Global Value Chains and Productivity Growth in Advanced Economies: Does Intangible Capital Matter?

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Abstract

This article investigates the impact of participation in global value chains (GVCs) on productivity growth considering the mediating effect of investment in intangible assets. We explore the existence of synergies between intangible capital accumulation and GVC participation and their influence on productivity in a sample of nine European economies in 1998-2013. The analysis relates the macroeconomic literature on the impact of intangibles and GVCs on productivity growth to microeconomic studies about the functions of intangibles along the value chain. The existence of complementarities between intangibles and GVC participation and their productivity effects are tested in an augmented production function framework. We find: a) positive and statistically significant productivity impact of backward participation; b) the marginal effect of GVC participation on growth is greater in countries-industries with higher intensity of intangible capital; c) non-R&D intangibles, and particularly organizational capital, exert a significant conditional effect on backward participation strengthening the productivity returns of global production activity.

Modern economies are increasingly based on knowledge and innovative technologies that are transforming how companies do business, how do they interact in the global market and consequently the drivers of international competitiveness and productivity growth.

In this respect the role of intangible capital as a source of growth

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(Corrado *et al.*, 2018) and international competition is gaining attention (Criscuolo *et al.*, 2015; Jona-Lasinio and Meliciani, 2018) and deserves a deeper investigation. At the same time, the structural and organizational changes associated with the knowledge economies have led to widespread processes of globalization of value chains which have also affected productivity in advanced and emerging countries (Criscuolo and Timmis, 2017).

In the economic literature, two unrelated areas of research have recently emerged investigating, respectively, the productivity impact of intangible capital and participation in Global Value Chains (GVCs). On one side, there is increasing evidence that intangible capital is a fundamental source of productivity growth in the United States but also in the European economies (see, e.g. Corrado *et al.*, 2018). On the other, theoretical models provide different predictions on the productivity gains accruing to countries from participation in GVCs (Baldwin and Robert-Nicoud 2014),[2] although the empirical evidence in this area supports the existence of a positive link (Kummritz, 2016; Constantinescu *et al.*, 2017).

The purpose of this article is to bridge these two areas of research by investigating whether the impact of participation in GVCs on productivity growth matters and whether it is amplified by investment in knowledge-based capital. We empirically address this research question drawing on the firm level literature on the role of different intangible assets for value generation along the supply chain (Mudambi, 2007; Shin *et al.*, 2009, 2012; Dedrick *et al.*, 2010). Further, as the managerial capabilities, design, brand and training have become crucial to firm's competitiveness in the global market (Chen *et al.*, 2017), we also test the productivity impact of the interactions between individual intangible assets and GVC participation. Intangibles might affect the productivity performance along a GVC because they generate relatively large returns to scale.

Durand and Milberg (2018) claim that intangible assets such as standards, specifications, R&D achievements, as well as software and organizational know-how are typically

2 In the model of Baldwin and Robert-Nicoud (2014), the rise of GVCs enables advanced countries to combine their superior technology with low wages in developing countries through the offshoring of some production tasks with positive gains for advanced countries. Emerging countries may also see an increase in their productivity and value added when there are technology spillovers. Differently, in Li and Liu (2014) GVCs allow developing countries to lower their unit labour requirements through a learning-by-doing process, but advanced countries experience a period of decreasing welfare because their comparative advantage deteriorates when emerging countries become more productive in tasks that are performed in advanced countries. Therefore, the overall effect of rising GVC participation on advanced countries value added can be negative.

scalable assets, imposing negligible marginal costs following the initial investment made to create them and resulting in infinite returns to scale. The difference in scale economies between tangible and intangible assets implies that the firms controlling intangible-intensive parts of the chain will be in the position of experiencing a relatively larger productivity improvement from network participation as output expands. This is why intangible capital is an essential element for productivity growth along the chain.

The empirical analysis is developed adopting an augmented production function framework and testing our model on a sample of nine European countries and 18 sectors over the period 1998-2013. Our main findings support the existence of a significant impact of participation on productivity growth and of a complementary relationship between intangible intensity and GVC participation. We find that the marginal impact of backward participation[3] on productivity is greater in industries/countries with higher intangible intensity and this result holds also for sub-categories of intangible assets.

The article is organized as follows. Section 1 reviews the literature. Section 2 describes the data and provides some descriptive analysis. Section 3 discusses the empirical strategy and the econometric results. Section 4 concludes.

Background Literature and Research Questions

In this section we review the main results emerging from two distinct strands of the empirical literature on the productivity impact of intangible capital and GVCs participation and then formulate a research question bridging these two research fields.

Intangible Capital, GVC and Productivity Growth

The research community and policymakers are currently paying increasing attention to intangible capital gaining fast-growing relevance on the supply side of the economy (Haskel and Westltake, 2017). The existence of a strong relation between intangible capital and productivity growth has been well documented both by micro and macroeconomic studies so far (see Thum-Tysen *et al.* (2017) for a review). Macro-level analyses support a statistically robust and significant positive link between intangible investment and productivity growth for the

3 Backward participation measures the foreign value added in domestic exports. For a more precise definition see Section 3.2.

EU economies and the United States (Corrado *et al.*, 2013 and 2018), for Japan and Korea (Chun *et al.*, 2015) as well as for China (Hao and Wu, 2018). The relevance of intangibles for productivity gains has been also demonstrated at the micro economic level by various research contributions (Black and Lynch, 2001; Bontempi and Mairesse 2008; Marroccu *et al.* 2012).

Overall, the empirical evidence demonstrates that intangible capital affects productivity growth via multiple mechanisms: directly, increasing capital deepening and interacting with other complementary assets (Corrado *et al.*, 2013 and 2018); and indirectly, being a driver of innovation and generating spillovers, mainly from non-R&D[4] intangible assets (Corrado *et al.*, 2017). Finally, intangibles are found to contribute to output growth one to three times more than tangible assets in the advanced economies thus making them strategic investment for long-run growth of single companies and the economy as a whole (Thum-Tysen *et al.*, 2017).

At the same time, the rising relevance of global value chains in modern economies stimulated new research efforts investigating the relationship between participation in GVCs by firms, industries, and countries and productivity gains. Criscuolo and Timmis (2017) identify several channels through which GVCs can help enhancing productivity. First, there is the classical argument of gains from specialization: in a value chain firms can specialise in the activities (the analogous to product specialization in the classical literature on trade liberalization) in which they are relatively more efficient and outsource the others. However, some studies have shown that, in terms of value added appropriation, the choice of the activities carried out in the GVC makes a material difference (Mudambi, 2007; 2008; Dedrick *et al.*, 2010).

A second channel through which participation in GVCs can affect productivity is by allowing firms to have access to a larger variety of cheaper and/or higher quality and/or higher technology imported inputs. Again, we can expect some heterogeneity in the ability of firms to exploit these advantages based on their core competencies and capabilities. Third, GVCs can facilitate knowledge spillovers allowing interaction of domestic firms with foreign multinational firms. Finally, similarly to the case of international trade, GVCs can give firms access to larger markets and increase competition, thus favoring the development of the most productive firms

4 Non-R&D assets include organizational capital, training, brand and design.

and inducing the exit of the least productive ones.

Empirical research in support of the theoretical predictions linking GVCs to productivity is however limited. Contributions include older strands of work focusing on benefits to countries that initiate offshoring (Feenstra and Hanson, 1996; Egger and Egger, 2006; Daveri and Jona-Lasinio, 2008; Amiti and Wei, 2009; Winkler, 2010), but also recent efforts that analyze the impact of vertical specialization on countries participating in GVCs (Formai and Vergara Caffarelli, 2016, Kummritz, 2016, Taglioni and Winkler, 2016; Constantinescu *et al.*, 2017).

Focusing on the most recent efforts, Formai and Vergara Caffarelli (2016) investigate the relationship between international fragmentation of production and (labour and total factor) productivity growth for US industries between the 1990s and the 2000s using Input-Output data provided by the Bureau of Economic Analysis (BEA). They find that participation in GVCs positively affects labour productivity and TFP in sectors with long and wide production chains in countries specialised in importing intermediate goods.

Other studies have extended the analysis to a larger sample of countries using the OECD World Input Output tables and measuring backward and forward participation in GVCs at the industry level. In particular, Kummritz (2016) shows that an increase in GVC participation leads to higher domestic value added and productivity in 54 countries independently of their income levels. Based on the preferred instrumental variable specification, he finds that a one percent increase in backward GVC participation generates an increase of 0.11 per cent of domestic value added in the average industry but does not affect labour productivity. On the other hand, a one percent increase in forward GVC participation causes an increase of 0.60 per cent of domestic value added and 0.33 per cent of labour productivity.

Finally, Constantinescu *et al.* (2017), using data on trade in value added from the World Input-Output Database, covering 13 sectors in 40 countries over 15 years find that participation in global value chains is a relevant driver of labour productivity. Differently from Kummritz (2016) backward participation in global value chains emerges as a particularly important factor affecting productivity growth.

An alternative approach has been suggested by Timmer (2017) arguing that Global Value Chains challenge the traditional approaches to productivity measurement. He suggests evaluating a production function where final output is produced using domestic and foreign factor inputs. Therefore, in this approach the flow of intermediate inputs will be netted allowing to express the production function of a final good exclusively in terms of factor inputs. The basis for this methodology is the analysis of the cost shares of the production factors that can be identified from synthetic input-output tables. This approach solves the problems linked to tracing the profits for intangible capital assets used in international production.

Global Value Chains and Productivity Growth: the Mediating Role of Intangible Capital

This article explores the mediating effect of intangible capital in the relationship between GVC participation and productivity growth. In particular, we investigate whether a higher intangible capital intensity augments the productivity gains from GVC participation across countries and industries.

This hypothesis draws upon the micro-level literature investigating value creation along the value chain. The empirical evidence indicates that a major part of value added of a final product is created in the first and last stages of the production process (R&D, design, marketing and sales), while firms involved in intermediate stages (such as the production of components and assembly) reap only a small part of the final value of the good or service produced (Mudambi, 2007; 2008). As suggested by Everatt *et al.*, (1999); Mudambi, (2007) and Shin *et al.* (2009 and 2012), the pattern of value-added along the value chain may, therefore, be represented by the 'smiling curve' or the 'smile of value creation.' Intangible assets are essential to create value added in the supply chain playing a differentiated function along it. R&D and design are relatively more relevant upstream and marketing and advertising more downstream (Mudambi, 2008), but exerting generally a positive contribution to company's competitiveness in the global market (WIPO, 2017).

Overall, intangibles may be strategic elements in the various mechanisms through which GVC affects productivity growth. A first channel through which GVCs can enhance productivity is true gains from specialization. In this respect, the microeconomic literature quoted above shows that, in terms of value added appropriation, the activity carried out along the chain is crucial. The classic example of the iPod supply chain discussed by Dedrick *et al.* (2010) shows that Apple captures between one-third and one-half of an iPod's retail value, Japanese firms such as Toshiba and Korean firms such as Samsung capture another major share while firms and workers in China capture no more than 2 per cent from assembling the product.

The capability of these countries to appropriate a larger share of value is related to the extent of their investment in R&D, design, brand and of their organizational capabilities to control the value chain. Intangible assets are thus strategic for value added creation and appropriation. Moreover, this value is created using high-skilled labour and the ratio between value added and hours worked is also expected to be higher in intangible intensive activities. It is, therefore reasonable to expect that the productivity impact of GVC participation will be higher for industries and countries with a higher investment in knowledge-based capital.

GVCs are assumed to increase productivity also by facilitating knowledge spillovers allowing interaction of domestic firms with foreign multinational firms. However, spillover do not occur automatically, but depend on investments in absorptive capacity. While the literature has focused on the role of R&D investments for absorptive capacity (Cohen and Levinthal, 1989), also other assets, particularly training and organizational capital, may be important. As a consequence, we expect that participation in GVCs will generate more spillovers thus providing a higher growth contribution in sectors and countries where investments in R&D, training and organizational capital are relatively higher.

Finally, intangibles might affect the productivity performance along a GVC because they generate relatively large returns to scale. The difference in scale economies between tangible and intangible assets (Durand and Milberg, 2018) implies that the firms controlling intangible-intensive parts of the chain will be in the position of experiencing a relatively larger productivity improvement from network participation as output expands. This is why intangible capital is an essential element for productivity growth along the chain.

According to the OECD (2013b), intangible assets contribute differently to gains appropriation along the global value. In particular, economic competencies, including firm-specific skills such as superior management, brand equity and organizational structure, can be rather valuable since they involve more tacit forms of knowledge and may therefore be more difficult to replicate than innovative property or computerised information. Consistently with this view, a survey of Japanese firms emphasizes the importance of economic competencies, notably "manufacturing skills," "brand and customer recognition" and "agile and flexible organisation" (OECD, 2013a).

Along these lines, we expect some heterogeneity in the mediating role of intangible assets in the relationship between productivity growth and GVC participation with economic competencies (particularly training and organizational capital) playing a major role because of their relatively higher content of more tacit forms of knowledge. Moreover, the importance of governance for extracting maximum rents from GVC participation (Gereffi *et al.*, 2005) suggests that organizational capital may be an essential asset in this respect.

Notwithstanding the rich qualitative evidence pointing to the centrality of knowledge-based investment for achieving higher benefits from participation in GVCs, we are not aware of any empirical study directly testing this hypothesis[5]. The purpose of this article is to provide a contribution in this direction by empirically estimating the impact of GVC participation on productivity gains accounting for the complementary function of intangible assets.

Data and Descriptive Statistics

Intangible Assets

Data on intangible investment are from INTAN-Invest[6] providing harmonized estimates of intangible investments covering three broad groups of asset categories originally proposed by Corrado *et al.* (2005): computerized information, innovative property and economic competencies.[7] Computerized information includes computer software and databases. Innovative property refers to the innovative activity built on a scientific base of knowledge as well as to innovation and new product/process R&D more broadly defined. Economic competencies indicate spending on strategic planning, worker training, redesigning or reconfiguring existing products in existing markets, investment to retain or gain market share and investment in brand names.

The Systems of National Accounts currently incorporates in the asset boundary only an array of in-

5 Baldwin and Yan (2014) test whether the integration of Canadian manufacturing firms in a GVC improves their productivity and find that the effects vary by industrial sector, internalization process, and import-source/export-destination country in a way that suggests the most substantial gains are derived from technological improvements.

6 INTAN-invest is a research collaboration dedicated to improving the measurement and analysis of intangible assets (www.intannvest.net).

7 For a detailed description of the methodology, see Corrado *et al.* (2018). These indicators have been used in many studies especially for assessing their contribution to GDP and productivity growth (see e.g. Corrado et al. 2009, 2013, 2016, 2017).

tangible assets, namely R&D, mineral exploration, computer software and databases, entertainment, literary and artistic originals, under the category "intellectual property products." The remaining intangibles identified by Corrado *et al.* (2005) as investments, are treated as intermediate expenditures in official statistics. The INTAN Invest initiative provides estimates for both National Account and Non- National Account intangible investment.

A relevant characteristic of the INTAN-Invest measures of intangibles is that they are consistent with National Account principles and are entirely based on official statistics. In this article, we select from the INTAN database information for the following set of intangible assets: R&D, design, advertising and market research (brand), training and organizational capital.[8] The main original data source to build indicators for these intangibles is Eurostat. In particular, investment in advertising and market research, design and organizational capital are calculated adopting an expenditure approach and resorting to expenditure data by industry from the Use Tables, compiled according to the new classification system (NACE Rev2/CPA 2008). Additional information about data sources and estimation methods can be found in Corrado *et al.* (2018).

Measures of GVC participation

The measure of backward participation used in our analysis is obtained from the World Input Output Database (WIOD). The indicator is based on the work of Koopman *et al.* (2010, 2014) extending the work of Hummels *et al.* (2001) and Johnson and Noguera (2012). Hummels *et al.* (2001) compute an index of vertical specialization accounting for the use of imported inputs in producing goods that are then exported. However, this indicator does not take into account that a country exports intermediates that are used to produce final goods absorbed at home. By using input-output data for source and destination countries simultaneously, Johnson and Noguera (2012) overcome this limitation and compute the ratio of value added to gross exports as a measure of the intensity of production sharing.

Finally, Koopman *et al.* (2010, 2014) provide a full decomposition of value added including returned domestic value added (domestic value

8 The database used in this paper resorts to R&D expenditure from BERD and not to R&D National Account data to be coherent with the EUKLEMS (2012) figures that were not yet adjusted to the new European System of National Accounts (ESA 2010). Moreover, we do not use INTAN data on software since we include total Information and Communication Technologies (ICT) capital taken from EUKLEMS.

added that comes back incorporated in foreign inputs produced with domestic inputs) and the indirect exports to third countries. They propose two measures of participation. These are the backward and the forward participation indicators, which are respectively the importing and exporting elements of GVCs (see Figure A1). The figure illustrates how gross exports can be decomposed into many different constituent elements. At their most basic, gross exports are composed of domestic and foreign value added which can themselves be further decomposed using Input-Output tables. For example, the domestic value added that is embodied in exports can serve to produce final goods and services (element (1) in figure A1) or it can be used to produce intermediates which are then used domestically (2) or exported (3+4). Forward participation refers to the domestic value added in foreign exports (3+4) while backward participation refers to the foreign value added in domestic exports (5+6).

In this article we focus on backward participation which is closer to traditional indicators of offshoring activity (such as the share of imported inputs in producing goods that are then exported). A variant of this indicator decomposes value added, similarly across countries and sectors, but according to final demand (Timmer *et al.*, 2013; Los *et al.*, 2015). This tracks not just the value added traded in the production of exports, but also that used to satisfy domestic and international final demand.[9] Both measures (one based on exports and one on final demand) involve similar calculation techniques, but the former is solely concerned with exporting activities whereas the latter considers the origin of value added in GDP. The difference is relevant because domestic final demand and gross export vectors are significantly different.

Since both measures have their pros and cons, we report the main econometric estimates using both the indicator of backward linkages based on exports and the other based on final demand. In particular, we focus on foreign value added in domestic exports over total exports (backward participation) for comparisons with other studies (this is the measure of participation mostly used by the OECD (OECD, 2013b)) but we report

9 To provide an example of the difference in the two indicators, imagine that the total demand for BMW cars is 100 of which 60 are sales to German customers while 40 are exports. The cars are assembled outside Germany using a variety of components such as car body parts, interior and exterior components, some of which are made in Germany, but others abroad. Out of the total value of each car two thirds is domestic (German) value added and one third is foreign value added. Using the export indicator the foreign value added in domestic exports of German cars would be (1/3)*40 while using the final demand indicator it would be (1/3)*100 (counting also the cars that are consumed by German customers).

also estimates based on foreign value added in domestic final demand over total final demand (backward participation based on final demand) to test the robustness of our findings. Much work on GVCs to date uses the backward participation indicator and identifies one of the most salient features to be the rise in the share of foreign value added used to produce exports (see for example OECD (2013), Taglioni and Wrinkler (2016), Baldwin and Lopez-Gonzalez (2015), and Kowalski *et al.* (2015)).

The database

The database employed in this article merges data on tangible capital inputs, ICT capital as well as standard growth accounting variables such as output and labour input from EUKLEMS[10] with data on intangibles from INTAN-Invest. Data cover the period 1998-2013 for nine European countries (Austria (AT), Germany (DE), Denmark (DK), Spain (ES), Finland (FI), Italy (IT), Netherlands (NL), Sweden (SE), United Kingdom (UK)) and 18 industries NACE REV 2.

Descriptive analysis

Chart 1 shows the rate of growth of our main variables of interest: labour productivity, backward participation (export-based measure) and intangible capital over the period 1998-2013. Manufacturing is in Panel A while business services in Panel B.

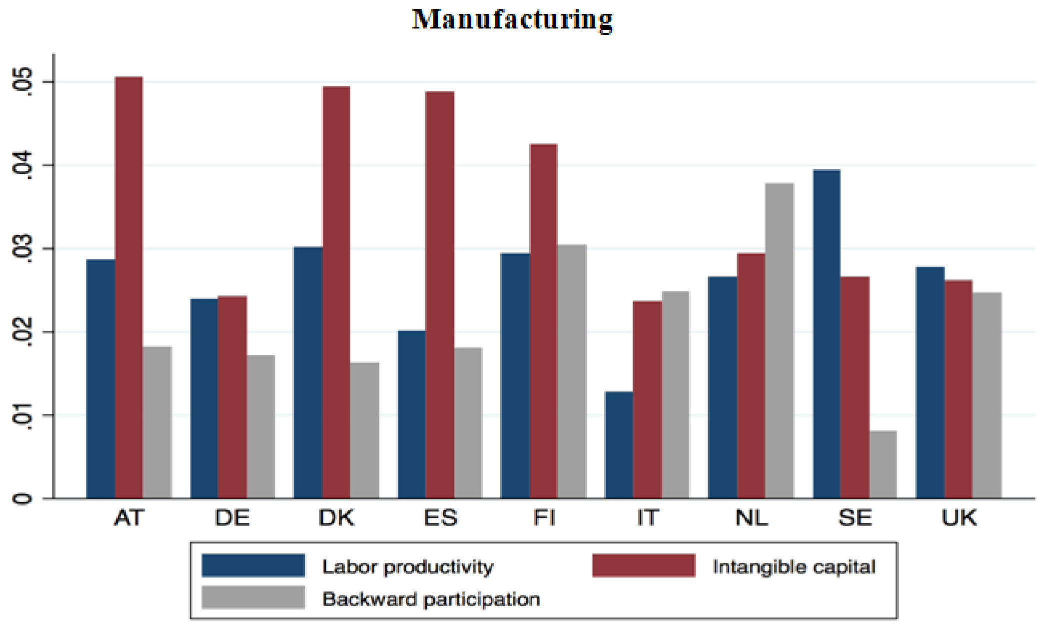
In manufacturing all countries have experienced on average positive rates of growth of labour productivity, intangible capital and backward participation. Austria, Denmark, Spain and Finland show the fastest intangible capital accumulation and, with the exception of Spain, higher than average labour productivity growth. Differences in backward participation across countries are less marked, with the Netherlands being the fastest (almost 4 per cent) and Sweden the lowest (below 1 per cent).

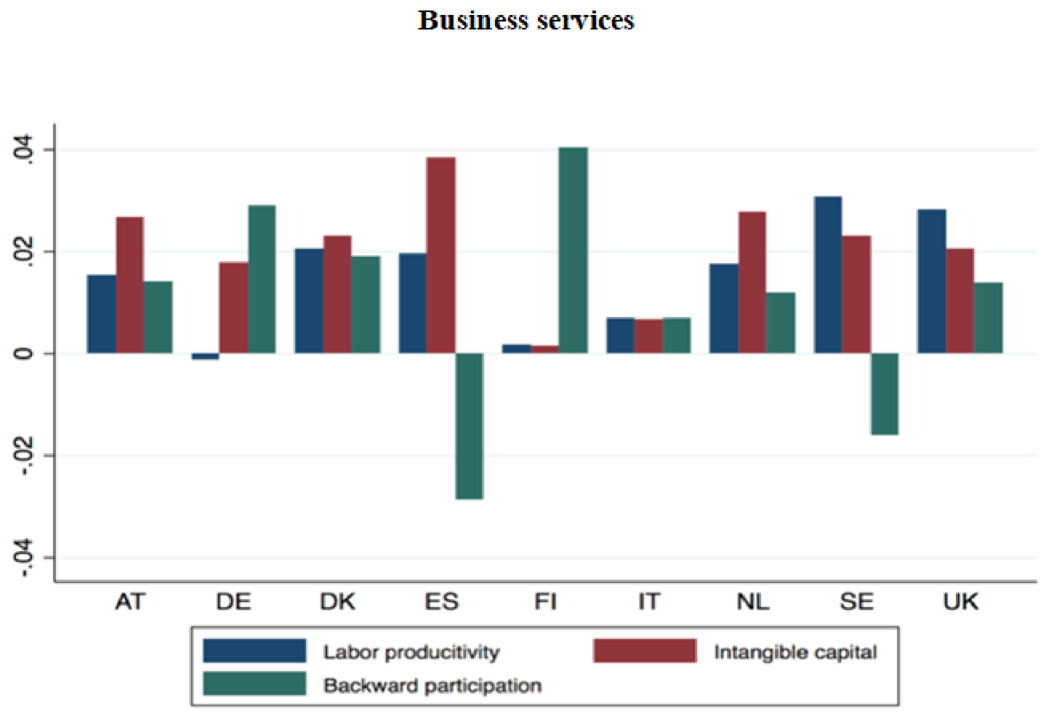
In business services, there is more variation across countries, particularly for backward participation. Two countries, Spain and Sweden, have negative rates of growth in foreign value added in domestic exports, while participation has been very high in Finland. Labour productivity growth upsurged in Sweden and the UK while slowed down in Germany, Italy and Finland. Finally, intangible capital accumulation is relatively faster in Spain, Austria and the Netherlands while it is almost stable in Finland and Italy.

Chart 2 focuses on differences in the intensity of intangibles (intangible capital per hour worked) across

10 http://www.euklems.net. See O'Mahony and Timmer (2009) for details.

Chart 1: Productivity, Backward Participation and Intangible Capital (Logarithmic Rates of Growth, Average Values 1998-2013)





Source: Author's calculation on EUKLEMS, WIOD and INTAN Invest data. Labour productivity is measured as real value added per hours worked.

countries distinguishing between different assets. Data suggest that Nordic countries (Denmark, Finland and Sweden) are the more intangible intensive economies, while the Mediterranean economies (Italy and Spain) are relatively low intensive. Non-R&D assets are quantitatively more relevant than R&D in all sample countries, suggesting the importance of exploring their contribution to the productivity growth differentials between countries. Moreover, although there appears to be some complementarity between R&D and non-R&D intangibles, there are also important differences. For example, UK and the Netherlands have very high intensities of non-R&D intangibles but rank below the average in terms of R&D intensity. Finally, among the non-R&D assets, organizational capital is quantitatively the most relevant asset particularly in the Netherlands, Sweden and the UK, followed by design, training and brand. Italy and Spain economies are confirmed to lag behind.

The first step of our analysis is to investigate if and to what extent intangible capital accumulation and backward participation are related to labour productivity growth. Thus, Chart 3 shows the relationship between labour productivity growth, per hour worked total intangible capital (growth and level) and backward participation (level) in manufacturing and services in the sample economies. The correlation is significantly positive in all cases and, as expected particularly strong between labour productivity growth and intangible capital per hour.

Moreover, there is a positive relationship between backward participation and labour productivity growth, but it is less marked. Our hypothesis is that this correlation depends on the extent to which countries and industries invest in intangible capital.

Finally, it is worth notice that nor GVC participation nor intangible investments were considerably and persistently affected by the financial crisis. Existing evidence shows that besides the immediate slowdown experienced during the crisis years (2008-2009) participation and intangible capital accumulation recovered quickly even if at different pace across countries (Corrado *et al.*, 2018; ECB, 2017).

Empirical Strategy

Econometric approach

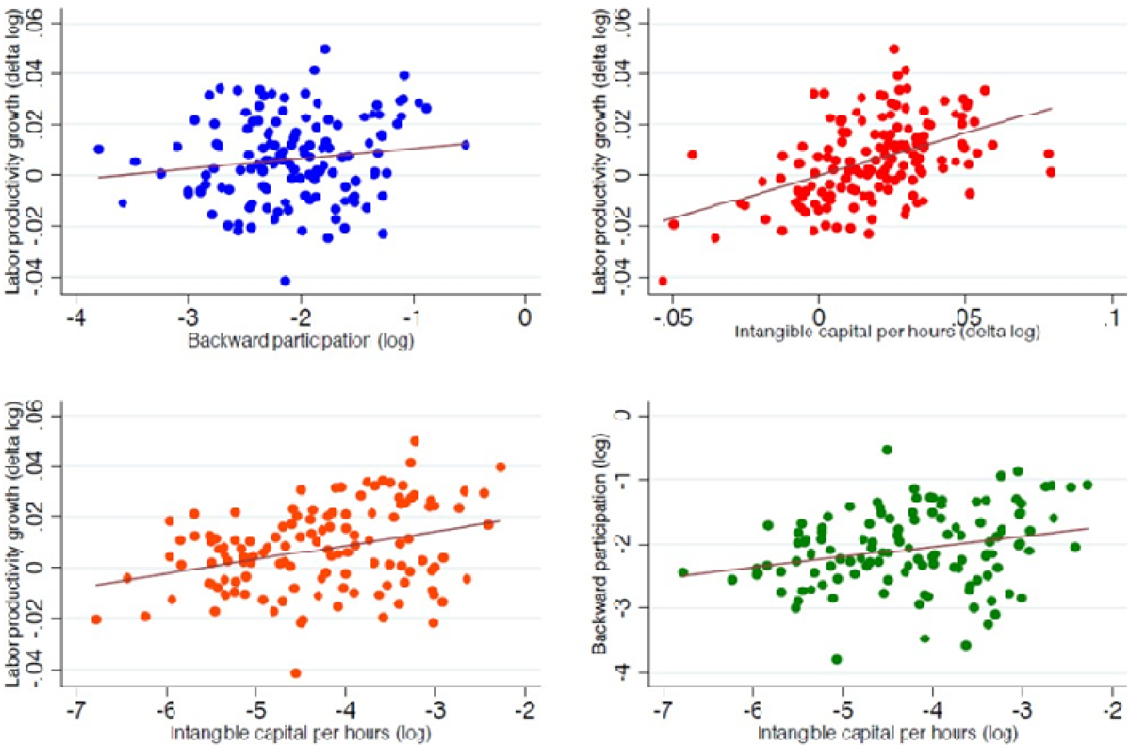
We explore the relationship between GVC participation, intangible capital and productivity growth estimating a production function including intangibles and augmented with a measure of backward participation.

First, we test the direct linkage

Chart 2: Intangibles Intensities: Capital Stocks per Hour Worked, Average Values 1998-2013

Source: Author's calculations on INTAN Invest data. Capital stock is chain linked values of national currencies in per hour terms.

Chart 3: Labour Productivity, Intangible Capital and Backward Participation



Source: Author's calculation on EUKLEMS, WIOD and INTAN Invest data between participation and productivity growth and then evaluate the extent to which the productivity returns from participation are conditional to intangible capital intensity across countries-industries. We adopt a difference-in-difference empirical approach following Rajan and Zingales (1998) who estimated the impact of financial development on economic growth in a model with country-industry interactions. Thus, our empirical specification is as follows:

$$\begin{aligned}\Delta\ln(Y/H)_{i,c,t} &= \alpha_1\Delta\ln(K^J/H)_{i,c,t}+ \\ \alpha_2\Delta\ln(K^I/H)_{i,c,t} &+ \alpha_3\ln(P_{gvc})_{i,c,t-2} \\ &+\alpha_4\ln(K^I/H))_{i,c}+ \\ \alpha_5\ln(P_{gvc})_{i,c,t-2} &* \ln(K^I/H)_{i,c} \\ &+\lambda_i+\lambda_t+\eta_{i,c,t}\end{aligned} \tag{1}$$

where variables vary by country c, industry i and time t; Y denotes value added adjusted to include intangible capital (as in Corrado, Hulten, and Sichel 2005, 2009), H is total hours worked, K^J is for $J =$ ICT and Non-ICT capital, K^I is for I=total intangible, brand, training, design, R&D and organizational capital, P_{gvc} is backward participation and $ln(K^I/H)_{i,c}$ denotes country-industry's average (log) intangible intensity, and Λ_i, Λ_t are industry and time dummies. The interaction variable is symmetric with respect to the interacted terms as it does not say anything about the causality between $ln(K^I/H)$ and $ln(P_{gvc})$ (Brambor *et al.*, 2006). Thus, we simply assume that intangible capital is our conditional variable affecting the influence of backward participation on productivity growth.

Notice that the term we use to capture the differential impact of participation on productivity growth in intangible intensive sectors is the time average of intangible intensity of all industries and countries interacted with the level of GVC participation in industry i country c, at time t-2. The adoption of the average intangible intensity in the interaction implies some restriction as it bounds the elasticity of labour productivity as intangible intensity rises.

If our proxy for intangible intensity in equation (1) is correct, we should find $\alpha_5 > 0$, indicating that each country industry experiences relatively higher productivity growth when participation in GVC is complemented by higher intangible capital intensity. This is because controlling intangible- intensive parts of the chain allows experiencing a relatively larger productivity improvement from network participation as output expands.[11] We include also the industry dummies to control for the possible correlation between specific industry characteristics and our measure of intangible intensity. Ultimately, the estimation of equation (1) can be affected by structural identification problems related to measurement error, multicollinearity, and endogeneity of factor inputs. Thus, we also test our results with IV and GMM estimation (Ackerberg *et al.*, 2015).

Empirical Results

Table 1 shows estimates of equation 1. All regression models contain industry and time fixed effects and are estimated by GLS. Column 1 estimates equation (1) with no participation and no interaction terms as our benchmark specification. The standard inputs and intangible capital have positive and statistically significant coefficients coherent with previous empirical literature (Corrado *et al.*, 2017). Column 2 includes the lagged GVC participation index, i.e. the export-based indicator of backward participation, to test the assumption that participating in global production generates positive productivity returns and that this takes time. Estimation results support this assumption showing positive and significant correlation across all the specifications. This is in line with the theoretical predictions of Baldwin and Robert-Nicoud (2014) and with the empirical evidence reported in Kummritz (2016).

Columns 3 to 5 check for the complementary effect of intangible capital and participation on productivity growth looking at the level effect of the interaction between intangible capital per hour and lagged backward participation. The conditional effect of intangible intensity on participation is affected by the inclusion of software in the aggregate level of intangible capital (column 3). Then excluding software (column 4) and also R&D (column 5) from total intangibles we uncover a positive and significant α_5 thus supporting the assumption that higher intangible intensity strengthens the positive effect of participation on productivity growth.

To judge the economic significance of our findings we look at the contribution of participation to labour productivity growth using column 2 in Table 1. The contribution from participation accounts for 0.14 percentage points per year of a growth rate of productivity equal to 0.5 per cent

11 In principle, there might be different representations of the production function (Cobb Douglas (CD) or CES) allowing for different degrees of variation in output elasticities. As our hypothesis of a significant interaction term implies that output elasticities vary, we assume a CES that is a more general function than CD allowing for variation in elasticities due to e.g. biases in technical progress, different factor prices etc.

Table 1: Production Function Augmented with Participation and Interacted Variables

	(1)	(2)	(3)	(4)	(5)
	Production function	Production function augmented with t-2 backp (level)	Production fcn augmented with t-2 backp(level) interacted with level *intg_isf*	Production fcn augmented with t-2 backp(level) interacted with level *intg_xsf* (t-2)	Production fcn augmented with t-2 backp(level) interacted with level *intg_xrdsf* (t-2)
$\Delta ln(K^{I}/H)$	0.204***	0.154***	0.162***		
	(0.017)	(0.019)	(0.020)		
$\Delta ln(K^{IxSF}/H)$				0.197***	
				(0.022)	
$\Delta ln(K^{IxSFR\&D}/H)$					0.207***
					(0.021)
$\Delta ln(K^{ICT}/H)$	0.032***	0.049***	0.043***		
	(0.008)	(0.009)	(0.010)		
$\Delta ln(K^{ICT\_iSF}/H)$				0.040***	0.040***
				(0.013)	(0.014)
$\Delta ln(K^{NonICT}/H)$	0.176***	0.175***	0.166***	0.175***	0.192***
	(0.020)	(0.024)	(0.025)	(0.025)	(0.024)
$\Delta ln(LH)$	0.088***	0.109***	0.104***	0.101***	0.085**
	(0.031)	(0.037)	(0.039)	(0.036)	(0.036)
$ln(K^{IxSF}/H)* ln(BackP)_{t-2}$				0.003*	
				(0.001)	
$ln(K^{I}/H)* ln(BackP)_{t-2}$			0.002		
			(0.001)		
$ln(K^{IxR\&D}/H)* ln(BackP)_{t-2}$					0.003*
					(0.001)
$ln(BackP)_{t-2}$		0.005**	0.014**	0.021***	0.022***
		(0.002)	(0.007)	(0.007)	(0.008)
$ln(K^{I}/H)$			0.005		
			(0.004)		
$ln(K^{IxSF}/H)$				0.007**	
				(0.004)	
$ln(K^{IxSFR\&D}/H)$					0.006
					(0.004)
Observations	1,958	1,507	1,495	1,531	1,495
Number of ctrysec	142	126	125	128	125

Note: All regressions contain country, industry and time fixed effects. To control for endogeneity of capital inputs we all specifications have been tested with GMM. Results are reported in the appendix.
Legend key: K^{I} is for I=total intangible, brand (br), training (tr), design (de), R&D and Organizational capital (OgC) and , K^{IxSF} is intangible capital excluding software, $K^{IxSF\&R\&D}$ refers to K^{I} excluding software and R&D, $K^{I}CT$ is ICT capital while K^{ICTxSF} is ICT excluding software. *Backp* is backward participation and *LH* refers to labour composition.

per year. That is a relatively large contribution.

Table 2 shows the estimates of equation (1) testing the interaction of average intangible intensity and lagged backward participation looking at both aggregate and individual intangible asset effects.

The interactive terms are positive and statistically significant for total intangibles (columns 1) and stronger if we exclude R&D (column 2) confirming a complementary relationship with lagged backward participation. Moreover, among intangibles, organizational capital has the strongest effect on productivity and interacts positively with GVC participation. This highlights the importance to go beyond R&D to capture the full effect of intangibles on productivity. The result is also consistent with the pos-

Table 2: Production Function Augmented with Participation and Interacted Variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Production fcn with lagged gvc level and average intang intensity interactions all sample						
$\Delta ln(K^I/H)$	0.169***		0.167***	0.184***	0.170***	0.184***	0.183***
	(0.020)		(0.020)	(0.020)	(0.020)	(0.020)	(0.021)
$\Delta ln(K^{ICT}/H)$	0.042***	0.046***	0.043***	0.046***	0.045***	0.046***	0.046***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
$ln(K^I/H)_{avg}$	0.011***						
	(0.004)						
$ln(BackP)_{t-2}$	0.025***	0.031***	0.013**	0.024***	0.020***	-0.004	0.017**
	(0.007)	(0.008)	(0.006)	(0.008)	(0.007)	(0.009)	(0.007)
$ln(K^I/H)_{avg}*$	0.004***						
$ln(BackP)_{t-2}$	(0.002)						
$\Delta ln(K^{IxR\&D}/H)$		0.177***					
		(0.019)					
$ln(K^{IxR\&D}/H)avg$		0.011***					
		(0.004)					
$ln(K^{IxR\&D}/H)avg*$		0.005***					
$ln(BackP)_{t-2}$		(0.002)					
$ln(KR\&D/H)avg$			0.003				
			(0.003)				
$ln(K^{R\&D}/H)avg*$			0.001				
$ln(BackP)_{t-2}$			(0.001)				
$ln(K^{OgC}/H)avg$				0.009***			
				(0.003)			
$ln(K^{OgC}/H)avg*$				0.003**			
$ln(BackP)_{t-2}$				(0.001)			
$ln(K^{Tr}/H)avg$					0.002		
					(0.003)		
$ln(K^{Tr}/H)avg*$					0.002*		
$ln(BackP)_{t-2}$					(0.001)		
$ln(K^{Br}/H)avg$						-0.002	
						(0.003)	
$ln(K^{Br}/H)avg*$						-0.001	
$ln(BackP)_{t-2}$						(0.001)	
$ln(K^{De}/H)avg$							0.005**
							(0.002)
$ln(K^{De}/H)avg*$							0.002*
$ln(BackP)_{t-2}$							(0.001)
Observations	1,519	1,663	1,519	1,687	1,547	1,687	1,525
Number of ctrysec	127	139	127	141	141	141	139

Note: All regressions contain country, industry and time fixed effects and controls for K^{NonICT} and Labor composition.

Legend key: K^I is for I=Total intangible, brand (br), training (tr), design (de), R&D and Organizational capital (OgC) and, K^{IxSF} is intangible capital excluding software, $K^{IxSF\&R\&D}$ refers to K^I excluding software and R&D, K^{ICT} is ICT capital while K^{ICTxSF} is ICT excluding software. *Backp* is backward participation and *LH* refers to labour composition.

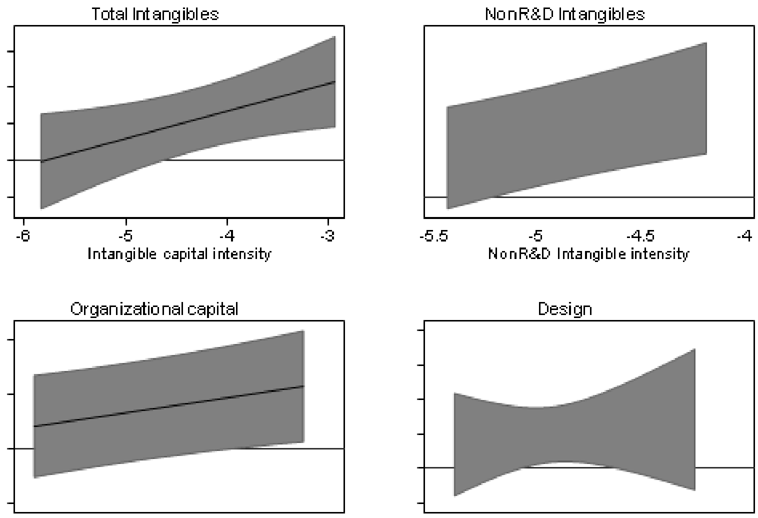
itive impact of managerial practices on firm productivity and profitability and on country total factor productivity (Bloom and Van Reenen, 2007; Bloom *et al.*, 2016). Overall these results support the assumption that labour productivity growth in above average intangible intensive countries-industries is faster in countries-industries participating relatively more to GVC production.

Chart 4 shows the marginal effects of backward participation between the 5^{th} and the 95^{th} percentile of the distribution of intangible intensities with the shaded area representing the 95 per cent confidence interval where the effects on productivity are statistically significant. In the four cases, the marginal effect increases as the degree of intangible intensity increases. To get some idea of the numbers involved, the top right panel shows the marginal effect of participation over the distribution of non-R&D intangible intensity. When this is at the 60^{th} percentile the elasticity is 0.008 whereas at the 95^{th} percentile it is 0.01.

As robustness checks, in Table 3, we report the results obtained using the backward participation indicator based on final demand (foreign value added in domestic final demand/ total final demand). We focus on the estimates testing the interaction of average intangible intensity and lagged backward participation looking at both aggregate intangible assets (column 1), intangible assets excluding R&D (column 2) and organizational capital (column 3). The results based on the final demand indicator of backward participation are very similar to those based on the export indicator. We also checked the robustness of our results with GMM and IV and report the main findings in Table A1 in the Appendix. The results of GMM estimates confirm the positive impact of backward participation on productivity and the fact that this is enhanced by investment in intangible capital.

Overall the empirical findings are consistent with our main hypotheses. Intangible capital positively affects productivity growth through two channels: a primary effect via capital deepening and secondary effect via complementary relationship with backward participation. When distinguishing among intangible assets, non-R&D intangibles emerge as the main drivers of growth, particularly organizational capital showing a strong synergy with GVC participation. R&D instead plays a relatively minor role in this respect. This is consistent with the view that more tacit forms of knowledge may be more difficult to replicate so that industries and countries investing more in these forms of knowledge may be in a better

Chart 4: Marginal effect of backward participation on productivity growth



Source: Authors' calculations.

position to appropriate the benefits of being engaged in global value chains.

Moreover, the results on the role of organizational capital confirm the relevance of governance for extracting maximum rents from GVC participation (Gereffi *et al.*, 2005).

Conclusion

Our analysis is a first attempt at bridging two streams of literature with the goal of testing whether intangible capital contributes to foster countries' capabilities to appropriate value added along the supply chain. To explore this linkage, we use a cross-country econometric approach and test the productivity gains of GVC participation and the mediating effect of intangible capital on productivity returns from GVC participation. Our sample covers nine EU countries, 18 industries in 2000-2013.

We have three main key findings. First, using our country-industry-time data, we find a positive and statistically significant impact of backward participation on productivity growth. Second, we uncover a complementary linkage between intangible capital intensity and GVC participation suggesting that productivity returns to backward participation are stronger in intangible intensive countries-industries. Finally, estimation results show that non-R&D intangibles, and particularly organizational capital, exerts a significant conditional effect on GVC involvement enhancing the productivity benefits from participation.

Overall, our findings are broadly consistent (and complementary) to the growing literature documenting the strategic role of intangible capi-

Table 3: Testing for Interactions Between Average Intangible Intensity and Backward Participation Based on Final Demand

	(1)	(2)	(3)
	Interaction between average intangible capital and backward participation	Interaction between average non R&D intangible capital and backward participation	Interaction between average Organizational capital and backward participation
$\Delta ln(K^{I}/H)$	0.139***		0.150***
	(0.020)		(0.020)
$\Delta ln(K^{ICT}/H)$	0.045***	0.047***	0.052***
	(0.011)	(0.011)	(0.010)
$\Delta ln(K^{NonICT}/H)$	0.176***	0.178***	0.170***
	(0.027)	(0.026)	(0.026)
$\Delta ln(LH)$	0.097**	0.089**	0.097**
	(0.040)	(0.040)	(0.040)
$ln(K^{I}/H)_{avg}$	0.010***		
	(0.003)		
$ln(BackPDem)_{t-2}$	0.009***	0.018***	0.009**
	(0.003)	(0.004)	(0.004)
$ln(K^{I}/H)_{avg}*$	0.002***		
$ln(BackPDem)_{t-2}$	(0.001)		
$\Delta ln(K^{IxR\&D}/H)$		0.144***	
		(0.021)	
$\Delta ln(K^{R\&D}/H)$		-0.006	
		(0.010)	
$ln(K^{IxR\&D}/H)_{avg}$		0.014***	
		(0.003)	
$ln(K^{IxR\&D}/H)_{avg}*$		0.004***	
$ln(BackPDem)_{t-2}$		(0.001)	
$ln(K^{OgC}/H)_{avg}$			0.008***
			(0.002)
$ln(K^{OgC}/H)_{avg}*$			0.002***
$ln(BackPDem)_{t-2}$			(0.001)
Observations	1,291	1,290	1,411
Number of ctrysec	108	108	118

Note: All regressions contain country, industry and time fixed effects and controls for K^{NonICT} and Labor composition.
Legend key: K^{I} is for I=Total intangible, brand (br), training (tr), design (de), R&D and Organizational capital (OgC) and, K^{IxSF} is intangible capital excluding software, $K^{IxSF\&R\&D}$ refers to K^{I} excluding software and R&D, K^{ICT} is ICT capital while K^{ICTxSF} is ICT excluding software. *Backp* is backward participation and *LH* refers to labour composition.

tal as driver of productivity growth (Corrado *et al.*, 2009, 2013, 2018) and GVC upgrading (OECD, 2013 and Criscuolo *et al.*, 2017).

The first set of results illustrated in this article suggest that further analysis focusing on complementarities between different modes of participation (backward and forward), individual intangible asset and skills would be strategic to better understand the novel drivers of international competitiveness and the productivity returns from GVC participation.

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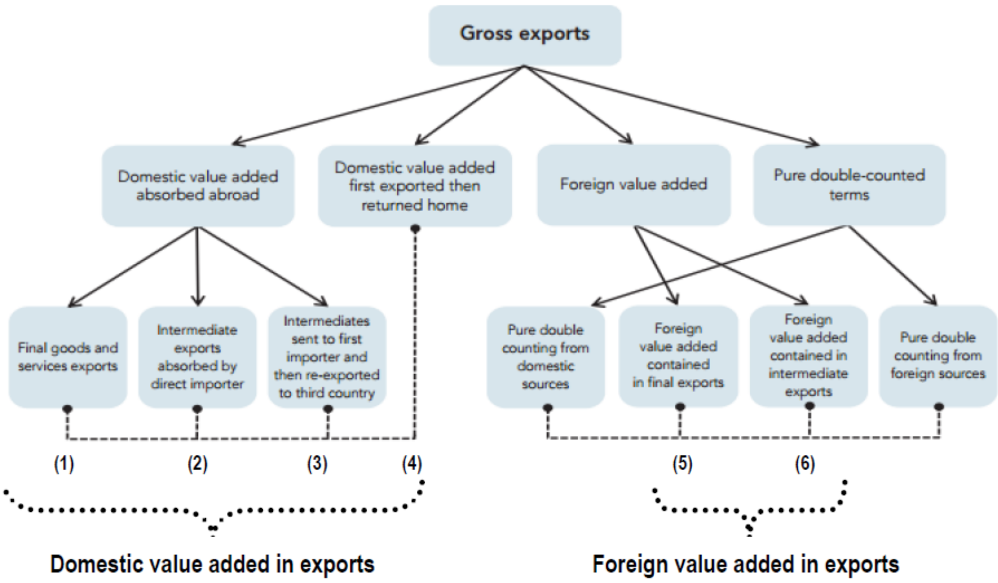
Appendix

Figure A1: Gross Trade Accounting Framework



Source: Adapted from WBG-IDE-OECD-UIBE-WTO (2017)

Table A1: GMM and IV estimates of Benchmark Specifications and Interaction Models

	(1)	(2)	(3)	(4)	(5)	(6)
	Benchmark Specifications Table 1, Col. 1 to 3 GMM			Interaction Models Table 2, Col. 1 and 2 IV		Table 3 Col. 1
$\Delta ln(K^I/H)$	0.248***	0.193***	0.134***	0.237***		0.284***
	(0.051)	(0.051)	(0.045)	(0.083)		(0.085)
$DlnKH_intan_xrd$					0.204***	
					(0.071)	
$ln(K^{I\_SW}/H)$			0.058***			
			(0.011)			
$ln(K^I/H)_{avg}$				0.014**		0.012***
				(0.006)		(0.004)
$ln(K^{IxR\&D}/H)_{avg}$					0.016***	
					(0.006)	
$ln(BackP)_{t-2}$		0.022***	0.064***	0.025**	0.030**	
		(0.007)	(0.021)	(0.013)	(0.013)	
$ln(K^{IxR\&D}/H)_{avg}*$					0.006**	
$ln(BackP)_{t-2}$					(0.002)	
$ln(K^I/H)_{avg}$				0.004*		
$ln(BackP)_{t-2}$				(0.003)		
$ln(K^{I\_SW}/H)_{avg}$			0.013***			
$ln(BackP)_{t-2}$			(0.005)			
$ln(QH)_{t-1}$	0.979***	0.964***	0.925***			
	(0.008)	(0.009)	(0.009)			
$ln(BackPDem)_{t-2}$						0.008*
						(0.005)
$ln(K^I/H)_{avg}$						0.002**
$ln(BackPDem)_{t-2}$						(0.001)
Observations	1,747	1,426	1,294	1,304	1,400	1,220

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Table A1 shows the GMM and Instrumental variable estimates of the main reference specifications illustrated in Tables 1 to 3. Estimates in columns 1 to 3 are GMM estimation results based on the Arellano-Bover/Blundell-Bond system estimator that is well suited for panels with small T as ours. Dependent variable in columns 1 to 3 is lnQHt, that is labour productivity level at time t. Dependent variable in cols 4 to 6 is the $DlnQH_t$. All specifications contain controls for ICT, NON-ICT and L quality as well as for time and industry fixed effects. Cols 1 to 3 refer to standard GMM estimates while cols 4 to 6 to Instrumental Variables.