403*** (0.0146)	-0.0436*** (0.0149)	0.0121 (0.00834)	0.0137 (0.00845)	0.0186** (0.00873)	0.0188** (0.00871)
Bwd Patent		-0.0739 (0.0623)		-0.0689 (0.0625)		0.0146 (0.0269)		0.0141 (0.0264)
Bottom decile patent _{t₀} *Bwd Patent		-0.176** (0.0770)		-0.158** (0.0805)		0.0538* (0.0318)		0.00850 (0.0305)
Bwd intangibles			0.791*** (0.186)	0.765*** (0.187)			-0.461*** (0.108)	-0.459*** (0.108)
Bottom decile patent _{t₀} *Bwd Intang.			-0.273 (0.197)	-0.151 (0.204)			0.384*** (0.135)	0.377*** (0.138)
Patents	-0.0172 (0.0127)	-0.0174 (0.0127)	-0.00967 (0.0131)	-0.00979 (0.0130)	-0.00618 (0.00659)	-0.00601 (0.00667)	-0.0100 (0.00671)	-0.0101 (0.00679)
Capital _{t₀}	0.0447*** (0.0144)	0.0488*** (0.0144)	0.0457*** (0.0141)	0.0492*** (0.0142)	-0.0336*** (0.00601)	-0.0348*** (0.00600)	-0.0344*** (0.00574)	-0.0345*** (0.00580)
Constant	-0.940*** (0.107)	-1.173*** (0.210)	1.449** (0.589)	1.153* (0.630)	-0.0827* (0.0429)	-0.0368 (0.0849)	-1.489*** (0.334)	-1.441*** (0.334)
Observations	2,575	2,575	2,575	2,575	2,589	2,589	2,589	2,589
R-squared	0.742	0.743	0.744	0.745	0.825	0.825	0.828	0.828

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The results from our preferred specification are not weighted and, as such, it is possible that they are driven by economically small country-industries that do not account for a large proportion of total employment across Europe. To make sure that the implications of our results apply to large swathes of Europe's labour force, we replicate our results but weighting for industries' shares of total employment across countries, finding rather similar results.

Table B3 GVC participation, quality and employment structure in the top decile, weighted for sectors' total employment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Managers				Manual Workers			
2006*PSM	0.533*** (0.0376)	0.535*** (0.0375)	0.527*** (0.0374)	0.528*** (0.0372)	0.699*** (0.0391)	0.706*** (0.0382)	0.684*** (0.0390)	0.693*** (0.0382)
2007*PSM	0.563*** (0.0368)	0.561*** (0.0364)	0.557*** (0.0367)	0.556*** (0.0362)	0.710*** (0.0481)	0.715*** (0.0471)	0.695*** (0.0489)	0.702*** (0.0479)
2008*PSM	0.492*** (0.0530)	0.491*** (0.0522)	0.485*** (0.0528)	0.484*** (0.0519)	0.620*** (0.0487)	0.624*** (0.0480)	0.602*** (0.0481)	0.608*** (0.0474)
2009*PSM	0.440*** (0.0398)	0.445*** (0.0399)	0.432*** (0.0397)	0.438*** (0.0397)	0.632*** (0.0454)	0.640*** (0.0441)	0.611*** (0.0450)	0.622*** (0.0437)
2010*PSM	0.484*** (0.0388)	0.487*** (0.0387)	0.480*** (0.0389)	0.483*** (0.0387)	0.657*** (0.0525)	0.664*** (0.0518)	0.636*** (0.0511)	0.645*** (0.0505)
2011*PSM	0.482*** (0.0432)	0.483*** (0.0430)	0.477*** (0.0434)	0.477*** (0.0432)	0.739*** (0.0543)	0.744*** (0.0529)	0.716*** (0.0539)	0.724*** (0.0525)
2012*PSM	0.457*** (0.0432)	0.459*** (0.0428)	0.449*** (0.0433)	0.450*** (0.0428)	0.764*** (0.0543)	0.771*** (0.0538)	0.738*** (0.0538)	0.747*** (0.0533)
2013*PSM	0.464*** (0.0537)	0.467*** (0.0535)	0.453*** (0.0538)	0.457*** (0.0535)	0.694*** (0.0526)	0.701*** (0.0516)	0.667*** (0.0521)	0.676*** (0.0512)
2014*PSM	0.483*** (0.0693)	0.487*** (0.0694)	0.472*** (0.0694)	0.476*** (0.0694)	0.734*** (0.0504)	0.741*** (0.0496)	0.706*** (0.0500)	0.715*** (0.0494)
Bwd GVC	0.00125 (0.0130)	-0.00283 (0.0127)	0.00282 (0.0133)	-0.00142 (0.0130)	0.0144** (0.00721)	0.0144* (0.00747)	0.0129* (0.00719)	0.0131* (0.00745)
Top decile patent _{t0}	0.0233 (0.0433)	-0.284** (0.126)	0.761* (0.429)	0.531 (0.446)	-0.0826*** (0.0263)	-0.0216 (0.0968)	-1.223*** (0.316)	-1.148*** (0.337)
Top decile patent _{t0} *Bwd GVC	0.0113 (0.0240)	0.0163 (0.0241)	0.00579 (0.0236)	0.0124 (0.0236)	-0.0277** (0.0128)	-0.0286** (0.0127)	-0.0322*** (0.0122)	-0.0334*** (0.0121)
Bwd Patent		-0.0638 (0.0577)		-0.0640 (0.0578)		-0.00649 (0.0253)		-0.00588 (0.0252)
Top decile patent _{t0} *Bwd Patent		-0.122*** (0.0468)		-0.144*** (0.0475)		0.0240 (0.0348)		0.0318 (0.0347)
Bwd intangibles			0.645*** (0.182)	0.656*** (0.182)			-0.170* (0.0969)	-0.174* (0.0968)
Top decile patent _{t0} *Bwd Intangibles			0.251* (0.142)	0.295** (0.141)			-0.380*** (0.104)	-0.382*** (0.104)
Patents	-0.0236* (0.0123)	-0.0240** (0.0122)	-0.0162 (0.0125)	-0.0165 (0.0124)	0.00485 (0.00562)	0.00480 (0.00564)	0.00298 (0.00581)	0.00288 (0.00583)
Capital _{t0}	0.0588*** (0.0142)	0.0597*** (0.0142)	0.0578*** (0.0141)	0.0588*** (0.0141)	-0.0347*** (0.00584)	-0.0347*** (0.00585)	-0.0337*** (0.00582)	-0.0338*** (0.00583)
Constant	0.0144** (0.00721)	0.0144* (0.00747)	0.0129* (0.00719)	0.0131* (0.00745)	0.0144** (0.00721)	0.0144* (0.00747)	0.0129* (0.00719)	0.0131* (0.00745)
Observations	2,575	2,575	2,575	2,575	2,589	2,589	2,589	2,589
R-squared	0.766	0.767	0.768	0.769	0.840	0.840	0.842	0.842

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table B4 GVC participation, quality and employment structure in the bottom decile, weighted for sectors' total employment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Managers				Manual Workers			
2006*PSM	0.520*** (0.0379)	0.517*** (0.0377)	0.513*** (0.0377)	0.510*** (0.0375)	0.707*** (0.0408)	0.707*** (0.0406)	0.704*** (0.0407)	0.705*** (0.0406)
2007*PSM	0.550*** (0.0369)	0.547*** (0.0364)	0.544*** (0.0368)	0.541*** (0.0363)	0.719*** (0.0497)	0.719*** (0.0496)	0.715*** (0.0501)	0.716*** (0.0501)
2008*PSM	0.479*** (0.0530)	0.477*** (0.0523)	0.473*** (0.0527)	0.471*** (0.0520)	0.627*** (0.0491)	0.627*** (0.0491)	0.624*** (0.0490)	0.624*** (0.0491)
2009*PSM	0.427*** (0.0397)	0.425*** (0.0395)	0.420*** (0.0395)	0.418*** (0.0393)	0.641*** (0.0455)	0.640*** (0.0455)	0.637*** (0.0455)	0.637*** (0.0455)
2010*PSM	0.472*** (0.0383)	0.470*** (0.0381)	0.469*** (0.0383)	0.467*** (0.0381)	0.668*** (0.0523)	0.668*** (0.0523)	0.667*** (0.0517)	0.667*** (0.0518)
2011*PSM	0.470*** (0.0425)	0.469*** (0.0422)	0.466*** (0.0425)	0.465*** (0.0423)	0.751*** (0.0532)	0.751*** (0.0532)	0.749*** (0.0529)	0.749*** (0.0530)
2012*PSM	0.446*** (0.0430)	0.444*** (0.0425)	0.439*** (0.0428)	0.437*** (0.0423)	0.778*** (0.0532)	0.778*** (0.0532)	0.774*** (0.0532)	0.774*** (0.0532)
2013*PSM	0.452*** (0.0532)	0.451*** (0.0529)	0.444*** (0.0531)	0.443*** (0.0528)	0.707*** (0.0521)	0.707*** (0.0521)	0.703*** (0.0519)	0.703*** (0.0519)
2014*PSM	0.472*** (0.0695)	0.471*** (0.0694)	0.463*** (0.0693)	0.462*** (0.0692)	0.748*** (0.0499)	0.747*** (0.0499)	0.742*** (0.0495)	0.742*** (0.0495)
Bwd GVC	0.00475 (0.0132)	0.00276 (0.0130)	0.00631 (0.0137)	0.00386 (0.0134)	0.00970 (0.00728)	0.00926 (0.00749)	0.00782 (0.00744)	0.00753 (0.00762)
Bottom decile patent ₁₀	0.0768 (0.0525)	-0.152 (0.294)	-0.184 (0.582)	-0.167 (0.579)	-0.0383 (0.0268)	0.0215 (0.144)	0.501 (0.419)	0.502 (0.422)
Bottom decile patent ₁₀ *Bwd GVC	-0.0275 (0.0188)	-0.0339 (0.0208)	-0.0296 (0.0190)	-0.0365* (0.0213)	0.0263** (0.0113)	0.0277** (0.0124)	0.0283** (0.0115)	0.0275** (0.0122)
Bwd Patent		-0.0623 (0.0576)		-0.0620 (0.0577)		-0.00852 (0.0248)		-0.00857 (0.0247)
Bottom decile patent ₁₀ *Bwd Patent		-0.0712 (0.0924)		-0.0889 (0.106)		0.0189 (0.0422)		-0.00996 (0.0462)
Bwd intangibles			0.697*** (0.164)	0.694*** (0.164)			-0.272*** (0.0919)	-0.273*** (0.0920)
Bottom decile patent ₁₀ *Bwd Intang.			-0.0824 (0.189)	0.0156 (0.220)			0.174 (0.134)	0.185 (0.149)
Patents	-0.00981 (0.0127)	-0.00944 (0.0126)	-0.00312 (0.0129)	-0.00263 (0.0128)	-0.00720 (0.00575)	-0.00717 (0.00577)	-0.00944 (0.00589)	-0.00941 (0.00590)
Capital ₁₀	0.0623*** (0.0140)	0.0630*** (0.0140)	0.0617*** (0.0139)	0.0623*** (0.0139)	-0.0370*** (0.00578)	-0.0371*** (0.00577)	-0.0366*** (0.00574)	-0.0366*** (0.00573)
Constant	-0.948*** (0.0953)	-1.133*** (0.197)	1.164** (0.513)	0.973* (0.535)	-0.0545 (0.0361)	-0.0790 (0.0815)	-0.888*** (0.284)	-0.914*** (0.286)
Observations	2,575	2,575	2,575	2,575	2,589	2,589	2,589	2,589
R-squared	0.770	0.770	0.771	0.771	0.845	0.845	0.846	0.846

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Finally we also want to test our results with more demanding fixed effects. In our preferred specification we include dummies for countries, industries and years while now we control for country-year and industry-year fixed effects. By doing this, we can control both for policies that affect all sectors in a given country and year – such as changes in the labour market – and technological changes that occur in a given year for a specific industry across all countries – such as the diffusion of digital technologies.

The results are, overall, very similar to those we found in our main specification. The only main difference we detect concerns the negative and statistically significant relationship between backward patent intensity and the share of managers (see columns 2 and 4 in Tables B5 and B6). In our main model, this only applies to country-industries that were in the top 10 per cent for patent intensity while now this appears to be the case for all country-industries.

It therefore appears that, as we control for country-year and industry-year fixed effects, the competition/substitution mechanism we put forward in section 4 is at play not only for country-industries in the top 10 per cent but along the whole distribution of patent intensity.

These results bring additional evidence in support of the conjecture that manufacturing industries that import value added from patent intensive GVC partners are likely to experience a decline in the share of workers employed in headquarter functions that are offshored to GVC partners.

Interestingly this effect is more relevant for countries in the top 10 per cent rather than those in the bottom 10 per cent, suggesting that it is technological leaders that stand to lose the most, in terms of employment structure, from other technologically advanced GVC partners.

Table B5 GVC participation, quality and employment structure in the top decile, controlling for country-year and sector-year fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Managers				Manual Workers			
2006*PSM	0.542*** (0.0707)	0.544*** (0.0704)	0.536*** (0.0698)	0.538*** (0.0696)	0.775*** (0.0496)	0.779*** (0.0501)	0.761*** (0.0483)	0.765*** (0.0489)
2007*PSM	0.490*** (0.0770)	0.492*** (0.0766)	0.484*** (0.0765)	0.487*** (0.0761)	0.771*** (0.0724)	0.774*** (0.0720)	0.755*** (0.0729)	0.759*** (0.0725)
2008*PSM	0.500*** (0.135)	0.501*** (0.133)	0.493*** (0.135)	0.494*** (0.133)	0.711*** (0.0957)	0.714*** (0.0955)	0.692*** (0.0939)	0.696*** (0.0937)
2009*PSM	0.339*** (0.0949)	0.341*** (0.0940)	0.333*** (0.0946)	0.336*** (0.0938)	0.593*** (0.118)	0.600*** (0.115)	0.580*** (0.116)	0.588*** (0.114)
2010*PSM	0.429*** (0.0779)	0.435*** (0.0772)	0.425*** (0.0776)	0.431*** (0.0770)	0.650*** (0.121)	0.658*** (0.120)	0.633*** (0.119)	0.642*** (0.118)
2011*PSM	0.481*** (0.0887)	0.487*** (0.0879)	0.478*** (0.0885)	0.484*** (0.0876)	0.601*** (0.132)	0.609*** (0.131)	0.587*** (0.131)	0.596*** (0.129)
2012*PSM	0.396*** (0.0824)	0.400*** (0.0819)	0.391*** (0.0834)	0.395*** (0.0829)	0.636*** (0.0972)	0.642*** (0.0967)	0.619*** (0.0948)	0.627*** (0.0944)
2013*PSM	0.447*** (0.140)	0.452*** (0.139)	0.441*** (0.141)	0.447*** (0.140)	0.520*** (0.120)	0.528*** (0.118)	0.504*** (0.118)	0.514*** (0.117)
2014*PSM	0.361*** (0.0936)	0.366*** (0.0939)	0.357*** (0.0940)	0.362*** (0.0943)	0.658*** (0.0870)	0.665*** (0.0877)	0.642*** (0.0847)	0.651*** (0.0859)
Bwd GVC	0.00524 (0.0118)	-0.000503 (0.0117)	0.00429 (0.0118)	-0.00113 (0.0117)	0.0121 (0.00760)	0.0133* (0.00769)	0.0116 (0.00760)	0.0128* (0.00769)
Top decile patent ₁₀	0.0180 (0.0390)	-0.252** (0.128)	0.279 (0.421)	0.145 (0.442)	-0.0819*** (0.0256)	-0.0336 (0.102)	-0.802** (0.319)	-0.753** (0.352)
Top decile patent ₁₀ *Bwd GVC	0.00791 (0.0197)	0.00923 (0.0199)	0.00432 (0.0199)	0.00769 (0.0201)	-0.0224* (0.0118)	-0.0217* (0.0117)	-0.0246** (0.0119)	-0.0244** (0.0117)
Bwd Patent		-0.182*** (0.0668)		-0.176*** (0.0672)		0.0434 (0.0286)		0.0394 (0.0279)
Top decile patent ₁₀ *Bwd Patent		-0.104** (0.0486)		-0.115** (0.0487)		0.0178 (0.0374)		0.0235 (0.0376)
Bwd intangibles			0.480** (0.238)	0.441* (0.238)			-0.225* (0.121)	-0.217* (0.120)
Top decile patent ₁₀ *Bwd Intangibles			0.0904 (0.140)	0.144 (0.135)			-0.241** (0.105)	-0.245** (0.104)
Patents	-0.0286** (0.0118)	-0.0289** (0.0118)	-0.0234* (0.0125)	-0.0240* (0.0124)	0.00893 (0.00588)	0.00871 (0.00587)	0.00656 (0.00611)	0.00640 (0.00610)
Capital ₁₀	0.0433*** (0.0138)	0.0435*** (0.0136)	0.0436*** (0.0137)	0.0436*** (0.0135)	-0.0332*** (0.00578)	-0.0332*** (0.00574)	-0.0329*** (0.00570)	-0.0328*** (0.00567)
Constant	-0.965*** (0.104)	-1.480*** (0.216)	0.481 (0.745)	-0.130 (0.788)	-0.0255 (0.0387)	0.0987 (0.0873)	-0.717* (0.374)	-0.580 (0.374)
Observations	2,575	2,575	2,575	2,575	2,589	2,589	2,589	2,589
R-squared	0.789	0.790	0.790	0.791	0.861	0.862	0.862	0.863

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table B6 GVC participation, quality and employment structure in the bottom decile, controlling for country-year and sector-year fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Managers				Manual Workers			
2006*PSM	0.521*** (0.0704)	0.517*** (0.0701)	0.516*** (0.0692)	0.513*** (0.0689)	0.785*** (0.0487)	0.785*** (0.0485)	0.780*** (0.0477)	0.779*** (0.0475)
2007*PSM	0.473*** (0.0757)	0.468*** (0.0751)	0.468*** (0.0751)	0.463*** (0.0745)	0.780*** (0.0717)	0.780*** (0.0711)	0.772*** (0.0719)	0.772*** (0.0713)
2008*PSM	0.484*** (0.133)	0.477*** (0.131)	0.477*** (0.133)	0.470*** (0.131)	0.721*** (0.0939)	0.721*** (0.0934)	0.711*** (0.0929)	0.711*** (0.0926)
2009*PSM	0.321*** (0.0918)	0.319*** (0.0910)	0.316*** (0.0913)	0.314*** (0.0906)	0.603*** (0.115)	0.604*** (0.115)	0.601*** (0.114)	0.602*** (0.114)
2010*PSM	0.413*** (0.0749)	0.413*** (0.0742)	0.410*** (0.0743)	0.409*** (0.0736)	0.660*** (0.119)	0.664*** (0.119)	0.656*** (0.118)	0.659*** (0.118)
2011*PSM	0.466*** (0.0860)	0.464*** (0.0852)	0.463*** (0.0855)	0.460*** (0.0846)	0.613*** (0.129)	0.617*** (0.130)	0.612*** (0.129)	0.615*** (0.129)
2012*PSM	0.382*** (0.0818)	0.379*** (0.0813)	0.377*** (0.0826)	0.373*** (0.0820)	0.647*** (0.0944)	0.649*** (0.0941)	0.645*** (0.0942)	0.647*** (0.0940)
2013*PSM	0.432*** (0.138)	0.430*** (0.138)	0.428*** (0.139)	0.425*** (0.138)	0.533*** (0.117)	0.536*** (0.117)	0.531*** (0.116)	0.533*** (0.117)
2014*PSM	0.348*** (0.0943)	0.346*** (0.0942)	0.344*** (0.0946)	0.342*** (0.0946)	0.670*** (0.0848)	0.673*** (0.0843)	0.669*** (0.0838)	0.671*** (0.0834)
Bwd GVC	0.0110 (0.0117)	0.00761 (0.0118)	0.00894 (0.0120)	0.00497 (0.0119)	0.00688 (0.00742)	0.00846 (0.00747)	0.00733 (0.00769)	0.00844 (0.00766)
Bottom decile patent _{t₀}	0.0421 (0.0494)	-0.262 (0.270)	0.292 (0.541)	0.289 (0.550)	-0.0615*** (0.0217)	-0.168 (0.125)	-0.168 (0.306)	-0.177 (0.305)
Bottom decile patent _{t₀} *Bwd GVC	-0.0403*** (0.0150)	-0.0479*** (0.0170)	-0.0417*** (0.0153)	-0.0535*** (0.0173)	0.0234*** (0.00767)	0.0213** (0.00882)	0.0242*** (0.00788)	0.0231*** (0.00890)
Bwd Patent		-0.182*** (0.0665)		-0.173** (0.0670)		0.0478* -0.028		0.0429 -0.0275
Bottom decile patent _{t₀} *Bwd Patent		-0.0962 (0.0854)		-0.170* (0.0924)		-0.0347 (0.0374)		-0.0206 (0.0402)
Bwd intangibles			0.486** (0.214)	0.447** (0.216)			-0.277** (0.116)	-0.267** (0.115)
Bottom decile patent _{t₀} *Bwd Intang.			0.0836 -0.178	0.256 -0.202			-0.036 -0.098	-0.0185 -0.108
Patents	-0.0130 (0.0119)	-0.0132 (0.0119)	-0.00793 (0.0124)	-0.00802 (0.0124)	-0.00749 (0.00614)	-0.00763 (0.00617)	-0.0101 (0.00631)	-0.0100 (0.00631)
Capital _{t₀}	0.0473*** (0.0137)	0.0484*** (0.0135)	0.0475*** (0.0135)	0.0491*** (0.0133)	-0.0360*** (0.00563)	-0.0356*** (0.00558)	-0.0357*** (0.00553)	-0.0355*** (0.00550)
Constant	-0.949*** (0.103)	-1.472*** (0.216)	0.515 (0.679)	-0.104 (0.729)	-0.0768** (0.0389)	0.0578 (0.0858)	-0.918** (0.359)	-0.767** (0.356)
Observations	2,575	2,575	2,575	2,575	2,589	2,589	2,589	2,589
R-squared	0.793	0.794	0.793	0.795	0.868	0.868	0.868	0.868

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

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