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Author(s) and company:	Tsakanikas, A. ^a , Roth, F. ^b , Caliò, S. ^b , Caloghirou, Y. ^a and Dimas, P. ^a ^a (National Technical University of Athens), ^b (University of Hamburg)
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The contribution of intangible inputs and participation in global value chains to productivity performance – Evidence from the EU-28, 2000-2014¹

Tsakanikas, A.^a, Roth, F.^b, Calì, S.^b, Caloghirou, Y.^a and Dimas, P.^a

^aLaboratory of Industrial and Energy Economics, National Technical University of Athens

^bDepartment of Economics, University of Hamburg

Abstract

This paper analyzes the contribution of intangible inputs and participation in global value chains (GVCs) to the productivity performance of an EU-28 country sample over the time frame 2000-2014. Utilizing new data from the GLOBALINTO Input-Output Intangibles database, this paper finds a positive relationship between a country's intangible inputs and its productivity performance once the interaction between intangible inputs and the participation in Global Value Chains is taken into account. This effect is stronger in the subset of 19 euro area countries. The results clarify that national and European policymakers should ensure the mechanisms, the tools and the legislative framework that will support sufficient production and development of intangible inputs by investing in public intangibles, such as the quantity and quality of a highly-skilled labour force and well-functioning formal and informal institutions that could lead to the further growth of intangibles. Furthermore, the need for a unified EU intangibles policy framework arises, in which common guidelines align national agendas in order to address the relevant gaps in intangibles industrial policy.

Keywords: Intangibles, Global Value Chain, Productivity Performance, European Union, Euro Area.

1. Introduction

At the dawn of the second decade of the 21st century, ICT investments, artificial intelligence (AI) and the bundle of related intangible assets are widely acknowledged as playing a pivotal role in the value-creation process of modern globalized economies. As envisaged by Brynjolfsson and Hitt (2000) and McAfee and Brynjolfsson (2012), the effective implementation of new technologies requires complementary investment in intangible assets, such as redesigned business models for firms and high-skilled employees. The bond between the globalized industrial production and the increasing demand for high-skilled workers was highlighted in Feenstra and Hanson (1996). Henceforth, the hypothesis that investment in technology and complementary intangible assets can drive successful participation in global value chains (GVCs) has found wide consensus in academic circles (see e.g. Baldwin (2013); Ali-Yrkkö and Rouvinen (2015); Criscuolo and Timmis (2017); Durand and Milberg (2019)), and has captured the interest of policy-makers (see e.g., OECD (2013a); Europe 2020 target for R&D).

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While the research on GVCs has so far emphasized the role of ICT investments over that of intangible investments, the purpose of this paper is to exploit the new GLOBALINTO Input-Output (I-O) Intangibles database to stress the pivotal importance of the flow of intangible inputs in successfully participating in GVCs. The GLOBALINTO I-O Intangibles database builds on the theoretical background for identifying intangible assets developed by Nakamura (2001), Corrado, Hulten and Sichel (2005, 2009)² and on data from the WIOD (Timmer et al. 2015). The approach of the GLOBALINTO Intangibles database tracks the flow of intangible inputs in an Input-Output framework, focusing on the EU-28 countries (including the UK) in the timeframe 2000-2014.

Using the described data sources, the main research hypothesis is that there is a combined effect of investing in intangibles and participating in GVCs at the country level. This implies that EU countries participating in GVCs with higher shares of intangible inputs reap an enhanced productivity effect. The main findings confirm the link between intangible inputs and a more successful (in terms of EU countries' productivity) participation in GVCs, with the euro area countries showing higher gains than the EU countries not adopting the single currency.

National and European policymakers should ensure and support the sufficient production and development of intangible inputs by investing in infrastructure and public intangibles, such as the quantity and quality of a highly-skilled labour force and well-functioning formal and informal institutions (Roth 2020 and Thum-Thyssen et al. 2019). In order to tackle several policy and legislative gaps regarding intangibles, the European Commission should focus the discussion around a unified EU intangibles policy framework that encompasses common guidelines with respect to each member state's national agenda. This framework should involve guidelines and diffusion policies under a common umbrella, aimed at achieving productivity and economic growth targets based on the concept of the regionalized EU value chain in which all member states can benefit, while providing data dissemination and protection safeguards.

The paper is structured as follows: Section 2 reviews the existing literature that links a wider set of intangible assets or input to the GVC participation. Section 3 introduces and describes the GLOBALINTO I-O Intangibles database. Section 4 illustrates the methodology for the empirical study. Section 5 presents the descriptive statistics. Section 6 presents the econometrics results. Section 7 provides our conclusions and policy implications.

2. Intangible investment and GVC participation: a review of the literature

The academic debate concerning value creation along the GVC has long acknowledged the key role of (some) intangible investment. The co-founder of the IT manufacturer Acer Inc., Stan Shih, observed as early as 1992 that the most lucrative stages of the value chain in the computer industry were the most intangible-intensive, namely the initial conception stage (R&D-intensive) and the final marketing stage. From the firm perspective, further anecdotal examples of big enterprises successfully using their intangible assets to establish and consolidate their dominant position on the market are given in Mudambi (2008), Shin et al. (2009), Ali-Yrkkö and Rouvinen (2015) and WIPO (2017).

From the international political economic perspective, in accordance, Baldwin (2013) formulated the concept of technology- and intangible-intensive headquarter economies (most notably, the US, the UK and Germany), where the most lucrative stages of the GVC are carried out and coordinated, and factory economies (China, India, Mexico), where the industrial production is outsourced. Durand and Milberg (2019: 20) strengthen Baldwin's hypothesis even further by arguing about the "intellectual monopoly" retained by the headquarter economies through their key intangible assets (patents, copyrights, organizational know-how). However, the question of how much a country gains by participating in the GVC if it increases its investments in intangible assets has not yet found a univocal answer, or a univocal framework.

² Henceforth, CHS (2005, 2009).

The refinement of Input-Output tables (henceforth, I-O tables) in the tradition of Leontief (1936), increased in time the availability of data to address such questions, but left open the problem of correctly assessing the VA creation process for goods crossing borders multiple times throughout their production. Several indexes to estimate how much VA a country reaps from GVC participation have been proposed in the literature. Using the value-added decomposition procedure in I-O Tables, Hummels et al. (2001) introduced the index of vertical specialization (VS) to account for the import content of a country's exports in terms of value added, i.e. the use of imported inputs in producing goods that are exported. Additionally, the same authors proposed the VS1 index to describe the domestic value added from a country that is incorporated into a foreign country's exports, relying on the assumption that a country's exports (both intermediate and final use exports) are entirely consumed abroad. Johnson and Noguera (2012) relaxed this assumption using I-O data for source and destination countries simultaneously and combining them with additional bilateral trade data. These steps result in the ratio of value added to gross exports (VAX ratio), intended as a measure of the intensity of production sharing. Similarly, Daudin et al. (2011) measured the value of a country's exported intermediates that were consumed in the production of final goods abroad and then returned into the domestic economy as final product. Building on the aforementioned, Koopman et al. (2010) and Koopman et al. (2014) provided a unified framework with a full decomposition of gross exports, which indeed is used as the basis for much of the empirical literature hereafter presented. In Koopman et al. (2014), gross exports are decomposed into two major elements: domestic value added (DVA) and foreign value added (FVA) embodied in gross exports.

The most commonly used measurement of GVC participation in the literature is the backward participation, defined as the share of FVA in gross exports (used e.g. in OECD (2013a), Baldwin and Lopez-Gonzalez (2015), Jona-Lasinio et al. (2019), and Lee et al. (2018)). The various metrics regarding forward participation relate to the DVA embodied in foreign gross exports (by a third country). The abovementioned papers about FVA and, more recently, Constantinescu et al. (2019) contributed to the literature by supporting the view of a positive effect of GVC participation on countries' and industries' productivity (measured in different ways). Consistent with these sets of relevant evidence, Timmer (2017) advocates complementing the *traditional* productivity studies with considerations on GVC participation, which is vital in modern economies.

Within the empirical literature on GVCs, only a few contributions showed the existence of a strong linkage between investments in intangible capital and (successful) GVC participation. Among these, an early OECD (2013a) report stressed the key role of intangible assets and urged better education and training institutions. Accordingly, Chen et al. (2017) and Fagerberg et al. (2018) stressed, respectively, that the share of VA creation due to intangibles is on a rising trend over time and that, coherently, countries with better innovation systems benefit more from GVC participation. Not surprisingly, even the emerging factory economies as China are found to be increasing their spending in intangible capital deepening, to improve their position in the GVC (Timmer et al. (2014); Lee et al. (2018)).

Focusing more closely on the European Union – the target of this paper – Daudin et al. (2011: 1428–1429) asserted that Europe was *the most regionalized region in the world* due to the high volume of intra-EU traded goods and services. This argument found further support in Baldwin and Lopez-Gonzalez (2015: 1710), who discuss, in particular, the case of German firms (headquarter economy, intangible-intensive) outsourcing their production to Poland (factory economy). Thus, the EU appears as a case of particular interest in the formation of GVCs, as it presents a dual perspective on intra- and extra-EU value chains. Moreover, as argued in Amador et al. (2015), the participation of euro Area countries in GVCs is on the rise (especially after 2009) and higher than the participation of the US and Japan.

Based on the above, a few contributions have recently attempted to empirically assess the drivers of GVC participation for the European countries and the gains they earned from participating. Among the latter (thus, studies that use a productivity measure as a dependent variable), Vrh (2018) reports a positive and significant effect of intangible investment (especially in business R&D) on domestic value added in exports. In addition, she corroborates the argument from Baldwin and Lopez-Gonzalez (2015) of a delay in intangible capital formation in the new (Eastern) EU member states.

Considering the full range of CHS' intangibles, Jona-Lasinio and Meliciani (2019) report a positive and significant return of non-R&D intangible (particularly organizational capital) on GVC backward participation, which, itself, results in higher productivity for the country's economy. Among the studies that assess the drivers of GVC participation (thus, using a measure of GVC participation as a dependent variable), Adarov and Stehrer (2019) highlight the importance of inward (outward) FDIs to enhance the backward (forward) GVC participation for EU member states. Jona-Lasinio et al. (2019) find a positive and significant relationship between GVC participation (both backward and forward) and investments in a wide set of intangible assets, most notably training (corresponding to the stream of literature originating from Feenstra and Hanson (1996)), organizational capital and R&D.

3. Description of the dataset

3.1. *The framework of the GLOBALINTO Input-Output Intangibles database*

Since the seminal works from Nakamura (2001) and CHS (2005, 2009), intangible assets have been in the foreground of economic research, with several studies attempting to capture their true effect on production values and productivity growth in a rapidly changing economic environment. Relevant information and concepts to measure business intangible investments in the EU have been adopted by several databases, namely INNODRIVE (Jona-Lasinio et al. (2011)), INDICSER (O'Mahony et al. (2012)), INTAN-Invest (Corrado et al. (2016)) and the most recent release of the EUKLEMS (Stehrer et al. (2019)). Whereas these databases provide insightful information on how much a country (industry) invested in intangibles in any given year, some delicate questions remain unanswered, such as: Where do these investments go? Who capitalizes these investments and produces the intangible assets? Input-output data can serve as a proper tool to properly address such questions. The GLOBALINTO I-O Intangibles database, thus, offers a different approach on the quantification of the impact of intangibles by treating them as production inputs based on an input-output concept, using available data from the World Input-Output Database³ (Timmer et al. (2015)), which provides the raw data on inter-sectoral global trade between 56 economic sectors of 43 countries (including all the EU-28).

The GLOBALINTO I-O Intangibles database relies on the framework first developed in CHS (2005) to identify the intangible assets and categorizing them as: computerized information (computer software and database), innovative properties (scientific and engineering R&D, mineral exploration, copyright and license costs, other product development, design and research expenses) and economic competencies (brand equity, firm-specific human capital, organizational structure). The fact that these assets are intangibles does not imply that access to them is free, nor that some of them are provided by nature.

From the I-O perspective, intangible assets are provided mainly by certain economic sectors. As a result, intangibles can be regarded as intermediate products and services in the inter-industry trade. Indeed, similar to the treatment of all other tangible intermediate inputs, intangibles are also included in the flow of global trade among different industries in different countries. Accounting for intangibles as intermediate inputs within an I-O framework is the main novelty of the GLOBALINTO Intangibles I-O database.

Building on the aforementioned concepts, the GLOBALINTO Intangibles database is based on a 2-digit NACE Rev.2 sector inputs approach, covering both the inter-sector and inter-country trade of utilities. The dataset is constructed at the industry level, based on production input data from those sectors that produce intangibles. Specifically, the database covers 56 sectors and the overall economy in the EU-28 countries. Its construction is based on the 2016 release of the WIOD. The sectors that are considered producing intangibles are J62-J63 (Computer programming, consultancy and related activities; Information service activities), M72 (Scientific research and development), M73 (Advertising

³ Henceforth, WIOD.

and market research) and N (Administrative and support service activities). Moreover, the GLOBALINTO I-O Intangibles database provides estimations regarding sectoral export activities, sectoral productivity and sectoral productivity performance relative to the world, as well as statistics related to R&D investment from Eurostat Structural Business Statistics and National Accounts. The data for 56 sectors are classified according to the International Standard Industrial Classification revision 4 (ISIC Rev. 4), which is consistent with the NACE Rev.2 industry classification. The tables adhere to the 2008 version of the SNA. We contribute to the emerging field of approximating and quantifying the impact of intangible inputs in an industry's production cycle by introducing a higher level, 2-digit sector analysis of the inter-sector and inter-country input and output flows of their utilities. The study of intangible inputs in combination with various statistics regarding investment in Research and Development (R&D) allows us to successfully approximate and quantify the impact of intangibles on a sector's activity. Moreover, using trade statistics and further study of inter-industry relationships, we are able to map the intangibles trade between countries.

The data used in the econometric estimations are country-level data that cover the period 2000-2014 for all EU-28 countries: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Great Britain, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden.

3.2. Description of the GLOBALINTO database

The GLOBALINTO Intangibles database is divided into two categories of data and indicators: sector inputs (Inputs side) and sector outputs (Outputs side).

Intangible sector inputs (at current prices)

Based on the I-O concept of WIOD and the categorization of intangibles introduced by CHS (2005), we approximate intangible assets as production inputs *made* in the following NACE Rev.2 sectors:⁴

- J62-J63: Computer programming, consultancy and related activities; Information service activities;
- M72: Scientific R&D;
- M73: Advertising and market research; and
- N sector: Administrative and support service activities.

Intangible inputs are produced in these sectors in 43 countries (all EU members included) and the rest of the world (RoW) and are used by 56 NACE Rev.2 (2-digit) sectors in each EU country, during the period 2000-2014. Overall country inputs, per category of intangibles in each year, are also provided. Moreover, the database includes aggregates of intangible inputs imported from BRIC economies (Brazil, Russia, India and China), the euro area and the EU-28.

Sector outputs (at current prices)

The database includes statistics on the share of production that is absorbed from exports for 56 NACE Rev. 2 sectors (2-digit), in each EU country. Exports are classified into five categories, with respect to usage, following the classification in the I-O tables of WIOD:

- Exports used as intermediate inputs;
- Exports used for household consumption;
- Exports to non-profit organizations serving household consumption;
- Exports used for government consumption; and
- Exports pertaining to gross fixed capital formation.

⁴ Referring to the CHS (2005) framework, the intangible assets from these sectors cover software, R&D input, organizational capital and branding.

These exported goods are produced in the EU-28 countries and exported into 42 countries (all EU members) and the rest of the world (RoW), for the period 2000-2014. The database also includes aggregates for sector intra- and extra- EU exports per usage, with an emphasis on the exports of intermediate inputs. Especially regarding exports of intermediate inputs, the database includes data for sectors producing intangibles. This fact enables the tracing of value chains of intangibles. In addition, we provide data regarding sector productivity, approximated by the ratio of value added to total output (at current prices) and an all-sectors (total economy) estimate. The database also includes an indicator for each sector's performance relative to the average sector productivity globally.

R&D sector inputs and outputs

Apart from the R&D production of the sector M72, firms from all sectors invest in R&D from in-house or joint R&D activities. These are not measured through the production of M72, but rather are estimated at the sectoral level (and ultimately national level) from various surveys, on an ad-hoc basis (e.g. the Community Innovation Surveys). Therefore, we need to distinguish between the two and capture this significant part of business R&D that is produced from all sectors of the economy. Two indicators regarding R&D inputs are included in the database (retrieved from Eurostat SBS):

- ratio of R&D spending to output (current prices): data cover 37 NACE Rev.2 sectors (2-digit) from all EU member states for the period 2007-2013; and
- ratio of R&D personnel to total employment: data cover 37 NACE Rev.2 sectors (2-digit) for the period 2008-2014.

Furthermore, in terms of R&D output and as a proxy for each sector's R&D activity, we have included:

- Patent applications to the European Patent Office: data cover 19 2-digit NACE Rev.2 sectors from all EU members for the period 2000–2013.

After consolidating all of the above, we have calculated a wide set of input and output variables, such as i) sector imports of intangibles, per type of intangible and per country of origin; ii) domestically purchased intangibles, per type of intangible; iii) share of sector exports to global sector exports, per destination and per use; and iv) share of exports to sector output, per use; etc. The full list of variables included in the database can be found in Appendix A2.

4. Methodology

4.1. Model specification

Our research aims to assess the relationship between intangible inputs, GVC participation and their combined effect on a country's productivity performance. To this end, the model specification is designed to explain a country's productivity performance as a function of the density of intangible inputs in its production, participation in the GVC, investment in R&D, expenditure in Education (intended as government actions towards improving productivity) and technological development. A similar approach was implemented in Lee et al. (2018), while studying the linkage between local innovation systems and GVC backward participation (i.e. the share of foreign value added to gross exports).

The empirical approach hereby used includes two model specifications: equation (1) studies the direct linkage between GVC participation and country productivity performance; equation (2) – the augmented version – evaluates the combined effect of intangible inputs and GVC participation on country performance. The two equations take the following form, with all variables linearized by taking their natural logarithm (\ln):

$$(1) \ln(\text{Perform})_{c,t} = \alpha_c + \beta_1 \ln(\text{Intan})_{c,t} + \beta_2 \ln(\text{GVC})_{c,t-1} + \beta_3 \ln(\text{GFCFX})_{c,t-1} + \beta_4 \ln(\text{R\&D})_{c,t-1} + \beta_5 \ln(\text{Edu})_{c,t-1} + \beta_6 \ln(\text{T}^2)_{c,t} + \delta_t + \varepsilon_{c,t}$$

$$(2) \ln(\text{Perform})_{c,t} = \alpha_c + \gamma_1 \ln(\text{Intan})_{c,t} + \gamma_2 \ln(\text{GVC})_{c,t-1} + \gamma_3 \ln(\text{GFCFX})_{c,t-1} + \gamma_4 \ln(\text{R\&D})_{c,t-1} + \gamma_5 \ln(\text{Edu})_{c,t-1} + \gamma_6 \ln(\text{T}^2)_{c,t} + \gamma_7 [\ln(\text{Intan})_{c,t} * \ln(\text{GVC})_{c,t-1}] + \delta_t + \varepsilon_{c,t}$$

Where $\ln(\text{Perform})_{c,t}$ stands for (the logarithm of the) country (c) total productivity performance in year t , $\ln(\text{Intan})_{c,t}$ accounts for the intangible inputs used in the production and $\ln(\text{GVC})_{c,t-1}$ for the country's participation to the GVC in period $t-1$. Equation (2) introduces the abovementioned interaction effect as product of $(\text{Intan})_{c,t}$ and $(\text{GVC})_{c,t-1}$.

As additional control variables, $\ln(\text{GFCFX})_{c,t-1}$ stands for other investments in physical capital, $\ln(\text{R\&D})_{c,t-1}$ for the share of gross domestic expenditure in R&D (GERD) on gross domestic product (GDP), $\ln(\text{Edu})_{c,t-1}$ for investment in education, and $\ln(\text{T}^2)_{c,t}$ for technological improvements occurring over time. Lastly, $\varepsilon_{c,t}$ represents the error term, δ_t the time fixed effect and α_c the country specific intercept, as the two equations are estimated using the fixed effects technique.

The following section presents the rationale of the chosen variables.

4.2. Description of the variables

The dependent variable of both equations, Country Total Productivity Performance (Perform) $_{c,t}$, is obtained from the GLOBALINTO Intangible database. Following suggestions by Cobbold (2003), performance at country level is measured by the ratio of productivity (value added to total output) of all sectors of a country, divided by the same productivity measure for all sectors globally. This dependent variable allows the evaluation of a country's productivity performance relative to the rest of the world and, thus, can be interpreted as measure of international competitiveness of country c in year t .

The independent variable $(\text{Intan})_{c,t}$ accounts for the intangible inputs used in the production, and it is defined as the share of intangible inputs (both domestic and imported) in total consumption of intermediates for production purposes (materials, energy and services). To proxy all the other types of investments in physical capital, the variable $(\text{GFCFX})_{c,t-1}$ is used. It is defined as the share of gross fixed capital formation (henceforth, GFCF) in total output. For the calculation of the relative indicator at country level, the needed data for all sectors of the economy were retrieved from the WIOD. This variable accounts for the GFCF of country c in year $t-1$, and thus the assumption made is that the investments return on productivity with one period lag. This appears to be the case because GFCF includes investments in (mostly physical) assets that are expected to affect performance in the long term, rather than intermediate inputs (as for the variable Intan) immediately entering the production cycle and affecting productivity performance.

Accounting for GVC participation, the indicator hereby chosen among the various methods revised is that of "value added exports" (VAX-D, as in Johnson and Noguera (2012), Los et al. (2016) and Los and Timmer (2018). VAX-D is calculated using the hypothetical extraction method on international I-O tables, and it includes domestic value added incorporated in exports for direct use (thus encompassing both intermediate and final consumption). The variable $(\text{GVC})_{c,t-1}$ in equations (1) and (2) is the ratio of VAX-D to gross exports at country level. The VAX-D measure appears to fit well the main purpose of this study, which is to address the combined effects of intangible inputs and GVC participation in the value-generation process of a country. Given this goal, the focus is shifted toward the impact of intangible inputs on DVA and how it is incorporated into gross exports (forward-participation orientation). To that end, the ratio of VAX-D to gross exports is a more relevant variable than the share of DVA in foreign exports, as the former includes all DVA exported and used in a foreign country (both for domestic direct use as well as for exports to a third country).

The interaction term between the proxy for intangible inputs $(\text{Intan})_{c,t-1}$ and the GVC participation measure $(\text{GVC})_{c,t-1}$ used in equation (2) aims at assessing the main research hypothesis of the complementary effect of intangible inputs and GVC (forward) participation. Following Brambor et al. (2006), this term is symmetric with respect to the interacting variables and does not capture a causal relationship between them.

The term $(R\&D)_{c,t-1}$ controls for the share of gross domestic expenditure in R&D (GERD) on gross domestic product (GDP), and it is retrieved from Eurostat. Such a control variable appears necessary, because, since the 2008 revision of the System of National Accounts (SNA), expenditures on research and development (R&D) are recognized as production of an asset instead of intermediate consumption, thus contributing to the country's gross fixed capital formation. In this sense, the proposed R&D control has a different nature compared to the intangible inputs captured by the variable *Intan* (investments rather than intermediate inputs), and a different source as it includes public R&D spending that is not accounted for in a country's gross fixed capital formation.

To better proxy investments in education, the variable $(Edu)_{c,t-1}$ is included in the model specification. This variable is the share of general government expenditure in education in total government expenditure, retrieved from Eurostat. The wide recognition that a country's education level is a significant source of its productivity is the rationale for the inclusion of this control variable (see e.g. Jorgenson and Fraumeni (1993), Jorgenson et al. (2018), Psacharopoulos and Patrinos (2004)). And the assumption made is that the investment will show returns in productivity with one period lag, following the suggestion of Psacharopoulos and Patrinos (2004) that investment in human (education) and physical (fixed) capital affect productivity in a similar manner.

The final term $(T^2)_{c,t}$ accounts for technological improvements occurring over time. Following the argument of Baldwin and Yan (2016) that technological improvements over time highly affect industrial productivity, we hereby proposed the proxy variable T^2 , with $T = 1, 2, \dots, 15$, counting in chronological order the years 2000-2014 covered in the sample. The quadratic form included in the model specification proxies the high sensitivity of intangible assets to the evolution of technology.

5. Descriptive Statistics

Following the model specification and definition of the variables presented in the previous subsection, Table 1 below presents the descriptive statistics for our dependent and main explanatory variables (i.e. the share of intangible inputs to total intermediate consumption and GVC participation proxy) in three reference years (2000, 2007 and 2014). Figure 1 displays the time series pattern of the main explanatory variables in the 2000-2014 period.

In terms of sector productivity (variable *Perform*), the top-performing countries are Greece, Cyprus, Lithuania, France, Great Britain and Sweden, exhibiting steady high performances in the current time span, with values no lower than 1.00 (Sweden in 2007).⁵ Time wise, all the EU-28 members show a decline in their performance in 2007 (except Belgium, Luxembourg and Malta) in response to the global financial crisis. Conversely, the values in 2014 capture the economic recovery and the productivity performance approaching the pre-crisis levels.

The second group of columns of Table 1 presents the share of intangible inputs in the production cycle of the EU-28 member states (*Intan*). The most-intensive intangible users in the EU are Ireland, Malta, Great Britain, France, the Netherlands and Luxembourg; respectively, these countries show values of intangible inputs over total intermediate consumption in 2014 of 25%, 16%, 13%, 12%, 12% and 11%. Over time, intangible inputs exhibit a relatively steady upward trend from 2000 to 2014 for most of the EU-28 members, unaltered from the global financial crisis. This finding is in line with the trend on intangible capital deepening discussed in Roth (2020). The sharp increase in the use of intangibles in 2014 for the majority of EU-28 is an indication of the European economies shifting their production strategies along the production chain, aiming at a better position and maximizing their respective gains and revenues in the GVCs. The jump is particularly remarkable in Ireland, for instance, which increased its share of intangible inputs from 18% in 2000 to 25% in 2014.

⁵ This result, at least for Greece and Cyprus, should be treated cautiously. Due to the significant decrease of employment in the examined period, the improvement in this trend may simply indicate a rationalization in the production and not actual productivity gains.

Table 1

Sector productivity performance relative to sector productivity globally (all sectors estimate), share of intangible inputs (domestic and imported) to total intermediate consumption and VAX-D as a share of gross exports for the EU-28 countries in 2000, 2007 and 2014

Country	Sector productivity (<i>Perform</i>)			Intangible inputs (<i>Intan</i>) – as %			VAX-D on gross exports (<i>GVC</i>) – as %		
	2000	2007	2014	2000	2007	2014	2000	2007	2014
AUT	1.05	1.01	1.03	7.39	8.14	8.49	68.41	63.19	60.95
BEL	0.85	0.90	0.94	7.82	8.37	8.63	55.15	52.85	50.25
BGR	0.86	0.79	0.88	3.95	4.09	4.33	64.26	52.20	56.87
CYP	1.16	1.12	1.15	4.21	3.81	4.41	65.45	71.32	68.89
CZE	0.82	0.79	0.82	4.70	5.58	5.75	64.01	53.27	49.48
DEU	1.06	1.01	1.06	10.44	10.15	10.74	74.27	70.09	68.93
DNK	1.08	1.01	1.06	8.47	9.77	10.11	65.69	58.67	59.30
EST	1.07	0.90	1.06	5.12	5.68	7.21	68.24	67.81	65.19
ESP	0.94	0.90	0.92	6.28	6.13	6.79	62.14	57.90	52.43
FIN	1.00	0.93	0.98	6.31	7.34	8.60	70.41	65.30	60.93
FRA	1.10	1.04	1.09	14.75	14.94	12.10	71.40	68.97	68.01
GBR	1.10	1.05	1.09	12.34	12.48	12.53	75.93	75.73	77.10
GRC	1.21	1.12	1.20	5.34	5.23	4.31	77.60	72.93	64.73
HRV	1.08	0.97	1.07	2.93	4.05	5.74	69.55	65.21	67.56
HUN	0.89	0.86	0.91	6.12	7.49	6.90	47.16	44.52	43.53
IRL	0.97	0.85	0.98	17.77	18.20	25.18	55.01	52.69	48.56
ITA	1.03	0.94	1.02	8.52	8.82	8.39	74.37	70.33	70.07
LTU	1.11	1.05	1.10	3.01	4.69	4.11	74.44	66.49	59.88
LUX	0.60	0.66	0.64	5.72	6.78	11.10	41.87	35.68	32.19
LVA	0.94	0.89	0.93	5.17	6.20	7.79	72.95	68.37	65.68
MLT	0.71	0.76	0.70	11.91	14.39	15.57	40.39	37.07	33.30
NLD	1.03	1.00	1.02	12.47	12.85	11.55	66.94	62.27	60.21
POL	0.96	0.89	0.96	5.25	5.31	5.55	69.03	61.08	65.14
PRT	1.06	0.97	1.06	6.62	7.10	7.46	65.59	64.26	62.12
ROU	0.97	0.96	0.95	2.05	4.34	5.27	70.02	69.08	68.38
SVK	0.87	0.82	0.86	3.74	3.52	4.69	56.47	46.81	47.04
SVN	0.99	0.92	0.98	5.68	6.56	8.22	62.89	56.96	58.31
SWE	1.09	1.00	1.08	10.32	10.15	9.26	68.70	66.68	67.99

Note: AUT = Austria, BEL = Belgium, BGR = Bulgaria, CYP = Cyprus, CZE = Czechia, DEU = Germany, DNK = Denmark, EST = Estonia, ESP = Spain, FIN = Finland, FRA = France, GBR = Great Britain, GRC = Greece, HRV = Croatia, HUN = Hungary, IRL = Ireland, ITA = Italy, LTU = Lithuania, LUX = Luxembourg, LVA = Latvia, MLT = Malta, NLD = the Netherlands, POL = Poland, PRT = Portugal, ROU = Romania, SVK = Slovakia, SVN = Slovenia, SWE = Sweden.

Source: Authors' calculations based on the GLOBALINTO Input-Output Intangibles database (*Perform* and *Intan*) and WIOD (*GVC*).

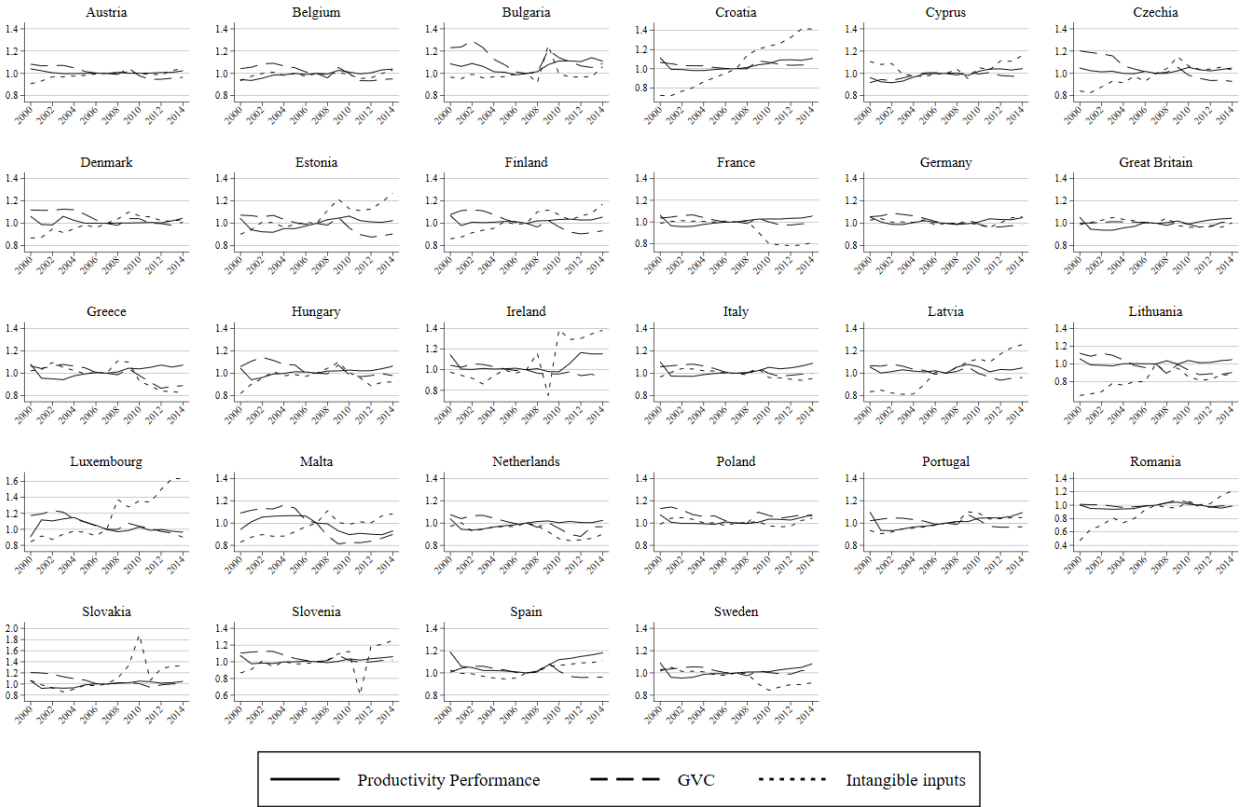
The third group of columns of Table 1 (variable *GVC*) shows that the majority of European economies incorporate high shares of domestically-produced value added in their gross exports, with Great Britain and Germany presenting the highest shares (respectively 77% and 70% in 2014). High shares of domestic value added embodied in gross exports constitutes a sufficient indication of forward participation in GVCs for the majority of European economies. Over time, the share of domestic value added in exports appears to be on a slightly declining trend from 2000 to 2014 for the majority of EU-28 members, highlighting the constant increase of the foreign value-added share and, by extension, providing evidence of backward participation in GVCs for these economies. Luxembourg and Malta, in particular, appear to incorporate the lowest shares of domestic value added in their exports, 33% and 32% respectively in 2014. This fact can be explained by a stronger orientation towards backward

participation in GVCs for the two small economies. Similar to the trend of sector productivity, several European economies experience a pattern of significant drop in their domestic shares in 2007 that is followed by an increase in 2014.

Table A1 in the appendix provides the full summary statistics of the variables used in the regressions.

Figure 1

Sector productivity performance relative to sector productivity globally (all sectors estimate), share of intangible inputs (domestic and imported) to total intermediate consumption and VAX-D as a share of gross exports for the EU-28 countries time series pattern for the period 2000-2014



Note: Productivity performance refers to the variable “Sector productivity performance relative to sector productivity globally (all sectors estimate)”, GVC to the variable “VAX-D as a share of gross exports” and Intangible inputs to the variable “share of Intangible inputs (domestic and imported) to total intermediate consumption”.

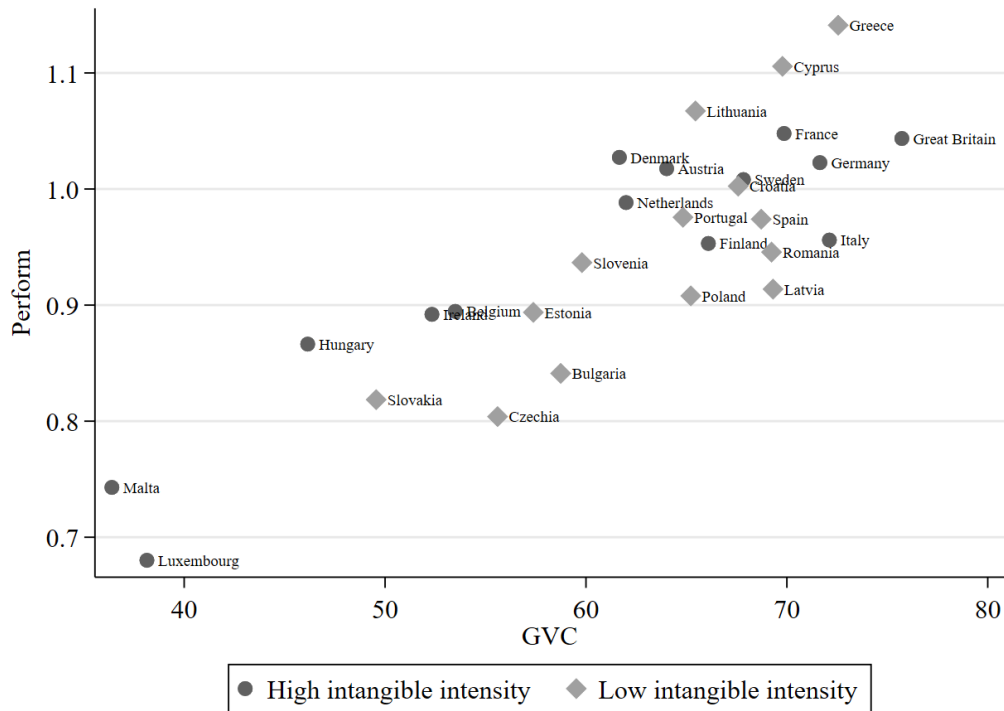
Source: Authors’ calculations on GLOBALINTO Input-Output Intangibles database and WIOD.

Figure 2 presents a scatterplot of the average levels of *GVC* and *Perform* in the timeframe 2000-2014, differentiating between high and low intangible-intensity countries. Consistent with the literature, higher *GVC* participation is linked to higher productivity in the EU-28 countries. Six out of the ten best performing countries belong to the euro area. In addition, these six euro area countries (Greece, Cyprus, Lithuania, France, Germany and Austria) present higher *GVC* participation levels. The econometric results presented in the following section will attempt to further explore and explain these trends, running separate regressions for the full sample, euro area and non-euro area countries.

The last insight from Figure 2 is the position of Malta and Luxembourg: the two countries present relatively low *GVC* (forward) participation levels, relatively low productivity performance but among the highest shares of intangible inputs (Table 1).

Figure 2

Scatterplot between domestic VA incorporated in gross exports (for direct use) and productivity performance in EU-28 countries, average of the period 2000-2014



Note: *Perform* refers to the variable “Sector productivity performance relative to sector productivity globally (all sectors estimate)”, and *GVC* refers to the variable “VAX-D as a share of gross exports”. Countries are differentiated between high and low intangible intensity based on their respective shares of Intangible inputs (domestic and imported) to total intermediate consumption.

Source: Authors’ calculations on GLOBALINTO Input-Output Intangibles database and WIOD.

6. Econometric Results

The selected method of estimation in this paper is Fixed Effects (FE) panel regression with Driscoll and Kraay (1998) standard errors, as they are robust to heteroscedasticity, autocorrelation and cross-sectoral dependence. Driscoll-Kraay (DK) robust standard errors were implemented in the panel regressions as suggested by Hoechle (2007) in order to account for the presence of cross-sectoral dependence, as identified using Pesaran (2004) diagnostic tests. FE models were selected in preference to Random Effects estimation after the implementation of a panel-robust Hausman test (Hausman (1978)), as proposed by Wooldridge (2010). The choice of using the Fixed Effects estimator is in line in particular with OECD (2013a), Tajoli and Felice (2018), Vrh (2018) and Jona-Lasinio et al. (2019).⁶

The regression results for both model specifications are presented in Table 2. Columns (1) to (3) present the results for model 1. In this specification the main driver of productivity performance for the EU-28 sample is GVC (forward) participation (1), with a highly significant coefficient of 0.44. This result remains significant once splitting the EU-28 sample into euro area (2) and non-euro area (3) countries, with the former showing a higher coefficient than the latter (0.51 and 0.45, respectively). Intangible inputs are not significant in model 1. This result is hereby explained by the non-inclusion of the cross effects of intangibles with other factors, as discussed below. Furthermore, within the scope of studying intangibles as production inputs, their respective share in total intermediate consumption cannot in fact constitute a sufficient driver for productivity performance as it is relatively low compared

⁶ Panel-robust Hausman test and Pesaran’s diagnostic test results are included in Appendix 2.

to the rest of the inputs consumed as intermediates. This fact underlines the pivotal role of the combined effect of intangible inputs and (forward) GVC participation. The remaining control variables in columns (1) to (3) do not show any significant pattern, suggesting the fact that within the present I-O framework, and especially for education and GFCF, the costs of the investments exceed their productivity return in the short term. Interestingly, the technology evolution term T^2 is significant only for the non-euro area countries, most of which are fast growing, catching-up *factory* economies (Poland, Romania, Bulgaria, Czech Republic, etc.).

Table 2
Determinants of productivity performance: Fixed effects regressions with DK robust standard errors

	Model 1			Model 2		
	(1) Full sample	(2) Euro area	(3) Non- euro area	(4) Full sample	(5) Euro area	(6) Non- euro area
Intan	-0.01 (0.02)	-0.01 (0.02)	-0.03 (0.02)	0.13*** (0.02)	0.17*** (0.02)	-0.01 (0.07)
GVC	0.44*** (0.03)	0.51*** (0.06)	0.45*** (0.04)	1.10*** (0.11)	1.26*** (0.07)	0.54 (0.53)
GFCFX	-0.01 (0.03)	-0.00 (0.03)	-0.01 (0.03)	-0.02 (0.02)	-0.01 (0.02)	-0.01 (0.04)
R&D	-0.00 (0.01)	-0.02 (0.03)	0.01 (0.02)	-0.00 (0.01)	-0.02*** (0.01)	0.01 (0.02)
Edu	-0.05* (0.02)	-0.11** (0.04)	0.07 (0.05)	-0.03 (0.02)	-0.08*** (0.02)	0.07 (0.05)
T^2	0.01 (0.02)	-0.01 (0.02)	0.05* (0.03)	0.08*** (0.02)	0.07*** (0.02)	0.06** (0.03)
Intan*GVC				0.25*** (0.04)	0.31*** (0.03)	0.03 (0.19)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	382	260	122	382	260	122
Adj. within R ²	0.56	0.55	0.72	0.62	0.65	0.72
Countries	28	19	9	28	19	9

Notes: *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level. Standard errors are reported in parentheses.

The introduction of the cross-effects variable in the second model specification has a significant impact on the estimations results, as shown in columns (3) to (6) for model 2. Most importantly, the joint term for intangible inputs and GVC (forward) participation is positive and statistically significant in the EU-28 full sample (4). This fact confirms our original research hypothesis that the combined effect of intangibles and GVC participation has a positive impact on country performance. Moreover, euro area countries (5) show a coefficient higher than the EU-28 average (respectively, 0.31 against 0.25), while the combined effect of (forward) GVC participation with higher shares of intangible inputs does not significantly affect the non-euro area countries (6). The coefficients suggest that there is a - ceteris paribus - 0.25 percentage point increase in productivity performance (0.31 in the euro area) for each percentage point increase in GVC participation combined with high shares of intangible inputs.

Introducing the interaction term changes the effect of intangible inputs to country productivity performance, which is found to be positive and statistically significant in columns (4) and (5) with coefficients, respectively, of 0.13 and 0.17. Furthermore, the positive effect of participation in GVCs has a bigger magnitude in columns (4) and (5) in comparison to (1) and (2). This finding, in combination with the previous results, hints at a “virtuous circle” in the production process: an increase in intangible

inputs enhances the value generation process of a country (i.e. its productivity), resulting in a more valuable (forward) participation in GVCs, which itself constitutes a motive for more investment in intangible assets. A more intense participation in GVCs for a country translates into better performance.

These results are in line with the firm-level literature and the famous “smiling curve” concept presented in Section 2, as well as with the findings from OECD (2013b, 2013a), Durand and Milberg (2019), Vrh (2018) and Jona-Lasinio et al. (2019). The results suggest that euro area economies are in fact intangible-intensive headquarter economies in a GVC environment, targeting economic activities in the lucrative intangible-intensive parts of the chain where the high shares of value added are translated into higher productivity growth (Baldwin 2013).

Interestingly, technological development also appears to be a significant driver for productivity in Model 2, in line with Baldwin and Yan (2016).

In contrast to the above, the non-euro area EU members (6) appear to not benefit from the combined effect of intangibles and GVC participation in terms of productivity performance. In fact, the main drivers for productivity growth in those economies are technological development and GVC participation (3, 6). This finding is in line with the concept of *factory* economies established by Baldwin (2013), where the rest of the EU members (mostly Eastern European economies) undertake industrial production-related activities.

7. Conclusions

This paper studies the economic effect of a country’s participation in global value chains (GVCs) combined with having a high share of intangible inputs on the productivity performance of an EU-28 country sample over the years 2000-2014. In order to conduct this study, we used the GLOBALINTO Input-Output Intangibles database, which covers the 28 countries of the European Union in the years from 2000 to 2014. In comparison to the existing available sources (INNODRIVE, INDICSER, INTAN-Invest and EUKLEMS), this new dataset offers a novel viewpoint on intangibles, considering them as production inputs in an I-O framework. Based on the 2016 release of the WIOD (Timmer et al. (2015)), the GLOBALINTO I-O Intangibles database provides data on the inter-sectoral and inter-country flow of intangible inputs. The sectors considered as producing intangibles are J62-J63 (Computer programming, consultancy and related activities; Information service activities), M72 (Scientific research and development), M73 (Advertising and market research) and N (Administrative and support service activities).

Our empirical analysis is based on the fixed effects estimation technique in order to assess our main research hypothesis. Basing the measurement of (forward) GVC participation on the value-added exports index (VAX-D) introduced by Los and Timmer (2018), this paper finds three main empirical results:

- i) (Forward) GVC participation has a general positive effect on a country’s productivity performance.
- ii) Intangible inputs are significant enhancers of productivity performance only when an interaction term with GVC participation is introduced (model 2), pointing toward a “virtuous circle” of higher shares of intangible inputs and GVC participation.
- iii) Euro area countries show higher positive effects than the EU-28 average, confirming their status as headquarter economies participating in highly profitable intangible segments of the GVC.

Findings (i) and (iii) are in line with existing research, in particular from Baldwin (2013), Fagerberg et al. (2018) and Jona-Lasinio and Meliciani (2019), while finding (ii) appears to make a novel contribution to the literature. Potential limitations to our results come from the country-level aggregation of data, which may overweight smaller-sized and outlying EU countries, as in the case of Malta and Luxembourg discussed in Section 5. Future research using disaggregated, industry-level data and the proper integration of industry-specific characteristics would better address this issue.

The aforementioned findings offer an initial basis for a discussion on industrial policy and related implications. Intangible assets and inputs play a pivotal role in the successful participation in GVCs; thus, policies that foster the production, accumulation and development of intangibles appear necessary for the future of European firms. This fact is especially evident in euro-area economies, which seem to

follow the characteristics of headquarter economies. Nevertheless, industrial policy development should also focus on country and industry heterogeneity, as in the case of the non-euro area economies, where the main driver of productivity is in fact GVC (forward) participation. The identification of intangibles and GVC participation as the main components of productivity performance should urge European industrial policymakers to formulate and implement policy agendas that enable the industrial transformation towards intangible-intensive, global economies that are supported by modern legislative frameworks (e.g. in intellectual property rights) and adequate levels of public investment in human capital growth (in term of both skills and quantity). The establishment of well-functioning formal and informal institutions is a related crucial step in the development and growth of intangibles where positive network externalities, interoperability and flows across economies promise substantial economic benefits (Lampel et al. 2020, Roth 2020, Thum-Thyssen et al. 2019).

At the present time, EU policies on intangibles are still incomplete, imbalanced and highly differentiated across countries, and lack a common framework that is able to encompass the full specter of intangibles. The major policy gaps that emerge are closely related to the absence of a consensus on the measurement of intangibles at the micro and macro levels (Lampel et al. 2020). Recent studies focus on the quantification of intangible investment without taking into account the aspect of intangible trade and inter-country and intra-industry transactions. The development of the GLOBALINTO I-O Intangibles database aims to tackle this missing link in quantifying the impact of intangibles. However, the mapping of industrial relations in terms of intangible flows needs to be supported by a proper policy framework in which intangibles are not only treated as an output of industrial activity, but also as factors of production. In addition to these observations, there are no systematic policies regarding data acquisition, dissemination and protection. These policies could shape a common basis regarding the measurement of intangibles that could be translated into effective policymaking.

The global economy is experiencing the initial effects of the Fourth Industrial Revolution, where the globalization of production and transformative technological development is rapidly reshaping the economic environment and allowing the quick and efficient dissemination of knowledge and information across countries. In this context, the general interdependence at the macro, sectoral and geographical level is a key element on which European economies can build their arsenal, and the rapid technological developments highlight the major significance of intangible assets. As a result, a significant need arises for policies that promote industry and country cooperation in terms of diffusing intangibles. The European Commission should undertake the crucial initiative of beginning the discussion around an EU intangibles industrial policy framework. This framework should involve guidelines at national level that align national intangible development and diffusion policies under a common umbrella and a unified measurement framework, towards productivity and economic growth targets based on the concept of the regionalized EU value chain, providing benefits to all member states. Relevant implications for data dissemination and protection should also be taken into account. Furthermore, it is of the utmost importance for the Commission to engage all member states in the discussion of this unified policy framework in order to fully respect each member state's policy agenda and to create an environment of mutual trust between all actors involved.

The discussion of a unified industrial policy framework creates an intriguing challenge: both regional and European policymakers should align their agendas towards the construction of the proper mechanisms, tools and infrastructure along with the suitable legislative framework that will enable EU economies to upgrade their already regionalized production network. Within this network, intangible flows will enable faster transfers of technology, innovation and knowledge, which can translate into maximum gains in terms of productivity performance for each member state. In order to properly implement this ambitious project, relevant studies at the country and industry level should be conducted in order to properly assess country- and industry- specific characteristics regarding the impact of intangibles in productivity performance within the global production network environment.

A1. Appendix: Correlation matrix and model specification test results

Table A1
Summary statistics, EU-28 2000-2014

	Mean	Standard Dev.	Min	Max
Perform	0.95	0.11	0.60	1.21
Intan Inputs (share of Total internal consumption)	0.08	0.04	0.01	0.02
GFCF (over total output)	0.11	0.02	0.05	0.20
VAX-D (share of gross exports)	0.62	0.10	0.30	0.79
R&D exp. (over GDP)	0.01	0.01	0.00	0.04
Edu exp. (over GDP)	0.12	0.02	0.07	0.19

Table A2
Correlation matrix of the variables used in the model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Perform (1)	1.000						
Intan (2)	-0.042	1.000					
GFCFX (3)	0.232	-0.329	1.000				
GVC (4)	0.737	-0.179	0.433	1.000			
R&D (5)	0.201	0.337	-0.110	0.087	1.000		
Edu (6)	-0.122	-0.115	0.112	-0.108	-0.214	1.000	
T ² (7)	0.147	0.086	-0.372	-0.217	0.149	-0.127	1.000

Table A3
Adjusted panel robust Hausman test results (based on Wooldridge's auxiliary regression)

	Model 1		Model 2	
	F- statistic	Prob.***	F- statistic	Prob.***
Test Summary	13249.03	0.00	13669.53	0.00

Notes: *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

Table A4
Pesaran's test for cross-sectional dependence results

	Model 1		Model 2	
	CD- statistic	Prob.***	CD- statistic	Prob.***
Test Summary	14.75	0.00	11.34	0.00

Notes: *Significant at the 10% level. **Significant at the 5% level. ***Significant at the 1% level.

A2. Appendix: List of calculated input and output variables included in the GLOBALINTO database

Input variables

- Sector imports of intangibles, per type of intangible and per country of origin
- Domestically purchased intangibles, per type of intangible
- Share of imported intangibles in global imports of intangibles, per type of intangible
- Share of euro area imported intangibles in sector's intangible inputs, per type of intangible
- Share of EU-28 imported intangibles in sector's intangible inputs, per type of intangible
- Share of BRIC economies' imported intangibles in sector's intangible inputs, per type of intangible
- Share of RoW imported intangibles in sector's intangible inputs, per type of intangible
- Share of domestically produced intangibles in domestic production globally, per type of intangible
- Share of intangibles in total intermediate consumption, per type of intangible and per origin (domestic & imported)
- Share of intangibles in output, per type of intangible and per origin
- Share of R&D expenditure in total output
- Share of R&D personnel in total employment

Output variables

- Value of sector exports, per destination (INTRA-EU & EXTRA-EU) and per use
- Share of sector exports in global sector exports, per destination and per use
- Share of exports in sector output, per use
- Share of exports in sector output, per use, performance relative to sector globally
- Value of sector exports to sectors producing intangibles, per use
- Share of sector exports of intangibles in global sector exports of intangibles, per destination
- Share of exports to sectors producing intangibles in sector output
- Share of exports to sectors producing intangibles in sector output, performance relative to sector globally
- Sector productivity (ratio of Value Added to total output per sector)
- Sector productivity, performance relative to sector productivity globally
- Patent applications to the European Patent Office per sector

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