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KNOWLEDGE BASED CAPITAL AND VALUE CREATION
IN GLOBAL SUPPLY CHAINS

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Knowledge Based Capital and Value Creation in Global Supply Chains

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This paper investigates the role of knowledge based capital for participation and value appropriation in global supply chains (GVC) for a sample of European countries over 1995-2011. We distinguish between different forms of participation in GVC entailing a different degree of capability to create value added domestically and examine how different intangible assets contribute to countries' engagement and value appropriation in GVC. We find that knowledge based capital is positively correlated with participation and value appropriation along the value chain. This finding is robust to introducing separately R&D and non-R&D intangibles. In particular, training and organizational capital have a large positive effect on value appropriation [JEL Classification: F23, O30].

Keywords: Knowledge based capital; global value chains; forward and backward participation; value added appropriation

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1. Introduction

The structural and technological changes associated with the rapid progress in Information and Communication Technologies (ICT) have led to widespread processes of *globalisation of value chains* (GVC) over the past two decades (for recent reviews, see Kaplinsky 2016; De Backer and Miroudot 2013; Timmer et al. 2014). Baldwin (2011) has defined these as a 'second unbundling' of globalisation, which has transformed the terms of international competition and shifted the barycentre of the world's global headquarters and peripheries.

At the same time, the changing nature of the global economy, the rising role of the service sector and the emergence of new business models have placed a novel attention on intangible capital or *knowledge based capital* as a key element of global competition and growth (Corrado et al. 2005, 2009).

However, the literature on the determinants of GVC participation (Hummels and Schaur 2012; WTO 2014; Cheng et al. 2015; López-Gonzalez et al. 2015; Kowalski et al. 2015) and gains from participation (Kaplinsky 2000; Gereffi et al. 2005; Dedrick et al. 2010; Shin et al. 2009, 2012; OECD 2013b) and the studies on the macroeconomic effects of investments in intangible assets (Jalava et al. 2007; Fukao et al. 2009; Hao et al. 2008; Marrano et al. 2009; Corrado et al. 2005, 2009, 2013, 2016, 2017) have remained two distinct fields of analyses.

The purpose of this paper is to bridge these two research fields by investigating the impact of investment in intangible capital on GVC participation in manufacturing and services and on gains from participation at the country level. In particular, we draw on the firm level literature on value appropriation along the value chain (Mudambi 2007; Shin et al. 2009, 2012; Dedrick et al. 2010) to formulate hypotheses on the relationship between different intangible assets and different modes of countries' participation in GVC.

We add to the literature in several respects. First, to the best of our knowledge, this is the only contribution to estimate the impact of intangible capital on countries' participation in GVC. Second, it distinguishes between forward and backward participation and between participation in manufacturing and in services; third it investigates the relationship between gains from participation (in terms of value added appropriation) and intangible assets. Finally, it exploits disaggregated data on different types of intangibles (R&D, marketing and advertising, design, training, organizational capital) to explore their (possibly) differentiated role in favouring GVC participation and gains.

The empirical analysis draws on data on countries' stocks of intangible assets for 11 European countries over the period 1995-2011 for manufacturing and total market services taken from INTAN-

Invest.net[1]. These data are merged with different measures of participation in global value chains gathered from OECD-WTO Trade in Value Added (TiVA) database: domestic value added embodied in foreign exports (or forward participation) and foreign value added embodied in domestic exports (or backward participation).

The paper is structured as follows. Section 2 provides an overview of the relevant literature and illustrates our research hypotheses. Section 3 offers some descriptive evidence on the extent of countries' participation in GVC and on its correlation with intangible investment. Section 4 presents the empirical strategy. Section 5 discusses the econometric results while Section 6 concludes.

2. Knowledge based capital and participation in Global Value Chains: Background literature and research hypotheses

The empirical literature on growth and international competitiveness has shown that competitive advantage, at both the country and firm level, is based on the ability to accumulate distinctive sets of capabilities and competencies and to assimilate knowledge more than on price-cost factors (Dosi et al. 1988, 1990, 2015; Fagerberg 1994; Cohen 2010; Laursen and Meliciani 2010).

More recently, intangible or knowledge based capital (broadly defined to include computerized databases, R&D, design, brand equity, firm-specific training, organizational efficiency) has emerged as an important driver of innovation, growth and competitiveness in the advanced economies (e.g., see Corrado et al. 2005, 2009, 2017). At the same time, the structural and technological changes associated with the rapid progress in Information and Communication Technologies (ICT), the rising role of the service sector and the development of new business models make intangible investments a key element of global competition in the 'knowledge-based economy'.

Empirical evidence shows that investments in intangible assets are expanding rapidly (e.g. in the United States, Japan and also in some European countries) outpacing investment in traditional assets (machinery and equipment, buildings, etc.) and impacting significantly on productivity growth directly (Marrano et al. 2007; Jalava et al. 2007; Fukao et al. 2009; Hao et al. 2008; Corrado et al. 2013)[2] and by generating knowledge spillovers to the economic system (Corrado et al. 2017). Moreover, export specialization in skill intensive industries is positively correlated with intangible intensity (OECD

[1] INTAN-Invest is an unfunded research initiative that periodically provides intangible investment estimates for 22 EU countries, the United States, and Norway see www.intan-invest.net for further details. The forthcoming INTAN-Invest update is reviewed and analyzed in Corrado et al. (2016).

[2] For a review of the literature see Thum-Thysen et al. (2017).

2013a). Thus, the more a country invests in intangible assets, the more likely is to foster comparative advantages in international trade in such industries. In this respect, organizational capital has the biggest impact among the knowledge based assets.

While there is a growing literature looking at the relationship between investment in intangible assets and productivity growth, the only study relating one specific intangible asset (organizational capital) and backward GVC participation is Marcolin et al. (2017). They find that industry-level investment in organizational capital is causally linked to GVC in the form of backward linkages with the foreign market.

In this paper, we draw from the firm level literature on value generation along the supply chain to put forward testable hypotheses on the role of intangible assets as a factor influencing countries' participation in GVC (distinguishing between backward and forward participation) and gains from participation in terms of value added appropriation.

We start from the observation that advanced countries are more likely to participate in GVC in those tasks that have a higher strategic value, are more complex in nature and allow them to have a higher control in the value chain (Dedrick et al. 2010; Rungi and Del Prete 2017). In this respect, assets such as R&D expenditures, training, organizational capital, etc. are expected to be the main drivers of competitiveness for advanced countries providing them not only with a higher level of technology but also with a greater flexibility and ability to monitor production across borders. Hence, we formulate our first hypothesis:

HP1 *Advanced countries displaying higher intangible investment intensity have a relatively higher level of participation in global value chains.*

The studies on GVC have mainly focused on manufacturing. However, an emerging literature highlights the growing service content of exports and GVC (Gereffi and Fernandez-Stark 2010; OECD 2013b; Kommerskollegium 2013; Lanz and Maurer 2015). It is, therefore, important to explore whether the determinants of GVC engagement differ between services and manufacturing (Lopez-Gonzalez et al. 2015).

Previous studies have shown that technology can play an important role for international competitiveness in services (Guerrieri and Meliciani 2005). However, the more traditional technological variables, such as R&D expenditures, might not be the most relevant for explaining

competitiveness in service industries[3]. The intangible and information-based nature of services makes the generation and use of ICT playing a central role in firms' innovative activities and performance (Evangelista 2000). The same role can also be played by other intangible assets different from R&D such as training. Niebel et al. (2017) find that the contribution of intangible investment to productivity growth in European countries is generally highest in manufacturing and finance but the data also show a high contribution in business services in several countries, most notably in the Netherlands and the UK[4]. Referring to this evidence we formulate our second hypothesis:

HP2 *Intangible assets contribute differently to GVC participation in manufacturing and services. R&D is expected to be more relevant in manufacturing than in services while ICT and other non-R&D intangibles are expected to be equally important in both sectors.*

Following Koopman et al. (2010), total GVC participation can be decomposed in domestic value added embodied in foreign exports or forward linkages (where the country provides inputs into exports of other countries, generating domestic value-added which goes into other countries' gross exports) and foreign value added embodied in domestic exports or backward linkages (where the country imports intermediate products to be used in its exports, leading other countries to generate foreign value added that goes into the domestic country's gross exports). The relative importance of backward and forward linkages may signal the position of a country in the value chain of a sector[5]. If a country lies upstream in the global value chain, it participates by producing inputs for others, and its forward linkages will be higher than its backward linkages. On the other hand, if a country lies downstream in the global value chain, it will use a large portion of other countries' intermediates to produce final goods for exports, and its backward linkages will be higher than its forward linkages (Koopman et al. 2010).

The role of intangible assets for countries' participation in GVC might, therefore, differ when considering backward and forward linkages and the innovative characteristics of each asset (product or process innovation). Ideally, R&D and design, lie upstream in a production sequence, while marketing and advertising are located more downstream. Other assets such as training and organizational capital cannot be easily located in a particular stage of a value chain and can be considered horizontal

[3] In fact, although manufacturing sectors spend more on R&D than service sectors, when the definition of technological innovation is broadened to include marketing, training and other innovative activities, many services have much higher spending than manufacturing (Tomlinson 2000).

[4] Marrocu et al. (2012) find that for service activities the marginal contribution to output formation of the intangible capital is higher than that of tangible capital.

[5] The relative importance of backward and forward linkages also depends on the size of the country and on the type of production activity. Natural resource-rich countries and headquarter economies tend to have higher domestic value added in their exports, while smaller countries and factory economies tend to exhibit lower domestic content of exports (Kowalsky et al. 2011; Baldwin and Evenett 2014).

(providing a contribution to all stages of production). Among intangibles some may contribute more to organizational innovation (organizational capital) others to product innovation (brand, design) while others can have a broader impact (R&D, training). Thus, for most intangibles we cannot assume that they univocally contribute only to one mode of participation. Further, the strong interdependence and complementarity between them[6] suggests that they may all contribute to both backward and forward linkages. We, therefore, formulate our third hypothesis:

HP3 *intangible assets are expected to positively affect forward and backward participation, but R&D and design are expected to contribute more to forward linkages while marketing and advertising are expected to exert a stronger impact on backward linkages.*

Participation in GVC can be important in itself by allowing countries at different stages of development to exploit foreign demand and specialize in tasks along the value chain rather than having to set up entire processes of production from scratch (see also OECD 2013b; Baldwin and López-Gonzalez 2015), however not all forms of participation entail the same gains (Gereffi et al. 2005; Kaplinsky 2000; Schmitz and Strambach 2009).

But how can we measure the gains from participation? And what are the factors allowing countries to benefit more from participation in GVC?

A break-up of forward linkages and backward linkages in GVC can provide a useful insight into the gains that go to a country from its participation (Banga 2013). If gains are measured in terms of 'net value-added' by participation in GVC, then the higher are the forward linkages as compared to the backward linkages, the higher are the gains. This would imply that by its participation in GVC, a country is creating and exporting more domestic value-added than the foreign value added which it is importing[7].

We argue that investment in intangible assets allows countries not only to participate in GVC but, more importantly, to gain from such participation in terms of net value added. The positive impact of intangible assets on total factor productivity and knowledge spillovers (Corrado et al. 2005, 2017) indirectly suggests that intangibles may also play a role in value added appropriation along the supply chain. Moreover, the literature at the firm level has shown that a great part of the value added of a final product is created in the first and last stages of the production process by firms involved in R&D,

[6]Previous studies have shown complementarity between ICT and intangibles (Corrado et al. 2017).

[7] Using these two measures, Banga (2013) finds that, in case of US, Japan and UK, forward linkages are much stronger than backward linkages, indicating net value-added gains from linking into GVC. China and Korea, on the other hand, have negative net value added gains.

design, marketing and advertising, 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; Shin et al. 2009, 2012; Dedrick et al. 2010) [8]. Firms which control technology through mechanisms like patents or licenses are in extremely powerful positions and are likely to extract maximum rents in GVC (Mudambi 2007; Dedrick et al. 2010). Finally, the balance of power in GVC depends on the type of governance (Gereffi et al. 2005) so that managerial capabilities are also expected to affect the net gains from GVC participation.

Translating this evidence at the country level, we can expect that the ability of a country to reap a higher share of value added from participation in global supply chains will be linked to the source of competitive advantage of the country. Countries competing on low wages will be more likely to engage in low value added activities, while countries investing in knowledge based capital will appropriate a higher share of value added created in the chain. The allocation of value created in a GVC varies according to the ability of participants to supply sophisticated products or services. The supply of these products or services critically depends on intangible assets such as R&D, brands, training and organizational structure. Therefore, we introduce our fourth hypothesis:

HP4 *Benefits from participation in GVC (in terms of net value added appropriation) increase with investment in intangible assets.*

3. Data and descriptive statistics

3.1 Measures of GVC participation

Our measures of GVC participation are gathered from the OECD-WTO Trade in Value Added (TiVA) database[9]. They track the origin of value added, by country and sector, which is embodied in

[8] The pattern of value-added along the value chain may, therefore, be represented by the 'smiling curve' (Everatt et al. 1999) or the 'smile of value creation' (Mudambi 2007): ranking activities on the x-axis along the value chain (activities at the left or 'input' end are supported by R&D knowledge while activities at the right or 'output' end are supported by marketing knowledge), value added will be higher in the first and last stages of the value chain. Rungi and Del Prete (2017), using data for more than two million of firms in the European Union, detect a non-linear U-shaped relationship between the value added generated by firms and their position on a productive sequence, for which tasks at the top and at the bottom show higher value added. They also find empirical support for a phenomenon of domestic retention of value added by multinational enterprises, which may prefer keeping at home the tasks at higher potential to safeguard present and future competitive advantages.

[9] Indicators of participation in GVC can also be computed using the WIOD (World Input Output Database). The two databases differ significantly in terms of country and time coverage: WIOD covers 40 countries and TiVA 63 countries (e.g. TiVA includes Southeast countries) and WIOD provides a complete time series from 1995 to 2011 while TiVa covers 1995, 2000, 2005 and on a yearly basis from 2008 to 2011. There are other small methodological differences between the two

gross exports. The indicators are based on the work of Koopman et al. (2010, 2014) and extend the work of Hummels et al. (2001) and Johnson and Noguera (2012). Hummels et al. (2001) compute an index of vertical specialization given by the use of imported inputs in producing goods that are 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 which includes returned domestic value added (domestic value added that comes back incorporated in foreign inputs produced with domestic inputs) and the indirect exports to third countries.

A variant of this indicator decomposes value added, similarly across countries and sectors, but according to final demand (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. Both indicators (that based on exports and that based 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 important because domestic final demand and gross export vectors differ. In this paper, we use the indicator based on gross exports. The choice is dictated by the focus on global value chains (this measure is also preferred by the OECD, 2013b).

3.2 Intangible assets

Intangible assets are classified into three broad groups - computerized information, innovative property and economic competencies. 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 (2008) currently incorporates in the asset boundary only an array of intangible assets namely R&D, mineral exploration, computer software and databases, entertainment, literary and artistic originals, under the category ‘intellectual property products’. The remaining assets are treated as intermediate expenditures in official statistics. The INTAN Invest

databases related to the use of the sources. However, the two databases provide comparable information. In our paper, we resort to TiVA mainly since it provides “ready to use” indicators of participation in GVC.

initiative[10] provides harmonized estimates of intangible investments covering all asset categories proposed by Corrado et al. (2005) combining National Accounts data on intangibles with estimates of the assets not yet incorporated in National Accounts.

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 paper, we select from the INTAN database information for the following set of intangible assets: Design, Advertising and Market research (Brand), Training and Organizational capital[11]. The main original data source to build indicators for these assets 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). Firm Specific Human Capital (training) is computed on the basis of total training investment expenditure from the Continuing Vocational Training Survey and Labour Cost Survey. Measures of own account organizational capital are obtained from employment data by type of occupation and by industry (e.g., from the Structure of Earning survey or the Labour Force survey) following the cost based approach widely adopted in national accounts. Additional information about data sources and estimation methods can be found in Corrado et al. (2013).

3.3 The database

The database employed in this paper includes also data on tangible capital inputs, ICT capital as well as standard growth accounting variables such as output and labour input.

The main source for output, labour, tangible and ICT capital is the EU KLEMS database[12] (see O'Mahony and Timmer 2009, for details). Finally, as control variables, we include population (from Eurostat), the corporate income tax rate (from OECD), a synthetic indicator of product market regulation encompassing barriers to trade and investment, barriers to entrepreneurship and state control (from the OECD, for further details see Koske et al. 2015) and public expenditure on education (from the Panel Dataset for Cross-Country Analyses of National Systems, Growth and Development, CANA, Castellacci and Natera 2011).

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[10] INTAN-invest is a research collaboration dedicated to improving the measurement and analysis of intangible assets (www.intan-invest.net)

[11] 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.

[12] http://www.euklems.net

Data from TiVa are available only for selected years (1995, 2000, 2005 and from 2008 to 2011) while all the other information covers the period 1995-2011 on a yearly basis. The country coverage refers to 11 European countries (Austria, Belgium, Germany, Denmark, Spain, Finland, France, Italy, Netherlands, Sweden and UK) for two industries (total manufacturing and total market services)[13].

3.4 Descriptive analysis

We start our analysis providing an overview of the diffusion of intangible capital accumulation and the level of participation in GVC across the EU countries.

Figure 1 shows that intangibles account for a relatively higher share of value added in services (8.2%) than in manufacturing (7.0%) in six out of eleven countries. Services are significantly more intangible intensive than manufacturing in UK, Netherlands, Denmark and Belgium while in Austria and Spain the two sectors show relatively comparable shares.

(Figure 1 about here)

Participation in global value chains (standardized by hours worked) is rather heterogeneous across countries with higher indexes for manufacturing compared to services (Figure 2). Nordic and Continental EU economies (with the exception of Belgium and Finland) participate relatively more in GVC compared to the Mediterranean countries.

(Figure 2 about here)

The main goal of our analysis is to investigate if and to what extent intangible capital accumulation is related to the degree and the benefits of country's participation in GVC. Thus, the following figures report the correlations between different measures of participation in GVC and intangible assets.

Figure 3 shows data on per hour worked total intangible capital against participation in GVC in manufacturing and services across the sample countries. Correlation is significantly positive in both sectors suggesting a deeper analysis is warranted.

(Figure 3 about here)

[13] Data on population, the corporate income tax rate, product market regulation and public expenditure on education are available only at the aggregate level. Moreover data on product market regulation are available only for the years 1998, 2003, 2008 and 2013. Values for these years are attributed to the closest years for which we have no information.

Figures 4 and 5 show forward and backward measures of GCV participation plotted against five different types of intangibles: R&D, Training, Advertising, Organizational capital and Design. As expected the correlation is strong for all assets, although in the case of Training and Organizational capital it seems stronger with forward than with backward participation.

(Figures 4 and 5 about here)

4. Empirical strategy

The descriptive evidence has shown a positive correlation between intangibles and participation in global value chains. However, in order to test our hypotheses we estimate equations for GVC participation taking into account the simultaneous effect of intangibles and other control variables. In particular, we estimate the following equation:

$$\ln Y_{i,c,t}^{GVC_j} = \alpha_1 \ln K_{i,c,t}^{Intg_s} + \alpha_2 \ln K_{i,c,t}^{ICT} + \alpha_3 \ln K_{i,c,t}^{Non\ ICT} + \alpha_4 \ln X_{i,c,t} + \delta_t + \gamma_i + \varepsilon_{c,i,t} \quad (1)$$

where:

c=country (11 EU member countries), i=industry (manufacturing and total market services), and t=time (1995, 2000, 2005, 2008-2011). Y^{GVC_j} represents different indicators of GVC participation (total, forward and backward) and gains from GVC measured as the ratio between forward and backward participation. K^{Intg_s} is intangible capital with s=Total Intangible Assets, R&D, Training, Design, Brand (advertising and marketing), Organizational capital; K^{ICT} is ICT[14] capital and $K^{Non\ ICT}$ is tangible Non ICT capital stock; X are other controls (corporate income taxes, country size, product market regulation, public expenditure on education as a share of GDP); δ_t and γ_i are time and industry dummies. All variables are in per hour terms[15].

[14] We resort to the usual ICT definition including software, hardware and communication equipment so that software is excluded from our intangible aggregate.

[15] We prefer to standardize GVC variables for hours worked rather than for exports for comparability with other variables. Moreover standardization by exports would not allow capturing whether investments in intangibles favours international competitiveness.

We use an export-based indicator to measure participation in GVC that can be split into backward and forward participation. In particular, domestic value added embodied in foreign exports (DVAFEX) captures the domestic value added content of gross exports and includes the value added generated by the exporting industry during its production processes as well as any value added created from upstream domestic suppliers that is embodied in exports. This measure is likely to be higher for countries (and sectors) involved in upstream production, with output and exports of that country feeding into the production and exports of downstream producers (i.e. forward integration). Foreign value added content of gross exports (FVADEX) captures the value of imported intermediate goods and services that are embodied in a domestic industry's exports. The value added can be generated from any foreign industry upstream in the production chain. It is used to measure the extent to which a country's exports are dependent on imported content, the so-called backward integration. It is therefore likely to be higher if a country (or sector) is involved in downstream production.

Finally, the sum of the two indicators is a measure of overall participation in GCV. Therefore, HP1 requires the coefficient of K^{intgs} to be positive and significant when the dependent variable is the sum of DVAFEX and FVADEX. HP2 is tested by allowing the coefficients on tangible, intangible and ICT investment to vary between manufacturing and service industries. In particular, we expect the coefficient on R&D to be higher for manufacturing while we do not have strong a priori expectation on the relative size of the coefficients for the other intangibles but we expect them to be important also in services. HP3 requires a different impact of investment in R&D, design, and brand on the two measures of forward and backward participation (for R&D and design higher for DVAFEX and for marketing and advertising higher for FVADEX). In order to test this hypothesis, we nest the forward and backward participation equations in a single model and we build a dummy variable equal to one for forward participation. We, then, estimate equation (1) where we include also all explanatory variables multiplied by the dummy variable so that t-statistics on these variables test for the difference in the coefficients associated to forward and backward linkages.

More precisely, domestic value added embodied in foreign exports (DVAFEX) measures the contribution in terms of value added to foreign exports while foreign value added embodied in domestic exports (FVADEX) measures how much foreign countries contribute in terms of value added to the exports of the domestic country. The ratio between DVAFEX and FVADEX is used as an indicator of the capability of a country to appropriate a large share of value added. Therefore, HP4 requires K^{intgs} to positively affect these ratios.

Since we have a short time series, we report estimates of generalized least squares on data pooled across countries, industries and over time, controlling for industry and time fixed effects. The estimations so obtained can suffer from problems of simultaneity bias arising when one or more of the explanatory variables are determined jointly with the dependent variable. It could be argued that firms/countries make decisions on investment in intangible assets partly based on their participation in GCV. One way of dealing with this problem is to use instrumental variables. However, we were not able to find reliable instruments, i.e variables strongly correlated with investment in intangible assets but uncorrelated with participation in GCV. For this reason, we run our main regression models also lagging the explanatory variables as robustness checks. The results of these estimations are reported in the Appendix[16].

5. Econometric results

Our first set of results is reported in Table 1 where we investigate the determinants of participation in GVC, then we check if factors affecting participation differ between manufacturing and services (Table 2) and between forward and backward participation (Table 3); finally we explore the relationship between intangible assets and gains for participation (Table 4).

Tables 1, 2 and 4 show regression results for total intangible assets (column 1) and distinguishing between R&D and other intangibles (columns 2, 3 and 4); then columns 5 to 8 analyze the individual effect of training, marketing and advertising, design and organizational capital[17]. Table 3 reports our findings for forward (columns 1 to 6) and backward (columns 7 to 12) participation and shows when intangible assets have a different impact on the two modes of participation.

Our first hypothesis is supported by results shown in Table 1: total intangible assets positively affect participation in global value chains. This confirms the relevance of knowledge investment for advanced countries. Moreover, when looking separately at R&D and non-R&D intangible assets, they are both positive and significant, with non-R&D intangibles showing a larger coefficient than R&D. However, when we control for their joint effect in a unique regression, R&D remains significant but becomes negative as a likely consequence of collinearity between them. Finally, all assets contribute positively and significantly to explain participation in GVC with training showing the largest coefficient

[16] Another option was to use Generalized Method of Moments (GMM). However, due to the short time series this would not give meaningful results (see also Draca et al. 2006 for a similar problem on productivity estimates).

[17] The high correlation coefficients between the various intangibles make it impossible to consider all of them simultaneously in the same equation.

suggesting a relatively important role of firm specific human capital in determining participation at the industry/country level.

Also tangible and ICT capital are positively related to participation in GVC pointing to the complementary role of tangible capital, intangible capital and ICT for countries and industries to take part in the global production process.

Finally, as expected, small countries, countries with a lower income corporate tax rate and with a more competitive market (lower barriers to entrepreneurship, to trade and investment and lower state control) experience higher participation in GVC. On the other hand, the intensity of public expenditure in education is positive and significant only in few specifications[18].

(Table 1 about here)

Our second hypothesis about a differentiated effect between manufacturing and services is partially supported by estimates in Table 2. As expected, R&D is positively correlated to GVC participation only in manufacturing while non-R&D intangibles matter for participation both in manufacturing and in services. However, all intangibles but training show a higher elasticity in manufacturing (training appears to be equally important in services and manufacturing). Finally, the impact of ICT is larger for services than for manufacturing.

Overall these results corroborate the assumption that some of the determinants of international competitiveness significantly differ between manufacturing and services. As expected, the traditional proxy of innovation (R&D) proves insufficient for explaining competitiveness in services, where other intangibles and, particularly, ICT and training seem to be more relevant[19]. At the same time, intangible assets and ICT are complementary to R&D in explaining GCV engagement in manufacturing. Finally, investment in tangible assets is important both in manufacturing and in services.

(Table 2 about here)

When looking separately at forward and backward participation (Table 3), we find partial support for our third hypothesis. As expected, all intangible assets contribute positively to both forward and backward participation; however, training and organizational capital matter relatively more for forward

[18] Robustness checks using lagged explanatory variables lead to very similar results (see Table A1 in the Appendix).
[19] See Guerrieri and Meliciani (2005) for the role of ICT for exporting services.

than for backward participation while brand and design are more important for backward linkages. In the case of R&D, although the coefficient is larger for forward than for backward participation, they are not statistically different.

The results on brand (marketing and advertising) are consistent with them being located more downstream in the supply chain. However, with the same logic, we would have expected design, which is located upstream, to matter more for forward participation. A possible explanation for our result is the complementarity between branding and design for the commercialization of a product or service. Finally, although we had no a priori expectations about the relative importance of training and organizational capital for backward and forward linkages, their larger elasticity for domestic value added in foreign exports suggests their strategic role for value appropriation along the supply chain.

As far as other assets are concerned, ICT is a key factor for backward participation while tangible capital contributes more to forward participation. Small countries participate more in GVC both backward and forward but the negative effect of size is larger for backward participation. This is in line with the expectation that smaller countries tend to exhibit relatively lower domestic than foreign content of exports (Kowalsky et al. 2011). Finally, while high corporate income taxes discourage both forward and backward participation, product market regulation is more important for forward participation[20].

(Table 3 about here)

The analysis developed so far supports the assumption that intangible capital matters for European countries to take part in global value chains. But then we may ask whether intangibles also contribute to the appropriation of a greater share of value added created in a GVC. We expect that since value appropriation varies according to the ability of participants to supply sophisticated products or services, countries investing more in intangible assets have a comparative advantage in producing such products or services. Table 4 reports estimates of the gains from participation measured as the ratio between domestic value added embodied in foreign exports and foreign value added embodied in domestic exports. The idea is that the higher is domestic value added compared to foreign value added, the higher is the domestic appropriation of value along the value chain.

Our findings show that intangible capital is positively related to value appropriation and this result is robust to introducing separately R&D and non-R&D intangible assets. However, not all intangibles are

[20] Robustness checks using lagged explanatory variables lead to very similar results (see Table A2 in the Appendix).

equally relevant: training and organizational capital have a large positive effect while brand does not matter and design has a negative impact. The big role of organizational capital in affecting value appropriation in GVC confirms the importance of governance for extracting maximum rents (Gereffi et al. 2005). This result is also consistent with the sizeable contribution of organizational capital for export specialization in skill intensive industries (OECD 2013a) and with the positive impact of managerial practices on firms' productivity and profitability and on countries' total factor productivity (Bloom and Van Reenen 2007; Bloom et al. 2016).

The result for training points to the importance of firm specific human capital not only for taking part in GVC but also for value appropriation at the country level. This is consistent with the importance of human capital for absorptive capacity (Lund Vinding 2006).

Looking at the other variables, tangible capital, population, the intensity of public expenditure in education and a more competitive market (lower barriers to entrepreneurship, to trade and investment and lower state control) positively affect gains from participation while ICT has a negative impact in most specifications. This last result is difficult to interpret. A possible explanation is that investment in information and communication technologies is particularly important for countries acting as export platforms, i.e. trading in international markets goods and services embodying high levels of foreign value added.

(Table 4 about here)

6. Conclusions

A recent stream of literature has emphasized the importance of knowledge based capital namely R&D but also organizational capital, training, marketing and advertising for firms', industries' and countries' productivity growth. At the same time, a growing field of research has highlighted how the globalization of value chains has changed the traditional factors of international competitiveness with different benefits accruing to different firms and countries depending on the tasks performed within the value chain. This paper is a first attempt at bridging the two streams of literature by investigating whether and how intangible capital contributes to foster advanced countries' participation in global value chains and their capability to appropriate value added along the supply chain. Our main findings can be summarized as follows.

First, intangible capital as a whole is positively related to participation in global value chains in advanced countries and is complementary to tangible capital and ICT. Moreover, non-R&D intangibles play a larger role than R&D with training being the main driver of participation.

Secondly, there are differences and similarities between manufacturing and services: while non-R&D intangibles matter for both services and manufacturing, R&D drives participation only in manufacturing industries and ICT is relatively more relevant for participation in services. This result supports previous evidence according to which the intangible and information-based nature of services gives to the generation and use of ICT a central role in firms/countries innovation activities and performance (Evangelista 2000; Guerrieri and Meliciani 2005).

Third, intangibles foster, even if to a different extent, both forward and backward participation: training and organizational capital matter significantly more for forward linkages while marketing and advertising and (surprisingly) also design are more relevant for backward linkages. This evidence only partially supports the role of intangibles along the smiling curve (Mudambi 2007, 2008; Shin et al. 2009, 2012; Dedrick et al. 2010 2007) and suggests strong complementarities between the use of different intangible assets in the supply chain.

Finally, knowledge based capital is positively correlated with value appropriation along the value chain (measured as the domestic value added embodied in foreign exports relative to the foreign value added embodied in domestic exports) and this finding is robust to introducing separately R&D and non-R&D intangibles. Among them, in particular training and organizational capital have a large positive effect on value appropriation.

The descriptive evidence reported in the paper also shows the heterogeneous behavior of European countries in terms of both intangible capital accumulation and participation in global value chains. In this respect, the low figures for Mediterranean countries (Italy and Spain) suggest that they may be trapped in a vicious circle of low investment in high value added creating activities and low competitiveness in international markets.

Overall, the results of this paper are broadly consistent (and complementary) with the growing literature showing the key role of intangible investment for productivity growth (Corrado et al. 2009, 2013). Further analyses should consider the joint impact of investment in intangibles, participation in GVC and productivity growth.

Finally, due to the short time series, this paper has not tested the possible two-way relationship between investment in intangible assets and participation in GVC and has not explicitly addressed

causality issues. In this respect, further studies with longer time series and more detailed industry data are needed to shed further light on these issues.

Appendix: robustness checks using lagged explanatory variables

(Tables A1 and A2 about here)

References

Baldwin, R. (2011), 'Trade and Industrialization after Globalization's 2nd Unbundling: How Building and Joining a Supply Chain Are Different and Why It Matters', NBER Working Paper n. 17716.

Baldwin, R. and J. López-Gonzalez (2015), 'Supply-Chain Trade: A Portrait of Global Patterns and Several Testable Hypotheses', *The World Economy,* 38, 1682-1721.

Banga, R. (2013), 'Measuring value in global value chains', Background paper n. RVC-8, UNCTAD.

Bloom, R. and J. Van Reenen (2007), 'Measuring and Explaining Management Practices Across Firms and Countries', *Quarterly Journal of Economics*, 122, 1351-1408.

Bloom, R., R. Sadun and J. Van Reenen (2016), 'Management as a Technology', NBER Workin Paper n. 22327.

Castellacci, F. and J. M. Natera (2011), 'A New Panel Dataset for Cross-Country Analyses of National Systems, Growth and Development (CANA)', *Innovation and Development*, 1, 205-226.

Cheng, K., Rehmen, S., Seneviratne, D. and S. Zhang (2015), 'Reaping the Benefits from Global Value Chains', IMF Working Paper 15/204.

Cohen, W.M. (2010), 'Fifty Years of Empirical Studies of Innovative Activity and Performance', in Hall, B. H., and N. Rosenberg (Eds.), *Handbook of the Economics of Innovation*, 129-213, North-Holland, Elsevier, Amsterdam.

Corrado, C., C. Hulten and D. Sichel (2005), 'Measuring Capital and Technology: An Expanded

Framework', in Corrado, C., J. Haltiwanger and D. Sichel (Eds.), *Measuring Capital in the New Economy*, National Bureau of Economic Research Studies in Income and Wealth, 11-45, The University Chicago Press**,** Chicago.

Corrado, C. A., D. E. Sichel and C. R. Hulten (2009), 'Intangible capital and U.S. Economic growth,' *Review of Income and Wealth*, 85, 661–685.

Corrado, C., J. Haskel, C. Jona-Lasinio and M. Iommi (2013), 'Innovation and intangible investment in Europe, Japan and the United States', *Oxford Review of Economic Policy,* 29, 261-286.

Corrado, C., J. Haskel, C. Jona-Lasinio and M. Iommi (2016), 'Intangible investment in the EU and the US before and since the Great Recession and its contribution to productivity growth', EIB Working Papers 2016/08, European Investment Bank, Luxemburg.

Corrado, C., J. Haskel and C. Jona-Lasinio (2017)*,* 'Knowledge Spillovers, ICT and Productivity Growth', *Oxford Bullettin of Economics and Statistics,* 79, 0305-9049.

De Backer, K. and S. Miroudot (2013), 'Mapping Global Value Chains', *OECD Trade Policy Papers,* 159, 1–46.

Dedrick, J., K.L. Kramer and G. Linden (2010), 'Who Profits from Innovation in Global Value Chain? A Study of the iPod and Notebook PCs', *Industrial and Corporate Change*, 19, 81-116.

Dosi, G., C. Freeman, R. Nelson, G. Silverberg, and L. Soete, Eds. (1988), *Technical Change and Economic Theory*, Pinter Publisher, London.

Dosi, G., K. Pavitt, and L. Soete (1990), *The Economics of Technical Change and International Trade*, New York University Press, New York.

Dosi, G., M. Grazzi and D. Moschella (2015), 'Technology and costs in international competitiveness: From countries and sectors to firms', *Research Policy,* 44, 1795-1814.

Draca, M., R. Sadun and J. Van Reenen (2006), 'Productivity and ICT: A Review of the Evidence', CEP Discussion Paper n. 749, Centre for Economic Performance, London School of Economics.

Evangelista, R. (2000), 'Sectoral patterns of technological change in services', *Economics of Innovation and New Technology*, 9, 183-221.

Everatt, D., T. Tsai and B. Chang (1999), 'The Acer Group's China manufacturing decision. Richard Ivey School of Business Case Series #9A99M009, University of Western Ontario.

Fagerberg, J. (1994), 'Technology and International Differences in Growth Rates', *Journal of Economic Literature* 32, 1147-75.

Fukao, K., T. Miyagawa, K. Mukai, Y. Shinoda and K. Tonogi (2009), 'Intangible Investment in Japan: Measurement and Contribution to Economic Growth', *Review of Income and Wealth* 55, 717–736.

Gereffi, G., J. Humphrey and T. Sturgeon (2005), 'The Governance of Global Value Chains', *Review of International Political Economy,* 12, 78-104.

Gereffi, G. and K. Fernandez-Stark (2010), 'The Offshore Services Value Chains. Developing Countries and the Crisis', *The World Bank Policy Research Working Papers* 5262.

Guerrieri, P. and V. Meliciani (2005), 'Technology and international competitiveness: The interdependence between manufacturing and producer services', *Structural Change and Economic Dynamics,* 16, 489-502.

Hao, J.X., V. Manole and B. van Ark (2008), 'Intangible Capital and Economic Growth – an International Comparison', Economics Program Working Paper Series.

Hummels, D., J. Ishii and Y. Kei-Mu (2001), 'The Nature and Growth of Vertical Specialisation in World Trade', *Journal of international Economics*, 54, 75-96.

Hummels, D., and G. Schaur (2012), 'Time as a Trade Barrier', NBER Working Paper n. 17758, Cambridge, Massachusetts.

Jalava, J., A. Pirkko and A. Aku (2007), 'Intangible Capital in the Finnish Business Sector 1975-2005', Discussion Papers n. 1103, The Research Institute of the Finnish Economy.

Johnson, R.C. and G. Noguera (2012), 'Accounting for Intermediates: Productions sharing and Trade in Value Added', *Journal of International Economics*, 86, 224-236.

Kaplinsky, R (2000), 'Globalisation and Unequalisation: What Can Be Learned from Value Chain Analysis?', *The Journal of Development Studies* 37, 117–46.

Kaplinsky, R. (2016), 'Global Value Chain, Where They Came From, Where They Are Going and Why This Is Important', in Weisse, J. and M. Tribe (Eds), *Routledge Handbook of Industry and Development*, 184-204, Routledge, London and New York.

Koopman, R., W. Powers, Z. Wang and S-J. Wei (2010), 'Give Credit Where Credit Is Due: Tracing Value Added in Global Production Chains', NBER Working Paper n. 16426.

Koopman, R., Z. Wang and S-J. Wei (2014), 'Tracing Value-Added and Double Counting in Gross Exports', *American Economic Review*, 104, 459-94.

Kommerskollegium (2012), 'Everybody in Services – The impact of Servicification in Manufacturing on Trade and Trade Policy', Swedish National Board of Trade.

Koske, I., I. Wanner, R. Bitetti and O. Barbiero (2015), 'The 2013 update of the OECD product market regulation indicators: policy insights for OECD and non-OECD countries', OECD Economics Department Working Papers n. 1200.

Kowalski, P., J.L. Gonzalez, A. Ragoussis and C. Ugarte (2015), 'Participation of Developing Countries in Global Value Chains: Implications for Trade and Trade-Related Policies', OECD Trade Policy Papers n. 179, OECD Publishing, Paris.

Lanz, R. and A. Maurer (2015), 'Services and Global Value Chains: Servicification of Manufacturing and Services Networks', *Journal of International Commerce, Economics and Policy,* 06, 1-18.

Laursen, K. and V. Meliciani (2010), 'The Role of ICT Knowledge Flows for International Market Share Dynamics', *Research Policy*, 39, 687-697.

López-Gonzalez, J., V. Meliciani and M. Savona (2015), 'When Linder Meets Hirschman. Inter-Industry Linkages and GVCs in Services', SPRU Working Paper Series SWPS 2015-20.

B. Los, M. P. Timmer and G. J. de Vries (2015), 'How Global are Global Value Chains? A New Approach to Measure International Fragmentation', *Journal of Regional Science*, 55, 66-92.

Lund Vinding, A. (2006), 'Absorptive Capacity and Innovative Performance: A Human Capital Approach', *Economics of Innovation and New Technology*, 15, 507-517.

Marcolin, L., Le Mouel M. and M. Squicciarini (2017, forthcoming), 'Investment in Knowledge-Based Capital and Backward Linkages in Global Value Chains', *OECD Science, Technology and Industry Working Papers*, OECD Publishing, Paris.

Marrano, M. G., J. Haskel, and G. Wallis (2009), 'What happened to the knowledge economy? ICT, intangible investment and Britain's productivity record revisited', *Review of Income and Wealth*, 55, 686–716.

Marrocu, E., R. Paci and M. Pontis (2012), 'Intangible capital and firms' productivity', *Industrial and Corporate Change*, 21, 377–402.

Mudambi, R. (2007), 'Offshoring: economic geography and the multinational firm', *Journal of International Business Studies*, 38, p. 206.

Mudambi, R. (2008), 'Location, control and innovation in knowledge-intensive industries', *Journal of Economic Geography*, 8, 699–725.

Niebel, T. and M. O'Mahony (2017), 'The contribution of intangible assets to the sectoral productivity growth in the EU', *Review of Income and Wealth,* 63, S49-S67.

O'Mahony, M. and M. Timmer (2009), 'Output, Input and Productivity Measures at the Industry Level: The EU KLEMS Database, *Economic Journal*, 119, F374-F403.

OECD (2013a), 'Knowledge-based capital and upgrading in global value chains', in Supporting Investment in Knowledge Capital, Growth and Innovation, OECD Publishing, Paris.

OECD (2013b), 'Interconnected Economies. Benefiting from Global Value Chains', OECD Publishing, Paris.

Rungi, A. and D. Del Prete (2017), 'The 'Smile Curve': where Value is Added along Supply Chains', Working Papers 05/2017, IMT Institute for Advanced Studies Lucca.

Schmitz, H. and S. Strambach (2009), 'The Organisational Decomposition of Innovation and Global Distribution of Innovative Activities: Insights and Research Agenda', *International Journal of Technological Learning, Innovation and Development,* 2, 231-249.

Shin, N., K.L. Kraemer, and J. Dedrick (2009), 'R&D, value chain location and firm performance in the global electronics industry', *Industry and Innovation*, 16, 315–330.

Shin, N., K. L. Kraemer and J. Dedrick (2012), 'Value Capture in the Global Electronics Industry: Empirical Evidence for the 'Smiling Curve' Concept', *Industry and Innovation*, 19, 89-107.

Thum-Thysen, A., P. Voigt, B. Bilbao-Osorio, C. Maier and D. Ognyanova (2017), 'Unlocking Investment in Intangible Assets', Discussion Paper 047, European Commission.

Timmer, M., B. Los, R. Stehrer and G. de Vries (2014), 'Slicing Up Global Value Chains', *Journal of Economic Perspectives*, 28, 99-118.

Tomlinson, M. (2000), 'Information and technology flows from the service sector: A UK-Japan comparison', in Boden, M. and I. Miles (Eds.), *Services and the knowledge-based economy*, Continuum, London.

World Trade Organization (2014), 'The Rise of Global Value Chains', World Trade Report, Geneva.

Figure 1 – Intangible capital shares of value added

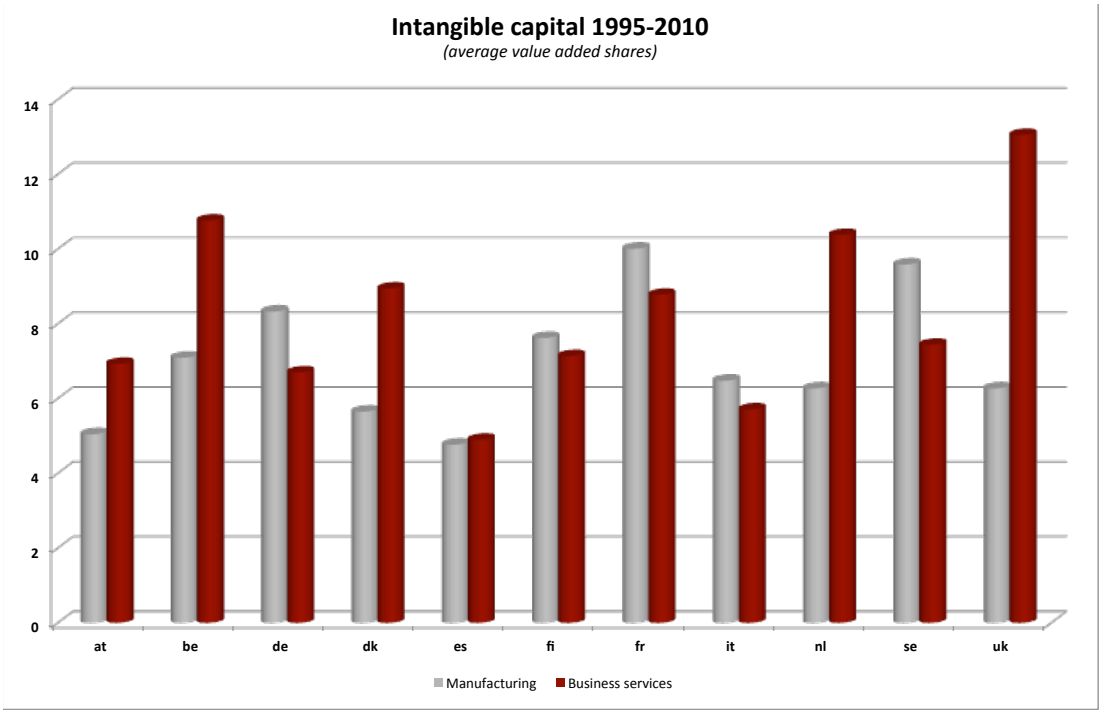

Figure 2 – Participation to Global Value Chains: manufacturing and services

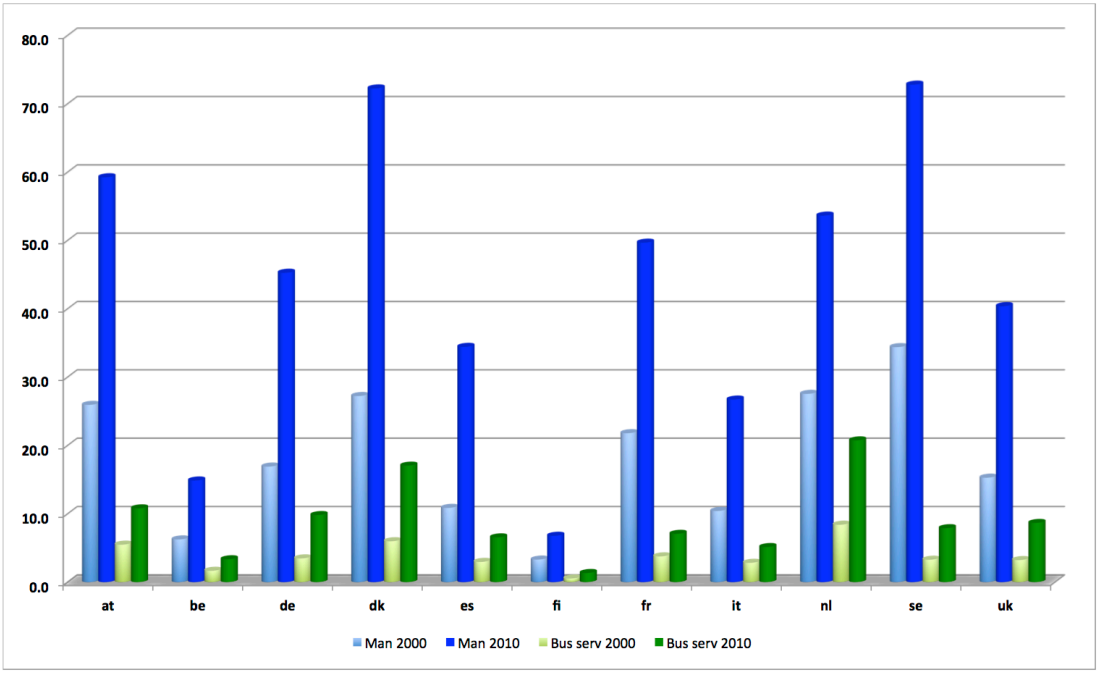

Figure 3 – Participation in Global Value Chains vs Intangible capital

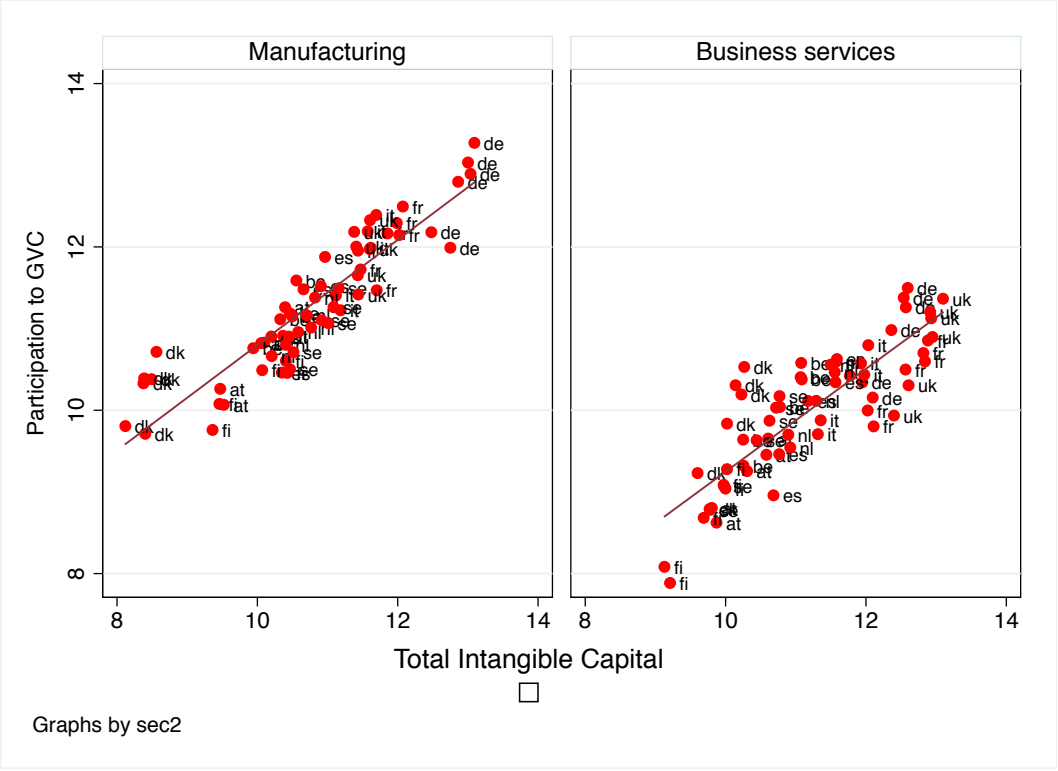

Figure 4 – Forward Participation in Global Value Chains and Intangible capital

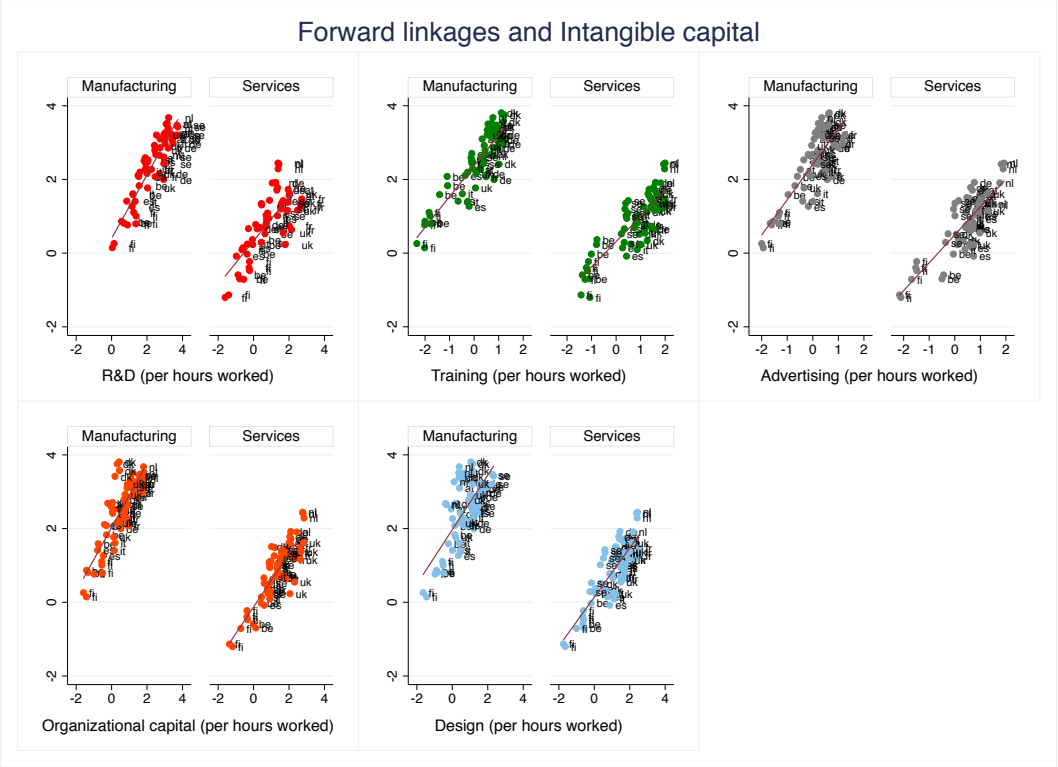

Figure 5 – Backward Participation in Global Value Chains and Intangible capital

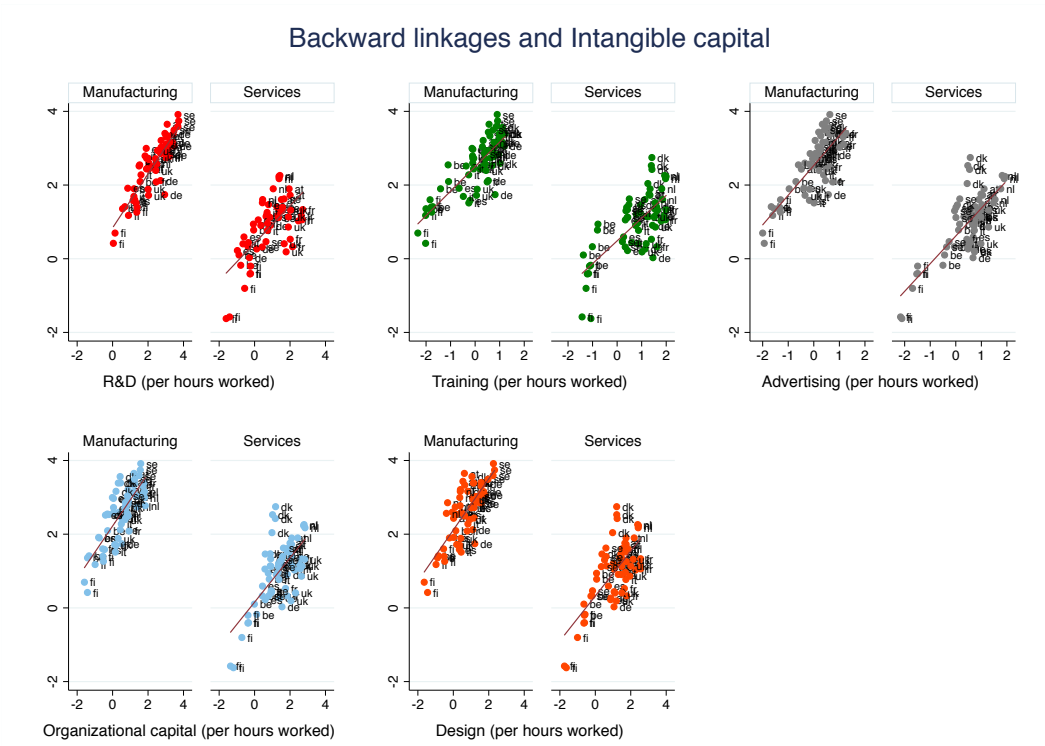

Table 1 The determinants of participation in GVC

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	((DVAFEX+FVAFEX)/H)							
lnH_D_totintg	0.521***							
	(0.035)							
lnH_D_k_ict	0.142***	0.426***	0.145**	0.055	0.263***	0.153	0.426***	0.248***
	(0.051)	(0.050)	(0.063)	(0.063)	(0.050)	(0.094)	(0.069)	(0.064)
lnH_D_all_tang_kstock_k	0.469***	0.503***	0.292***	0.427***	0.160***	0.442***	0.381***	0.502***
	(0.048)	(0.064)	(0.062)	(0.068)	(0.051)	(0.067)	(0.073)	(0.060)
lnH_D_rd_kstock_k		0.128***		-0.087**				
		(0.035)		(0.037)				
lnH_D_intg_xrd_kstock			0.639***	0.724***				
			(0.064)	(0.087)				
lnH_D_train_kstock_k					0.530***			
					(0.035)			
lnH_D_adv_mkt_kstock_k						0.433***		
						(0.072)		
lnH_D_arch_des_kstock_k							0.223***	
							(0.055)	
lnH_D_orgcap_kstock_k								0.267***
								(0.038)
corporateincometaxrate	-0.010***	-0.010*	-0.013***	-0.015***	-0.009***	-0.014***	-0.013**	-0.009***
	(0.004)	(0.005)	(0.003)	(0.004)	(0.002)	(0.005)	(0.006)	(0.004)
ln_pop	-0.200***	-0.184***	-0.234***	-0.245***	-0.232***	-0.140***	-0.198***	-0.152***
	(0.028)	(0.033)	(0.031)	(0.029)	(0.026)	(0.031)	(0.036)	(0.030)
ln_eduexp	0.458***	0.054	0.092	0.225	-0.194	0.358**	0.089	0.159
	(0.140)	(0.189)	(0.150)	(0.194)	(0.156)	(0.167)	(0.176)	(0.157)
pmr	-0.152	-0.388***	-0.150	-0.235**	-0.031	-0.452***	-0.499***	-0.261**
	(0.093)	(0.122)	(0.111)	(0.111)	(0.085)	(0.106)	(0.107)	(0.109)
services	-2.185***	-2.388***	-2.568***	-2.860***	-2.423***	-2.246***	-2.548***	-2.473***
	(0.058)	(0.104)	(0.048)	(0.095)	(0.041)	(0.081)	(0.059)	(0.049)
2000.year	0.363***	0.234***	0.348***	0.403***	0.299***	0.327***	0.211***	0.318***
	(0.050)	(0.052)	(0.054)	(0.053)	(0.040)	(0.066)	(0.072)	(0.057)
2005.year	0.297***	0.014	0.287***	0.275***	0.416***	0.142	-0.076	0.216**
	(0.071)	(0.075)	(0.084)	(0.084)	(0.063)	(0.095)	(0.084)	(0.085)
2008.year	0.347***	-0.010	0.332***	0.293***	0.582***	0.157	-0.112	0.251**
	(0.090)	(0.104)	(0.109)	(0.109)	(0.091)	(0.118)	(0.103)	(0.108)
2009.year	0.064	-0.286***	0.080	0.051	0.339***	-0.060	-0.358***	-0.007
	(0.090)	(0.103)	(0.110)	(0.112)	(0.091)	(0.122)	(0.103)	(0.109)
2010.year	0.181	-0.164	0.238	0.229	0.435***	0.116	-0.195	0.141
	(0.156)	(0.144)	(0.162)	(0.162)	(0.136)	(0.163)	(0.155)	(0.160)
Observations	92	82	92	82	92	92	92	92
Number of ctrysec	18	16	18	16	18	18	18	18
Standard errors in parentheses								
*** p<0.01, ** p<0.05, * p<0.1								

Table 2 The determinants of participation in GVC: differences between manufacturing and services

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	((DVAFEX+FVAFEX)/H)							
lnH_D_totintgman	**0.599*** **							
	(0.028)							
lnH_D_totintgser	**0.182*** **							
	(0.070)							
lnH_D_rd_kstock_k_man		**0.402*** **		**0.219*** **				
		(0.036)		(0.054)				
lnH_D_rd_kstock_k_ser		**-0.003**		**-0.158*** **				
		(0.036)		(0.036)				
lnH_D_intg_xrd_kstock_man			**0.919*** **	**0.430*** **				
			(0.088)	(0.120)				
lnH_D_intg_xrd_kstock_ser			**0.318*** **	**0.623*** **				
			(0.076)	(0.092)				
lnH_D_train_kstock_k_man					0.575***			
					(0.044)			
lnH_D_train_kstock_k_ser					0.496***			
					(0.059)			
lnH_D_adv_mkt_kstock_k_man						**0.577*** **		
						(0.092)		
lnH_D_adv_mkt_kstock_k_ser						**0.283** **		
						(0.113)		
lnH_D_arch_des_kstock_k_man							**0.425*** **	
							(0.080)	
lnH_D_arch_des_kstock_k_ser							**0.110**	
							(0.087)	
lnH_D_orgcap_kstock_k_man								**0.472*** **
								(0.058)
lnH_D_orgcap_kstock_k_ser								**0.152*** **
								(0.044)
lnH_D_k_ict_man	**0.079***	**0.168*** **	**0.015**	**0.022**	**0.188*** **	0.104	**0.402*** **	**0.083**
	(0.044)	(0.051)	(0.067)	(0.053)	(0.062)	(0.101)	(0.083)	(0.065)
lnH_D_k_ict_ser	**0.471*** **	**0.493*** **	**0.423*** **	**0.148***	**0.359*** **	0.275**	**0.643*** **	**0.424*** **
	(0.083)	(0.082)	(0.084)	(0.081)	(0.067)	(0.140)	(0.103)	(0.083)
lnH_D_all_tang_kstock_k_man	0.501***	0.589***	0.218***	0.506***	0.183***	0.388***	0.308***	0.517***
	(0.037)	(0.051)	(0.058)	(0.053)	(0.052)	(0.074)	(0.081)	(0.054)
lnH_D_all_tang_kstock_k_ser	0.382***	0.531***	0.317***	0.487***	0.087	0.479***	0.226*	0.416***
	(0.104)	(0.111)	(0.104)	(0.106)	(0.111)	(0.119)	(0.125)	(0.109)
corporateincometaxrate	-0.010***	-0.011**	-0.010**	-0.012***	-0.006**	-0.014***	-0.014**	-0.011**
	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.005)	(0.006)	(0.005)
ln_pop	-0.195***	-0.155***	-0.275***	-0.211***	-0.235***	-0.176***	-0.231***	-0.160***
	(0.026)	(0.028)	(0.033)	(0.026)	(0.029)	(0.039)	(0.041)	(0.029)
lneduexp	0.592***	0.519**	0.165	0.624***	-0.173	0.234	0.097	0.295*
	(0.127)	(0.215)	(0.135)	(0.176)	(0.162)	(0.193)	(0.183)	(0.157)
pmr	-0.224**	-0.408***	-0.249**	-0.285***	-0.005	-0.503***	-0.426***	-0.242**
	(0.093)	(0.115)	(0.105)	(0.108)	(0.101)	(0.119)	(0.119)	(0.112)
services	-1.271***	-1.864***	-2.350***	-2.554***	-2.204***	-2.888***	-2.333***	-2.287***
	(0.328)	(0.351)	(0.338)	(0.343)	(0.380)	(0.484)	(0.444)	(0.370)
2000.year	0.326***	0.307***	0.315***	0.425***	0.278***	0.324***	0.171**	0.301***
	(0.046)	(0.055)	(0.054)	(0.046)	(0.048)	(0.077)	(0.076)	(0.063)
2005.year	0.206***	0.043	0.227***	0.277***	0.432***	0.133	-0.129	0.195**
	(0.064)	(0.075)	(0.081)	(0.076)	(0.069)	(0.106)	(0.088)	(0.084)
2008.year	0.255***	0.050	0.241**	0.322***	0.625***	0.130	-0.164	0.228**
	(0.080)	(0.097)	(0.102)	(0.099)	(0.097)	(0.130)	(0.105)	(0.103)
2009.year	-0.038	-0.232**	-0.011	0.064	0.377***	-0.093	-0.422***	-0.019
	(0.081)	(0.097)	(0.103)	(0.100)	(0.098)	(0.134)	(0.106)	(0.103)
2010.year	0.068	-0.101	0.122	0.183	0.502***	0.082	-0.291**	0.124
	(0.128)	(0.136)	(0.136)	(0.152)	(0.123)	(0.164)	(0.148)	(0.140)
Observations	92	82	92	82	92	92	92	92
Number of ctrysec	18	16	18	16	18	18	18	18
Standard errors in parentheses								
*** p<0.01, ** p<0.05, * p<0.1								
Bold indicates significant differences between the coefficient on manufacturing and that on services at 10%								

Table 3 The determinants of forward and backward participation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	(lnH_dvafex)	(lnH_fvadex)	(lnH_dvafex)	(lnH_fvadex)	(lnH_dvafex)	(lnH_fvadex)	(lnH_dvafex)	(lnH_fvadex)	(lnH_dvafex)	(lnH_fvadex)	(lnH_dvafex)	(lnH_fvadex)
lnH_D_totintg	0.482***	0.389***										
	(0.051)	(0.072)										
lnH_D_rd_kstock_k			0.169***	0.105**								
			(0.047)	(0.046)								
lnH_D_train_kstock_k					**0.643*** **	**0.447*** **						
					(0.055)	(0.089)						
lnH_D_adv_mkt_kstock_k							**0.269*** **	**0.569*** **				
							(0.102)	(0.107)				
lnH_D_arch_des_kstock_k									**0.160** **	**0.370*** **		
									(0.077)	(0.083)		
lnH_D_orgcap_kstock_k											**0.393*** **	**0.193*** **
											(0.047)	(0.069)
lnH_D_k_ict	**0.016**	**0.389*** **	**0.273*** **	**0.566*** **	**0.047**	**0.450*** **	0.145	0.202	0.277***	0.463***	**0.036**	**0.510*** **
	(0.072)	(0.101)	(0.078)	(0.077)	(0.061)	(0.099)	(0.119)	(0.124)	(0.095)	(0.102)	(0.077)	(0.112)
lnH_D_all_tang_kstock_k	**0.625*** **	**0.308*** **	**0.672*** **	**0.382*** **	0.218***	0.020	**0.569*** **	**0.240** **	**0.558*** **	**0.211** **	**0.617*** **	**0.291*** **
	(0.066)	(0.093)	(0.096)	(0.095)	(0.066)	(0.107)	(0.089)	(0.093)	(0.091)	(0.098)	(0.070)	(0.102)
corporateincometaxrate	-0.011*	-0.015*	-0.013*	-0.015**	-0.003	-0.010	-0.010	-0.016*	-0.011	-0.017*	-0.012**	-0.016*
	(0.006)	(0.008)	(0.007)	(0.007)	(0.005)	(0.009)	(0.008)	(0.008)	(0.008)	(0.009)	(0.006)	(0.009)
ln_pop	**-0.104*** **	**-0.305*** **	**-0.097** **	**-0.299*** **	**-0.176*** **	**-0.352*** **	**-0.073**	**-0.284*** **	**-0.111** **	**-0.372*** **	**-0.072** **	**-0.279*** **
	(0.034)	(0.048)	(0.044)	(0.043)	(0.032)	(0.051)	(0.046)	(0.048)	(0.051)	(0.054)	(0.036)	(0.053)
lneduexp	0.436***	0.269	0.444	-0.261	-0.556***	-0.483**	0.066	0.203	-0.128	-0.209	0.330*	0.043
	(0.169)	(0.239)	(0.356)	(0.351)	(0.147)	(0.237)	(0.226)	(0.237)	(0.219)	(0.234)	(0.178)	(0.260)
pmr	**-0.527*** **	**0.107**	**-0.690*** **	**-0.061**	**-0.276*** **	**0.256**	**-0.725*** **	**-0.006**	**-0.737*** **	**-0.029**	**-0.433*** **	**0.079**
	(0.102)	(0.145)	(0.136)	(0.134)	(0.098)	(0.158)	(0.135)	(0.142)	(0.137)	(0.147)	(0.113)	(0.166)
services	**-2.170*** **	**-2.386*** **	**-2.187*** **	**-2.559*** **	**-2.299*** **	**-2.509*** **	-2.284***	-2.239***	-2.431***	-2.543***	-2.411***	-2.598***
	(0.068)	(0.096)	(0.143)	(0.141)	(0.056)	(0.090)	(0.107)	(0.112)	(0.085)	(0.091)	(0.064)	(0.095)
2000.year	0.401***	0.194*	0.270***	0.091	0.356***	0.140	0.276***	0.191*	0.237**	0.116	**0.360*** **	**0.111**
	(0.076)	(0.107)	(0.097)	(0.096)	(0.066)	(0.107)	(0.103)	(0.107)	(0.101)	(0.109)	(0.080)	(0.117)
2005.year	0.206**	0.146	-0.097	-0.037	0.510***	0.328**	0.084	0.237*	-0.033	-0.005	0.239**	0.078
	(0.086)	(0.122)	(0.106)	(0.105)	(0.088)	(0.141)	(0.123)	(0.129)	(0.113)	(0.121)	(0.094)	(0.138)
2008.year	0.199**	0.275*	-0.173	0.056	0.698***	0.591***	0.080	0.405***	-0.070	0.092	0.245**	0.206
	(0.101)	(0.143)	(0.131)	(0.130)	(0.109)	(0.176)	(0.146)	(0.153)	(0.133)	(0.142)	(0.110)	(0.161)
2009.year	-0.016	-0.003	-0.389***	-0.224*	0.487***	0.314*	-0.115	0.176	-0.290**	-0.190	0.033	-0.072
	(0.101)	(0.144)	(0.131)	(0.130)	(0.110)	(0.177)	(0.151)	(0.158)	(0.133)	(0.143)	(0.111)	(0.163)
2010.year	0.135	-0.018	-0.240	-0.106	0.637***	0.296	0.029	0.161	-0.154	-0.221	0.174	-0.097
	(0.166)	(0.235)	(0.205)	(0.202)	(0.161)	(0.260)	(0.234)	(0.246)	(0.225)	(0.241)	(0.179)	(0.262)
Observations	92	92	82	82	92	92	92	92	92	92	92	92
Number of ctrysec	18	18	16	16	18	18	18	18	18	18	18	18

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Bold indicates significant differences between the coefficient onforward and backward linkages at 10%

Table 4 The determinants of the domestic to foreign value added content of exports

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	((DVAFEX/FVAFEX))							
lnH_D_totintg	0.127**							
	(0.057)							
lnH_D_rd_kstock_k		0.085***		0.086*				
		(0.030)		(0.044)				
lnH_D_intg_xrd_kstock			0.185**	-0.004				
			(0.083)	(0.119)				
lnH_D_train_kstock_k					0.268***			
					(0.064)			
lnH_D_adv_mkt_kstock_k						-0.112		
						(0.096)		
lnH_D_arch_des_kstock_k							-0.158**	
							(0.071)	
lnH_D_orgcap_kstock_k								0.197***
								(0.043)
lnH_D_k_ict	-0.375***	-0.286***	-0.403***	-0.284***	-0.400***	-0.220**	-0.216***	-0.419***
	(0.067)	(0.044)	(0.074)	(0.074)	(0.063)	(0.092)	(0.068)	(0.065)
lnH_D_all_tang_kstock_k	0.302***	0.273***	0.269***	0.274***	0.123*	0.361***	0.373***	0.261***
	(0.052)	(0.050)	(0.058)	(0.057)	(0.070)	(0.051)	(0.047)	(0.051)
corporateincometaxrate	0.002	0.001	0.001	0.001	0.002	0.005	0.004	0.001
	(0.007)	(0.006)	(0.007)	(0.006)	(0.007)	(0.007)	(0.006)	(0.007)
ln_pop	0.232***	0.206***	0.217***	0.206***	0.206***	0.232***	0.254***	0.233***
	(0.030)	(0.030)	(0.030)	(0.030)	(0.029)	(0.033)	(0.034)	(0.028)
lneduexp	0.815***	0.817***	0.744***	0.816***	0.560***	0.641***	0.657***	0.653***
	(0.207)	(0.222)	(0.204)	(0.224)	(0.208)	(0.228)	(0.221)	(0.183)
pmr	-0.575***	-0.536***	-0.532***	-0.538***	-0.378***	-0.674***	-0.682***	-0.456***
	(0.101)	(0.095)	(0.105)	(0.108)	(0.108)	(0.112)	(0.106)	(0.093)
services	0.305***	0.408***	0.204***	0.410***	0.295***	0.102	0.150**	0.251***
	(0.093)	(0.083)	(0.076)	(0.100)	(0.081)	(0.105)	(0.074)	(0.073)
2000.year	0.219***	0.163***	0.232***	0.162**	0.222***	0.183***	0.181***	0.206***
	(0.063)	(0.058)	(0.063)	(0.065)	(0.061)	(0.071)	(0.068)	(0.056)
2005.year	0.033	-0.077	0.083	-0.080	0.210**	-0.045	-0.013	0.091
	(0.081)	(0.069)	(0.087)	(0.096)	(0.093)	(0.103)	(0.088)	(0.076)
2008.year	-0.073	-0.229***	-0.015	-0.232**	0.192	-0.181	-0.130	-0.006
	(0.098)	(0.085)	(0.106)	(0.116)	(0.118)	(0.123)	(0.104)	(0.095)
2009.year	-0.019	-0.164*	0.046	-0.167	0.252**	-0.136	-0.075	0.060
	(0.100)	(0.086)	(0.109)	(0.120)	(0.120)	(0.130)	(0.106)	(0.099)
2010.year	0.055	-0.090	0.129	-0.094	0.328**	-0.064	-0.001	0.155
	(0.108)	(0.094)	(0.118)	(0.129)	(0.132)	(0.141)	(0.117)	(0.106)
Observations	92	82	92	82	92	92	92	92
Number of ctrysec	18	16	18	16	18	18	18	18
Standard errors in parentheses								
*** p<0.01, ** p<0.05, * p<0.1								

Table A1: The determinants of participation in GVC

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	((DVAFEX+FVAFEX)/H)							
L.lnH_D_totintg	0.481***							
	(0.041)							
L.lnH_D_rd_kstock_k		0.095***		-0.124***				
		(0.033)		(0.033)				
L.lnH_D_intg_xrd_kstock			0.556***	0.728***				
			(0.062)	(0.077)				
L.lnH_D_train_kstock_k					0.481***			
					(0.033)			
L.lnH_D_adv_mkt_kstock_k						0.402***		
						(0.057)		
L.lnH_D_arch_des_kstock_k							0.190***	
							(0.039)	
L.lnH_D_orgcap_kstock_k								0.180***
								(0.038)
L.lnH_D_k_ict	0.174***	0.492***	0.200***	0.078	0.273***	0.188**	0.527***	0.380***
	(0.062)	(0.055)	(0.069)	(0.067)	(0.054)	(0.085)	(0.056)	(0.071)
L.lnH_D_all_tang_kstock_k	0.450***	0.471***	0.300***	0.427***	0.194***	0.421***	0.274***	0.424***
	(0.056)	(0.061)	(0.065)	(0.056)	(0.053)	(0.060)	(0.069)	(0.067)
corporateincometaxrate	-0.014***	-0.019***	-0.016***	-0.020***	-0.010***	-0.018***	-0.021***	-0.015***
	(0.003)	(0.005)	(0.003)	(0.003)	(0.002)	(0.004)	(0.004)	(0.004)
ln_pop	-0.182***	-0.169***	-0.225***	-0.243***	-0.209***	-0.131***	-0.207***	-0.153***
	(0.029)	(0.032)	(0.033)	(0.026)	(0.028)	(0.027)	(0.034)	(0.032)
L.lneduexp	0.501***	0.214	0.140	0.349**	-0.079	0.357***	0.037	0.167
	(0.150)	(0.195)	(0.154)	(0.155)	(0.159)	(0.132)	(0.139)	(0.157)
pmr	-0.015	-0.278**	-0.064	-0.159*	0.069	-0.459***	-0.364***	-0.122
	(0.105)	(0.119)	(0.107)	(0.094)	(0.089)	(0.094)	(0.096)	(0.118)
44.sec2	-2.215***	-2.508***	-2.579***	-2.966***	-2.429***	-2.315***	-2.567***	-2.529***
	(0.061)	(0.092)	(0.043)	(0.085)	(0.040)	(0.065)	(0.049)	(0.048)
2005.year	0.126*	-0.103	0.092	0.050	0.255***	-0.092	-0.106*	0.051
	(0.066)	(0.074)	(0.066)	(0.061)	(0.050)	(0.062)	(0.058)	(0.075)
2008.year	0.320***	-0.041	0.228***	0.163**	0.507***	-0.022	-0.105	0.187*
	(0.088)	(0.093)	(0.088)	(0.079)	(0.078)	(0.083)	(0.072)	(0.097)
2009.year	-0.085	-0.432***	-0.138	-0.213***	0.183**	-0.369***	-0.475***	-0.178*
	(0.087)	(0.100)	(0.091)	(0.081)	(0.082)	(0.084)	(0.078)	(0.099)
2010.year	0.033	-0.324***	-0.004	-0.064	0.313***	-0.214**	-0.343***	-0.048
	(0.087)	(0.099)	(0.091)	(0.083)	(0.082)	(0.087)	(0.078)	(0.099)
Observations	88	78	88	78	88	88	88	88
Number of ctrysec	18	16	18	16	18	18	18	18
Standard errors in parentheses								
*** p<0.01, ** p<0.05, * p<0.1								

Table A2: The determinants of backward and forward participation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	(lnH_dvafex)	(lnH_fvadex)	(lnH_dvafex)	(lnH_fvadex)	(lnH_dvafex)	(lnH_fvadex)	(lnH_dvafex)	(lnH_fvadex)	(lnH_dvafex)	(lnH_fvadex)	(lnH_dvafex)	(lnH_fvadex)
VARIABLES	xtgls	xtgls	xtgls	xtgls	xtgls	xtgls	xtgls	xtgls	xtgls	xtgls	xtgls	xtgls
L.lnH_D_totintg	**0.432*** **	**0.364*** **										
	(0.046)	(0.075)										
L.lnH_D_rd_kstock_k			0.148***	0.064								
			(0.043)	(0.045)								
L.lnH_D_train_kstock_k					**0.544*** **	**0.394*** **						
					(0.053)	(0.092)						
L.lnH_D_adv_mkt_kstock_k							**0.266*** **	**0.642*** **				
							(0.096)	(0.109)				
L.lnH_D_arch_des_kstock_k									**0.146** **	**0.360*** **		
									(0.071)	(0.085)		
L.lnH_D_orgcap_kstock_k											**0.337*** **	**0.153** **
											(0.044)	(0.072)
L.lnH_D_k_ict	**0.061**	**0.395*** **	**0.292*** **	**0.586*** **	**0.108**	**0.473*** **	0.192	0.136	0.339***	0.484***	**0.097**	**0.554*** **
	(0.074)	(0.120)	(0.079)	(0.082)	(0.067)	(0.118)	(0.120)	(0.137)	(0.097)	(0.117)	(0.082)	(0.132)
L.lnH_D_all_tang_kstock_k	**0.630*** **	**0.294*** **	**0.697*** **	**0.385*** **	0.288***	0.035	**0.539*** **	**0.213** **	**0.524*** **	**0.176**	**0.613*** **	**0.251** **
	(0.066)	(0.106)	(0.090)	(0.094)	(0.066)	(0.116)	(0.088)	(0.100)	(0.090)	(0.109)	(0.072)	(0.117)
corporateincometaxrate	-0.018***	-0.020**	-0.025***	-0.021***	-0.008	-0.012	-0.020***	-0.020***	-0.020***	-0.022***	-0.021***	-0.022**
	(0.005)	(0.008)	(0.006)	(0.006)	(0.005)	(0.008)	(0.006)	(0.007)	(0.007)	(0.008)	(0.005)	(0.008)
ln_pop	**-0.103*** **	**-0.276*** **	**-0.082** **	**-0.269*** **	**-0.174*** **	**-0.325*** **	**-0.080** *	**-0.254*** **	**-0.118** **	**-0.348*** **	**-0.080** **	**-0.256*** **
	(0.032)	(0.052)	(0.039)	(0.041)	(0.032)	(0.056)	(0.043)	(0.050)	(0.048)	(0.058)	(0.035)	(0.057)
L.lneduexp	**0.450*** **	**0.380**	0.689**	-0.019	-0.464***	-0.347	0.108	0.403*	-0.094	-0.087	0.307*	0.105
	(0.154)	(0.249)	(0.308)	(0.322)	(0.140)	(0.245)	(0.205)	(0.235)	(0.196)	(0.237)	(0.165)	(0.267)
pmr	**-0.597*** **	**0.314** *	**-0.753*** **	**0.118**	**-0.382*** **	**0.449** **	**-0.768*** **	**0.170**	**-0.758*** **	**0.195**	**-0.483*** **	**0.299**
	(0.107)	(0.173)	(0.134)	(0.140)	(0.107)	(0.186)	(0.142)	(0.162)	(0.145)	(0.175)	(0.121)	(0.196)
services	-2.230***	-2.364***	**-2.285*** **	**-2.663*** **	**-2.365*** **	**-2.497*** **	-2.336***	-2.157***	-2.493***	-2.534***	-2.448***	-2.578***
	(0.066)	(0.106)	(0.127)	(0.132)	(0.057)	(0.099)	(0.103)	(0.118)	(0.081)	(0.098)	(0.064)	(0.104)
2005.year	**-0.115**	**0.151**	**-0.325*** **	**0.027**	0.151**	0.330**	-0.158	0.227**	-0.229**	0.054	-0.059	0.132
	(0.070)	(0.113)	(0.092)	(0.096)	(0.075)	(0.131)	(0.097)	(0.110)	(0.095)	(0.115)	(0.079)	(0.128)
2008.year	**-0.073**	**0.403*** **	**-0.355*** **	**0.195** *	0.298***	0.649***	-0.161	0.496***	-0.271**	0.228*	-0.016	0.353**
	(0.086)	(0.139)	(0.109)	(0.114)	(0.096)	(0.168)	(0.119)	(0.136)	(0.115)	(0.138)	(0.097)	(0.157)
2009.year	**-0.420*** **	**-0.001**	**-0.728*** **	**-0.182**	0.044	0.318*	-0.468***	0.122	-0.578***	-0.144	-0.349***	-0.027
	(0.086)	(0.139)	(0.118)	(0.123)	(0.100)	(0.175)	(0.120)	(0.137)	(0.116)	(0.140)	(0.097)	(0.157)
2010.year	**-0.339*** **	**0.096**	**-0.668*** **	**-0.087**	0.141	0.425**	-0.371***	0.269*	-0.502***	-0.050	-0.259***	0.071
	(0.086)	(0.140)	(0.118)	(0.123)	(0.102)	(0.177)	(0.123)	(0.141)	(0.117)	(0.141)	(0.098)	(0.159)
Observations	88	88	78	78	88	88	88	88	88	88	88	88
Number of ctrysec	18	18	16	16	18	18	18	18	18	18	18	18
Standard errors in parentheses												
*** p<0.01, ** p<0.05, * p<0.1												