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MICROPROD

Raising EU Productivity: Lessons from Improved Micro Data

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Supply and demand-oriented economic policies to boost robust growth in Europe –

Addressing the social and economic challenges in Europe

D1.3

Report on productivity and its development over time across European countries (and industries) using the new data

WP 1 – Firm-level data and productivity measurement

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Key word list

Productivity, Intangibles, Micro-Aggregated Data, Micro Data

Definitions and acronyms

Acronyms	Definitions
MDI	Micro Data Infrastructure
MMD	Micro Moments Database
NSI	National Statistical Institute

1. Introduction

1.1. General context

The surge and current disruptions of global production networks, innovation in production technologies and in general new modes of generating economic output are receiving increasing attention by researchers, policy makers and the public. Heterogeneity in firms' ability to take advantage of the new production possibilities requires reliable and cross-country harmonized microdata. Using newly combined firm-level data, MICROPROD aims to better understand the micro- and macro-level determinants of observed production and productivity patterns and improve productivity measurement.

1.2. Deliverable objectives

Work Package 1 (WP 1) experiments with new data and techniques to broaden our understanding of the slowdown of productivity growth and heterogeneity in firm productivity both within and across countries. As part of these experiments, we developed a prototype of a cross-country harmonized micro data infrastructure (MDI) in coordination with several National Statistical Institutes (NSI).

Deliverable 1.3 ("Report on productivity and its development over time across European countries (and industries) using the new data") documents the prototype MDI and showcases its potential in an analysis of the relationship between productivity and intangibles inputs.

2. Methodological approach

Various deliverables of MICROPROD experiment with new data and methods to purge productivity from biases due to systematic firm heterogeneity, for example in intangible capital, access to financing and access to global production networks (deliverables 1.4, 1.5 and 1.6).

Over the last three years, these insights, which result mostly from single-country studies, have been shared and disseminated via the existing CompNet infrastructure. In particular, key indicators related to intangibles and revised productivity concepts have been implemented in the cross-country harmonized CompNet Micro Moments Database (MMD). For each of the included indicators, the dataset features its aggregate and average level, but also provides information on the indicators' distribution and joint distributions at various levels of aggregation.

The CompNet dataset is built to generate a minimum common denominator of firm-level based variables, which are available for the greatest number of European countries: this creates a limit to the depth of the dataset given the uneven availability of firm level data across countries. As a complement to this database, we have therefore established at each pilot NSI a prototypical cross-country harmonized micro data infrastructure (MDI), which features the micro data necessary to replicate and expand the studies conducted in the experimental stage of MICROPROD in a cross-country setting. The infrastructure consists of a collection of linkable datasources related to the MICROPROD objective, as well as comprehensive metadata and pre-programmed modules and tools hosted at each NSI. The goal is to set up, in each country, a research infrastructure that allows common code code to be run at each site, while minimizing efforts for both the researcher and the statistical institutes. We provide resources and tools for metadata translation that harmonize the data across countries. The aim is to enable researchers to apply one research design to multiple sites, even if the details of the underlying datasets and technical infrastructure vary. To reduce NSI staff workload, we provide output documentation tools and obligatory disclosure routines that are accustomed to each country's confidentiality practice.

This report (i) describes the setups of both the CompNet Micro Moments Database and the Micro Data Infrastructure, and (ii) showcases their potential in an application on the relationship between intangibles and firm performance both on the aggregate and firm level.

3. Summary of activities and research findings

Previous research shows that firm-level information is pivotal to understand aggregate productivity development, as aggregate statistics mask substantial and re-enforcing firm heterogeneity (Bartelsman and Doms, 2000) and reallocation between firms influences aggregate productivity developments (Decker et al., 2017). The micro-aggregated CompNet datasets provide information on distributions of various indicators related to firm productivity and performance and are therefore suited to shed light on firm heterogeneity and dynamics within industries and across countries.

Moreover, the experimental studies conducted in Microprod show that our understanding of determinants of productivity and productivity measurement itself benefit from combining various data sources such as financial reports, administrative and survey data. Owing to various EU regulations and Eurostat model questionnaires, cross-country harmonized micro data sources are readily available in most EU countries. Harmonized definitions of variables and statistical units and unified firm coverage allow to conduct cross-country analyses using micro data. The MDI links various firm-level data sources related to firm performance, intangible inputs and global integration, and therefore provides an additional database for researchers to study the determinants of productivity and business dynamics using firm-level data across multiple countries.

In an application of both data sources, we find that productivity dispersion has increased over the last decade. However, while the most productive firms were the drivers of aggregate productivity growth in the last decade, we find productivity growth to be muted also in frontier firms in the most recent years.

At the same time, intangible inputs such as investment in intellectual property rights and use of information and communication technology are an increasingly important input to the firm's production process. We experiment with different proxies to capture various aspects of intangibles, ranging from intangible assets reported in the balance sheet to innovative activity. We find robust evidence that intangibles are positively correlated with firm performance as measured by profits, revenues and employment. However, we do not find evidence of a positive relation with average firm productivity, but with aggregate industry level productivity. At the same time, we find higher dispersion of productivity in industries that rely more on intangible inputs. This suggests higher volatility in returns to intangible assets, muting productivity gains from investing in intangibles on average.

Moreover, we show that intangibles are highly concentrated in the economy and positively related to product market concentration and markups over marginal costs, raising concerns of intangibles fostering market power (De Loecker et al., 2020; De Ridder, 2019; Bajgar et al., 2021). However, intangibles are characterized by scalability and low marginal costs, but involve high sunk costs and return volatility. Thus, the returns to such investments are skewed, with increasing size and price-cost markups for the successful firms and increases in concentration in industries. The paper does not provide conclusions whether the increased concentration and mark-ups harm competition and provide excess returns to total investment in intangibles.

We further find preliminary evidence that the effect of intangibles on firm market power may operate through the labor market channel, as we find a positive correlation of intangibles with profit concentration, but a negative correlation with average wage growth. However, we document a diverse picture between the Nordic countries and France and the Netherlands, where only the latter group experiences increasing profit concentration in time, pointing either towards differences in technology diffusion between firms or the regulatory environment.

4. Conclusions and future steps

This report summarizes the lessons drawn from experimenting with new data sources to improve our understanding of observed productivity patterns. Based on pilot studies with several National Statistical Institutes (NSIs), we set up a prototype Micro Data-Infrastructure (MDI) that allows cross-country comparative analysis of firm-level micro data and complements the micro-aggregated dataset supplied by CompNet. We showcase the potential of the data infrastructure in a study on the relation between intangibles and firm performance.

Our findings only provide initial evidence that by investing in intangibles firms increase the dispersion of future productivity outcomes. The returns to such investments are skewed, with increasing size and price-cost markups for the successful firms and increases in concentration in industries. This calls for more rigorous empirical analysis, both for determining the mechanism that associates intangibles with improved firm performance, but also on potential issues that the concentration of these assets might entail. In addition, the need for further cross country analyses in this field remains high, as country-specific regulatory frameworks may influence the degree of technology diffusion, thus encouraging technology adoption and creation across firms.

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Exploring Intangible Assets

Evidence from MDI and CompNet*

Eric Bartelsman[1], Mirja Haelbig[2], Sergio Inferrera[3], Filippo di Mauro[3] and Alessandro Zona Mattioli[1]

[1]Vrije Universiteit Amsterdam, Tinbergen Institute

[2]Halle Institute for Economic Research (IWH)

[3]CompNet

Abstract This paper explores the effects of intangible assets on firm-level productivity, firm dynamics and aggregate productivity. The paper starts with a brief overview of firm-level productivity developments from the CompNet database. Next, a more detailed overview is given of the development of a 'Micro Data Infrastructure' that will allow cross-country analysis of firm-level data on firms' inputs and outputs including a broad set of measures related to intangible assets. The paper concludes with an analytical exploration of various measures of intangible affect firm-level behavior, dynamics and market outcomes. Our findings are consistent with the story that by investing in intangibles firms increase the dispersion of future productivity outcomes. The returns to such investments are skewed, with increasing size and price-cost markups for the successful firms and increases in concentration in industries. The paper does not provide conclusions whether the increased concentration and mark-ups harm competition and provide excess returns to total investment in intangibles.

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Email: e.j.bartelsman@vu.nl (Bartelsman) a.zonamattioli@vu.nl (Zona Mattioli) mirja.haelbig@iwh-halle.de (Haelbig)

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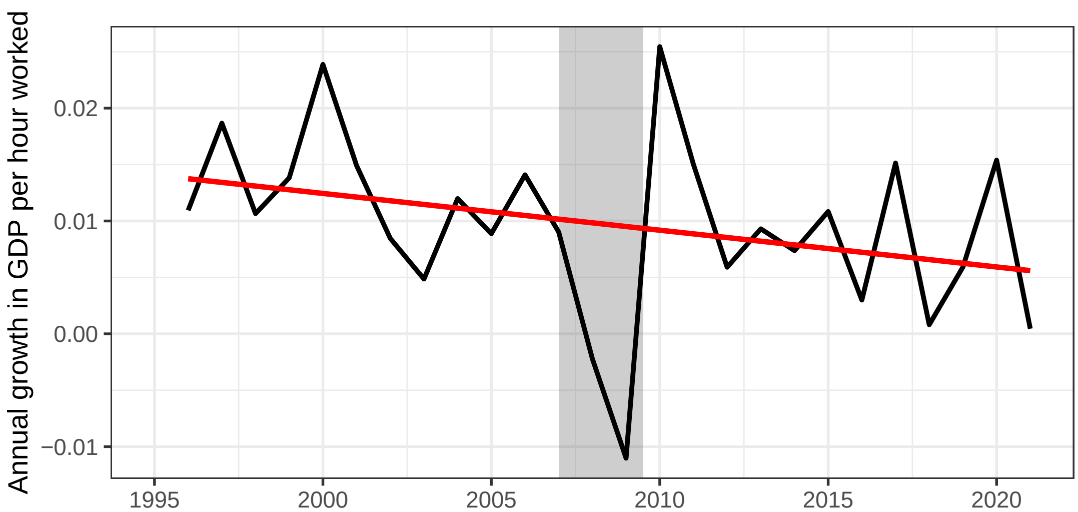
1 Introduction

Productivity is the key driver of a country's living standards, affecting output, employment and wages. Yet over the past decade, aggregate productivity grew at a fairly low and decreasing rate in most developed countries. Syverson (2017) estimates that labor productivity growth across the OECD countries fell on average by 1.2 percentage points per year between the periods, from 2.3 percent during 1995–2004 to 1.1 percent over 2005–2015. Figure 1 confirms that productivity growth in the Euro Area (EA19), herein measured as real GDP per hour worked, steadily decreased starting already before the Financial Crisis and approaches zero in 2021. At the same time, the economy experienced a phase of intense technological acceleration and deepening globalization of production, expected to bring large productivity gains through multiple channels. The absence of aggregate productivity gains despite these processes is referred to as 'productivity puzzle' or 'productivity paradox' (Acemoglu et al. 2014).

Figure 1: Annual growth rate in real GDP per hour worked in the Euro Area.



Notes: Annual growth rate in real GDP (PPP-adjusted, constant prices) per hour worked in the Euro Area (EA19). The red line depicts the linear trend, the shaded area the Financial Crisis. Source: OECD Productivity Database.

The literature has put forward several hypotheses for the observed productivity puzzle. One strand of literature argues that the full benefits of ICT and other new technologies are yet to unfold, as exploiting the full potential requires complementary investments and adjustments by both firms and workers (Brynjolfsson et al. 2021; Ark 2016). Another strand of literature argues that technologies introduced in the fourth industrial revolution are less path-braking and productivity enhancing than previous innovations. Moreover, ideas are getting increasingly harder to find and research productivity is declining (Bloom et al. 2020; Gordon 2015).

Not only sluggish within-firm technology adoption and creation might help explain the productivity puzzle, but also a slowdown of technology diffusion between firms. Andrews et al. (2015) finds that firms at the global productivity frontier are many times as productive as their laggard peers and that this gap is increasing. Similarly, Bahar (2018) show increasing productivity dispersion even in narrowly defined sectors, which is mostly driven by knowledge intensive industries. The decrease in knowledge diffusion across firms is directly related to the observed decline in business dynamism. New technologies might create barriers for firms as they imply high fix costs and therefore impede catching-up with the productivity frontier, who profit from increasing returns to scale (Akcigit and Ates 2021; Decker et al. 2017). This can lead to 'winner-takes-all' economics, discouraging non-frontier firms from investing in technology creation and adoption and hampering aggregate productivity growth as the process of creative destruction is distorted.

In addition, the *mismeasurement hypotheses* states that recent innovations and associated utility gains are not fully reflected in GDP due to a mismeasurement of official ICT prices (Byrne and Corrado 2017) and because intangibles are both inputs and outputs to the firm's production process and it requires 'traditional' production factors to accumulate unmeasured intangible capital (Brynjolfsson et al. 2021).[1]

Due to substantial and increasing differences in productivity between firms and across countries, studying the causes for the observed productivity slowdown requires comprehensive and cross-country comparable micro-based data. While many countries publish official productivity statistics providing information on aggregate productivity development, these aggregate statistics hide a lot of relevant variation at the micro-level. Statistical offices have only recently started to provide information on firm heterogeneity in the productivity statistics. Most notably, international research initiatives such as CompNet[2] have worked together with statistical offices to construct indicators that allow researchers to explore cross-country differences in dispersion and business dynamics.

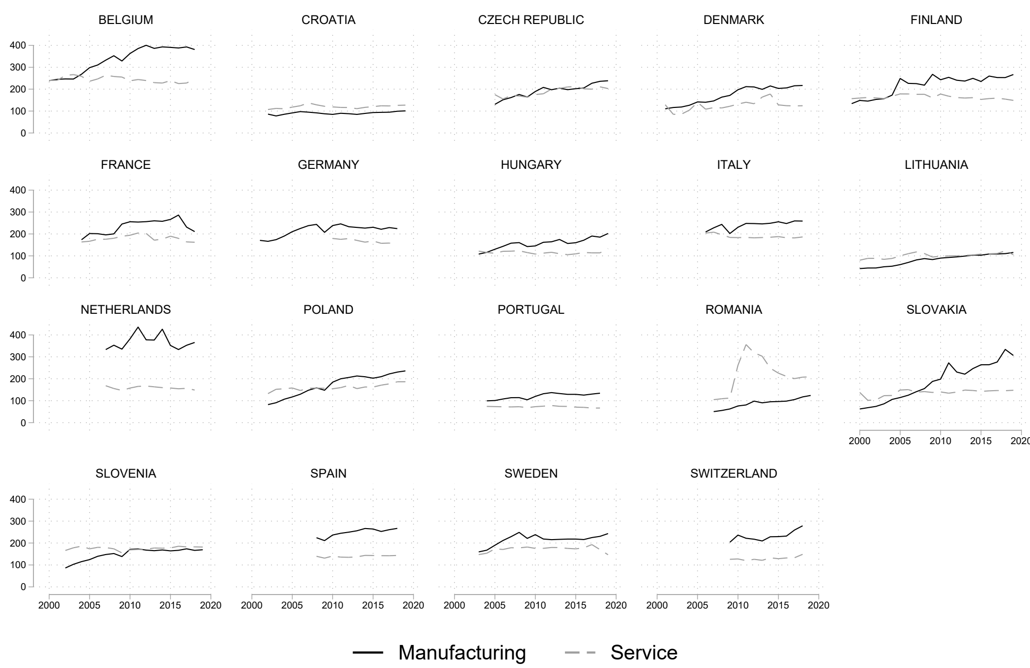
Productivity Development and Dispersion - Evidence from CompNet CompNet, a research initiative dedicated to study firm performance across the EU, collects and provides a micro-aggregated cross-country harmonized dataset. The distribution of different indicators of firm performance is available at different degrees of (industry) ag-

[1] Syverson (2017) however argues that mismeasurement alone cannot explain the observed productivity slowdown.

[2] https://www.comp-net.org/

gregation and for a total of 22 countries.[3] To study the sources of the productivity slowdown, within-industry and cross-country information is important. The literature finds substantial and stable differences in firm productivity even within narrow defined sectors (Bartelsman and Doms 2000). The large dispersion in firm size and productivity even within narrowly defined sectors implies that resource reallocation across firms can be productivity-enhancing. Moreover, even though productivity levels vary largely between sectors, productivity growth in the EU is mainly driven by intra-sector developments rather than by resource reallocation across sectors (Modery et al. 2021). Micro-founded datasets can shed light on changes in productivity that occur on the narrow sector levels.

Figure 2: Trends in Labor Productivity.



Notes: Aggregate labor productivity (PPP adjusted real revenue per person employed) in manufacturing and non-financial services (G-J & L-N) firms with more than 20 employees by country. Source: CompNet 8th vintage.

In addition, within sectors, micro data based cross-country studies reveal substantial heterogeneity in productivity and technology adoption (Andrews et al. 2018; Bartelsman et al. 2018; Hagsten and Kotnik 2017). Cross-country research can provide insights on institutional frameworks and infrastructure that may support innovation and the adoption and diffusion of new technologies. Thus, from a policy perspective it is essential to know which types of firms in which sectors are driving technology adoption and productivity

[3] See chapter 2.1 for further information on dataset content and construction.

improvements and how changes in institutional factors affect adoption and growth across different types of firms.

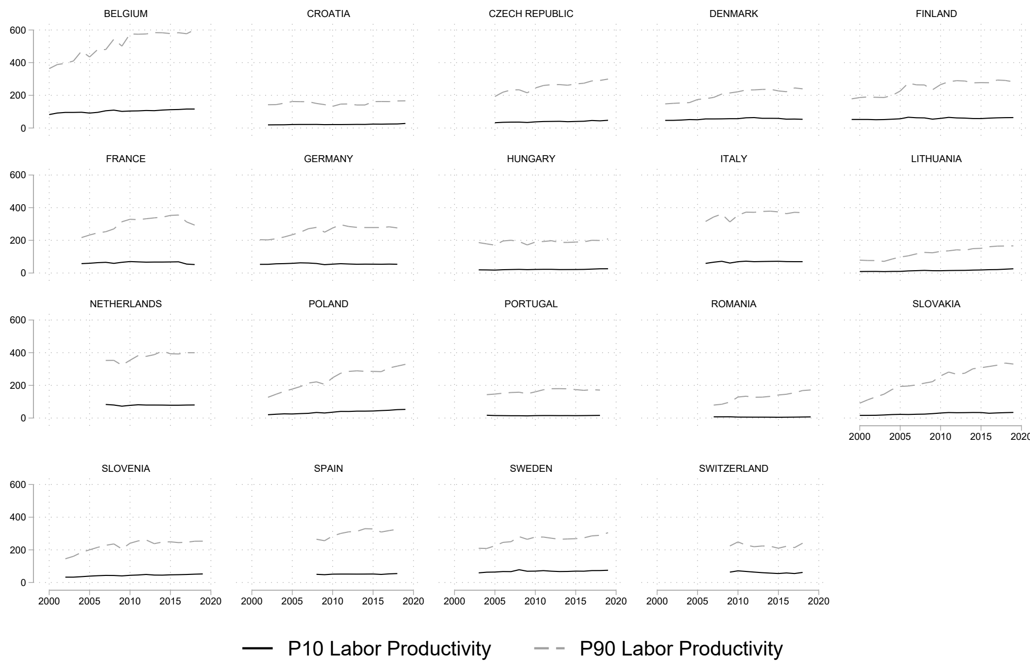
Figure 2 shows real revenue per worker by broad sector for a selection of countries using micro-aggregated CompNet data. Productivity has been generally flat in both manufacturing and the service sector in older EU member states. In newer member states such as the Czech Republic, Hungary, Lithuania, Poland, Slovenia and especially Slovakia, labor productivity in manufacturing is growing, while labor productivity growth in the service sector is muted. Modery et al. (2021) document that the main driver of aggregate productivity growth in Europe is intra-industry productivity growth in manufacturing, while in the United States, the ICT sector is the source of aggregate productivity growth. Yet, we document a gradual loss of employment shares of manufacturing in favor of business services (see Figure A.1 in the appendix), thus confirming the negative contribution of between-sector reallocation to aggregate productivity growth documented by Modery et al. (2021).

Within the manufacturing industry, Figure 3 shows the development of an index of labor productivity in the 10% least (P10) and most (P90) productive firms. In the past two decades, manufacturing firms at the national productivity frontier have become more productive relative to firms at the bottom of the productivity distribution. In 2018, labor productivity in the most productive firms is about 4 to 10 times higher than productivity at the bottom of the distribution. While productivity in frontier firms grew at an annual rate of 3% (Portugal) to 12% (Slovakia), firms at the bottom of the productivity distribution grew at an annual average rate of for example -5% (Portugal) and 5% (Slovakia), respectively, before the Financial Crisis.[4]. This suggests that aggregate productivity growth in the 2000s was mainly driven by firms at the productivity frontier. However, even at the frontier labor productivity growth seems to have slowed down (with the exception of some Eastern European economies) after the Financial Crisis.

In addition to being widely dispersed, the productivity distribution is also highly skewed to the right with most firms being concentrated at lower productivity levels (see Figure 4). Moreover, we observe a widening and outward shift of the labor productivity distribution in the manufacturing industry in the previous years relative to the pre-crisis year 2007. This suggests that less productive firms exit the market and resources and market shares were reallocated to the most productive firms in the event of the Great Financial Crisis. However, the labor productivity distribution seems to be largely unchanged from 2010 onwards, confirming the observation that reductions in reallocation

[4]With the exception of Italy, Lithuania, and Hungary, productivity growth in frontier firms was by far higher than in laggard firms.

Figure 3: Labor Productivity (REV/L) Dispersion in Manufacturing.



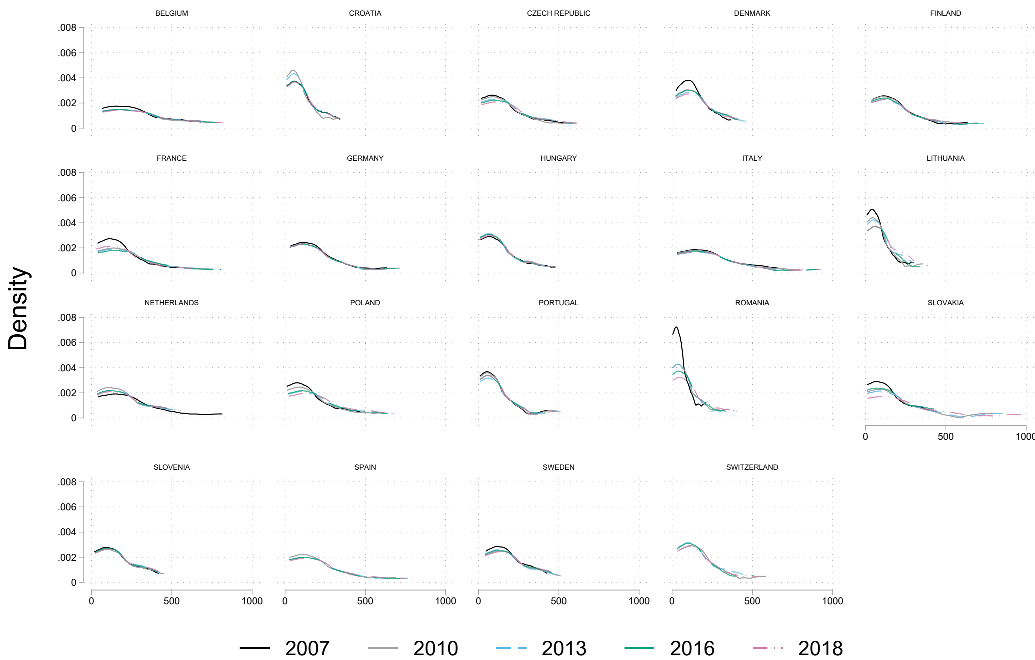
Notes: Dispersion of labor productivity (REV/L) in the manufacturing sector by country. P10 (P90) depicts the 10% least (most) productive firms.

may be underlying muted aggregate productivity growth, as seen in Figure 2.

Following this brief summary of findings using micro-aggregated CompNet data, the remainder of this report is organized as follows: Section 2 introduce the micro-aggregated data from CompNet and the new 'micro data infrastructure' (MDI) that has been under development within the EU Horizon 2020 project MICROPROD[5]. MDI provides a platform to explore cross-country developments in business dynamics and identify the underlying mechanisms contributing to the observed productivity slowdown; Section 3 utilizes a pilot study using MDI to analyse the relationship between firm performance, concentration and use of intangible assets. Section 4 concludes.

[5]http://www.microprod.eu/

Figure 4: Labor Productivity (REV/L) Distribution in Manufacturing.



Notes: Distribution of labor productivity (REV/L) in the manufacturing sector by country. Source: CompNet 8th vintage.

2 Description of Data Infrastructure

Accessing confidential administrative firm-level databases in Europe is possible only on a country-by-country basis and requires individual arrangements with the respective data provider. In fact, the possibility of acquiring access and the modes of access if available vary substantially across counries. While some statistical institutes provide access to firm-level information for research purposes to eligible researchers in a secure remote access environment, other institutes have not yet established a formalized way of providing access to this firm-level data. Moreover, even when access is established, heterogeneity in survey design, coverage, variable definitions and availability, the structure of the datasets and technical infrastructure require researchers to adapt to each country's setting. At the same time, knowledge from past or current users, for example regarding data preparation, is not transmitted to new users in an organized way in many countries. This implies insurmountably high fix costs for researchers to engage in cross-country research. As a result, the literature using firm-level data is concentrated on a few countries with relatively easy access, and most research is done on a single-country basis. In what follows, we present a review of (i) the cross-country harmonized micro-aggregated dataset (the *CompNet Vintages*) that offers the ability to conduct cross-country research using a country-industry-year panel of moments from the underlying firm-level data and (ii) the development of the *Micro Data Infrastructure (MDI)* which provides researchers with the ability to conduct harmonized cross-country firm-level research by running common code on confidential data in each country.

2.1 CompNet Vintages

2.1.1 Content and Data Creation

The CompNet vintages are a set of cross-country harmonized indicators at different levels of aggregation built using harmonized data collection protocols, which are executed by national statistical institutes and centrals banks in Europe on administrative firm-level data. The resulting dataset is an unbalanced panel and includes - for the most recent 9th vintage - 22 European countries, while the time span differs among countries and ranges from 1999 to 2020. The data provide information on the firms' labor and total factor productivity, as well as firm input, output, and investment information, among others. These measures include typical aggregates, such as sums and means, but also higher moments of distributions of variables of interest, as well as moments from multivariate distributions, regressions and transition matrices.

The harmonized data collection protocols ensure input variable harmonisation and adequate coverage and representativeness of the dataset. The data collection process is accompanied by exchange between data providers and the CompNet team, for example in order to agree on a common definition for a set of core variables. The data provider then construct a dataset including all the required variables on which the common code is executed. Data provider specific variable names are mapped to a common nomenclature in the code execution. To ensure that the information of the CompNet dataset is representative and comparable, variables are weighted by firm population weights and, in case of monetary variables, deflated by PPP-adjusted deflators.

The common code also includes an automatic disclosure routine that is adjusted to the respective countries' data protection rules and that ensures confidentiality of the output dataset.

2.1.2 Underlying Firm-Level Data Sources

Oftentimes, the data providers in CompNet need to combine multiple sources to construct the firm-level database on which the common codes are executed. Various types of sources are used including administrative, financial and balance sheet information as well as customs data. Among the data sources there are business registers (BR) covering the universe of firms, but also structural business statistics (SBS) surveys covering only a sample. These sources, however, are based on EU regulations and are already harmonised across countries.[6]

2.1.3 Data Access

The CompNet datasets are openly accessible for all researchers upon applying for data access via the IWH research data centre.[7]

2.1.4 Audience

The CompNet vintages aim at researchers interested in studying firm performance and business dynamics, but also as basis for policy evaluation for both policy advisors and policy makers. In order to make the data more easily accessible, the CompNet team provides a reduced dataset focusing on a core set of variables which also provides visualization tools. For the future, the data will also be available via an interactive online tool.

2.2 Micro Data Infrastructure (MDI)

2.2.1 Content and Data Creation

While the CompNet vintages are standardized datasets (country-industry-year panels of micro-aggregated moments from firm-level data) available at different levels of aggregation, the Micro Data Infrastructure (MDI) presented below offers researchers access to the underlying firm-level data and allows to flexibly combine various administrative and survey-based firm-level panels, while at the same time providing the tools to ensure that the generated results are comparable across countries.

Data harmonization In order to ensure that the firm-level data and methods used to study a specific research question are comparable across countries, the MDI consists of comprehensive metadata, data processing tools, and analytical modules. These features respectively allow for harmonizing the data across countries, standardizing research through common data preparation, and simplifying and streamlining analytical through sharing and re-use of code. In short, the MDI provides researchers with the ability to generate reproducible research designs that can be executed in each country, even if details of the underlying datasets vary.

[6]For further information, see CompNet (2018).
[7]See here for applying for the CompNet dataset.

Table 1: Remapping of Variable Names

MPname	DataSource	NSIname	Year	Description
firmid	br	ENT_ID	2009	Unique enterprise identification
birthyr	br	start_ent	2009	Start year for the enterprise ID
nace	br	NACE_M	2009	Main activity of the enterprise (NACE 4-digit)
...	...	...	...	
firmid	br	ent_id	2018	Unique enterprise identification
birthyr	br	start_ent	2018	Start year for the enterprise ID
nace	br	nace_m	2018	Main activity of the enterprise (NACE 4-digit)

Notes: Concordance table for mapping NSI specific variable names (column 'NSIname') to a common naming scheme (column 'MPname').

Comprehensive metadata, that are machine- and human readable, are the key to data harmonization. Data harmonization pertains to (i) using consistent nomenclature of the variables included in the panel dataset, and (ii) consistent content and format of the variables in the dataset and iii) common classifications for categorical identifiers such as activity, product, or region. Metadata files are available to allow linking of the appropriate datasets to common firm-level panels, concording statistical classifications (e.g. activity or region) to common definitions, and mapping of variables in each country to a common nomenclature and format. Table 1 shows a machine- and human-readable mapping of the variables from the underlying datasets to a common name to be used by program code of infrastructure users. The NSIs, in conjunction with the MDI team, will maintain required metadata.

In addition, the data harmonization tools map categorical values to a common scheme to which the user refers. For example, table 2 shows possible variable formats (NSIvtype) and native response categories (NSIcatval) as coded by the NSI. In the process of data harmonization within the MDI, these response categories are mapped to a unified code-book (MPcatval). Using this machine- and human readable codebook, the program code translates the name and coding in use at each NSI into a common variable name and format. In addition, program code can be used to remap classifications (e.g. industry, product, region) in use at each NSI into a common classification or even to allow the user to generate their own custom classification hierarchies. Table 4 shows an example of a non-standard aggregation hierarchy for business activity.

The selection of datasets and variables takes place via a project specific machine- and human readable file to be filled in by the user (see table 5). Based on the selection of

Table 2: Codebook

Source	NSIvtype	MPvtype	NSIcatval	MPcatval
ictec	numeric	bool	.	.
ictec	numeric	bool	9	.
ictec	numeric	bool	0	0
ictec	numeric	bool	1	1
ictec	character	bool		.
ictec	character	bool	9	.
ictec	character	bool	0	0
ictec	character	bool	1	1
...	...	...	...	...

Notes: Concordance table for mapping NSI specific coding of categorical variables (column 'NSIcatval') to a common codebook (column 'MPcatval').

Table 3: Example of Alternate Industry Concordance.

NACE Rev.2 (4-dig)	Alt. Ind
1091	LTmfg
1092	LTmfg
...	LTmfg
1910	MLmfg
1920	MTmfg
...	MTmfg
...	...
5911	HTKIsv
...	HTKIsv
6399	HTKIsv
...	...

Notes: Example of an industry concordance that maps NACE Rev.2 (4-digit) to a customized specification distinguishing industries by technological and knowledge intensity.

variables, the code reads the required firm-level data sources and links them to the BR. At this point, firm-level sample weights can be generated, using a re-weighting algorithm that compares firms available in a linked dataset with the universe of firms in the BR.

Besides metadata, the MDI provides data preparation and cleaning tools such as outlier detection programs, and aggregation tools to traverse standard and custom classification

Table 4: Example of Alternate Industry Hierarchy.

Alt. Ind	Description
TOTa	Total Economy
HT	high-tech industries
HTmfg	high-tech manufacturing
HTKIsv	high-tech knowledge intensive services
KI	knowledge-intensive industries
MHmfg	medium-high tech manufacturing
KImsv	knowledge intensive market services (excl high-tech and fin services)
KIfin	knowledge intensive financial services
KIoth	other knowledge intensive services
Low	other industries
MLmfg	medium-low tech manufacturing
LTmfg	low tech manufacturing
OTHmsv	less knowledge intensive market services
OTHsv	other less knowledge intensive services

Notes: Example of a customized industry hierarchy.

Table 5: Selection of variables

Select	MPname	DataSource	Description
X	firmid	br	Unique enterprise identification
	birthyr	br	Start year for the enterprise ID
X	nace	br	Main activity of the enterprise (NACE 4-digit)
...	...	...	...
X	firmid	sbs	Unique enterprise identification
X	emp	sbs	Number of employees
	persons	sbs	Number of persons employed
X	nv	sbs	Value-added at factor costs

Notes: Exemplary selection of variables from the BR and SBS. All in column 'Select' tick-marked rows are read in.

hierarchies (e.g. industry, product group, region). Additional analysis tools (for example for productivity estimation or clustering) facilitate and ensure a streamlined, yet reproducible, approach to analysis of the data.

The MDI team also will provide some basic analytical modules, akin to modules provided by CompNet. More importantly, MDI allows researchers a fast track to writing their own analytical modules to be run on firm-level panels in multiple countries. Such modules start with a selection of variables and linked panels presented in the metadata. The code that is run in each country reads the required firm-level data sources and links them to the BR. After processing and linking the datasets, the code maps the variables available in the different datasets to a common nomenclature, available to all users of the MDI. The analytical code also can tap into auxiliary data, for example common industry-level deflator timeseries for each country for output, value added and intermediate inputs sourced from Eurostat and apply them in a uniform manner to the firm-level data. Over time, other auxiliary data can be added to the MDI with appropriate metadata, for example input-output data (WIOD) or macro and sectoral national accounts data.

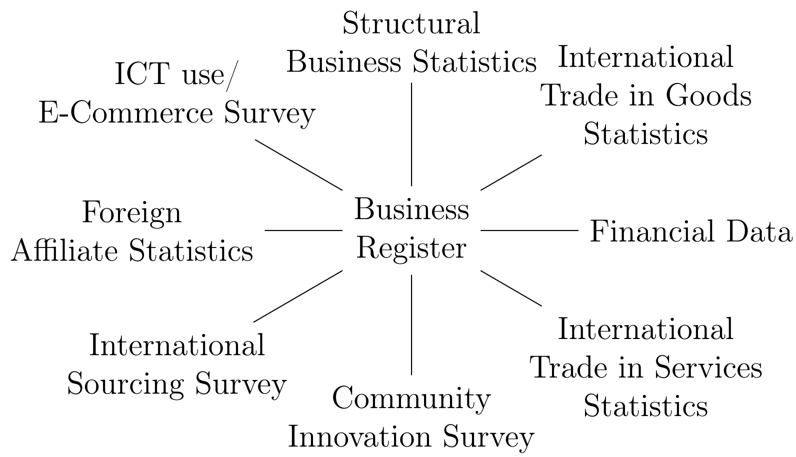
Confidentiality Routine The data confidentiality tool available through MDI warrants explicit mention. The output of a researcher-written code module can consist of output datasets, aggregated to industry or other firm-level characteristics to avoid breaking confidentiality, or tables of analytical results (i.e. regression coefficients and diagnostics). Pre-programmed aggregation and output and documentation tools and obligatory disclosure routines, customized to each country's confidentiality practice, aim to reduce NSI staff workload for disclosure analysis. The parameters of the disclosure routine are chosen by NSI staff in concordance with the respective national law.

Software Taking into account heterogeneity across NSIs and users with respect to the technical storage facilities and available analytical software, all tools are presently available in two different software languages (R and SAS).

2.2.2 Underlying Firm-Level Data Sources

In the EU, Eurostat regulations mostly harmonize (aggregate) output of statistical indicators in each country. In recent years there has been some progress in harmonizing micro-level data, for example by regulations on Business Registers (Regulation (EC) No 177/2008) and surveys on ICT usage in business (Regulation (EC) NO 808/2004), as well as by Eurostat model questionnaires, .e.g. for the Community Innovation Survey (with voluntary participation). With the Business Register as a 'backbone', NSIs have been able to link information from these datasets and other survey or register-based information at the individual enterprise-level (in this document loosely referred to as 'firm-level'). The result is an incredibly rich set of information which allows us to understand for instance how a variety of disparate factors affect productivity at the firm level and aggregate level. Figure 5 provides an overview of the underlying data sources available at the MDI to be introduced in what follows.

Figure 5: Linked Microdata Sources



Statistical Business Register (BR) The statistical business register (BR) plays a central role in the production of business statistics and is the starting point for establishing statistical survey frames. The BR contains information on identifying characteristics such as ID numbers, names and addresses, demographic characteristics, economic activity, legal form and institutional sector code as well as information on control and ownership relations for enterprises, their local and legal units and enterprise groups. In MDI, the BR serves as a 'backbone' or connection between various surveys and administrative datasets.

Structural Business Statistics (SBS) The Structural Business Statistics (SBS) describe the economic activities within the business economy, including industry, construction, distributive trade and services. SBS indicators at the detailed sector level are transmitted to Eurostat and published by all European Statistical System (ESS) members (EU Member States, Norway and Switzerland, some candidate and potential candidate countries). Harmonization of the SBS has taken place regarding the detail and coverage of the sectors (now NACE 2.1) and the statistical definition of the transmitted indicators (Commission Regulation (EC) No 250/2009). Generally, the SBS indicators in each country are collected at the level of individual enterprises engaged in economic activity.

The firm-level sources for each of the SBS indicators vary, across indicators, sectors and across countries, but possibly also across statistical units. For example, business surveys could be used to collect data for the indicator 'production value' for manufacturing firms while administrative data could be used to collect production value for firms in the telecommunications industry. The source for the indicator 'wages and salaries' could be administrative data on payroll taxes, or could be collected through a statistical survey. For gross investment expenditures the source data frequently are investment surveys amongst large firms with the small firms' contribution to the sector aggregate imputed or estimated, for example using a supply-use framework. The SBS includes information on various types of tangible investment as well as the following intangible investments (i) concessions, patents, licenses, trade-marks and similar rights, (ii) purchased software and (iii) total intra-mural R&D expenditure.

For the purpose of the micro-data infrastructure, a firm-level SBS is created in each country for a common set of output and input indicators, using the underlying firm-level sources available in each country. Care is taken to flag for the researcher when data are observed rather than imputed. The main variables in the firm-level SBS are monetary values, or as counts (for example, persons employed).

Community Innovation Survey (CIS) The Community Innovation Survey (CIS) is part of the EU science and technology statistics and provides mostly qualitative information on firm innovative activity. Surveys are carried out every two years by EU member states and a number of ESS member countries on a voluntary basis. The harmonized survey contains information on the types of innovation and various aspects of the development of an innovation, such as the type of funding and innovation expenditures. The CIS covers both innovation outputs and the innovative process and inputs (type of funding, R&D expenditure) and distinguishes four innovation types: process, product, organizational, marketing, thus covering both innovative property as well as capabilities and organizational capital. Additionally, the CIS asks about the novelty of the innovation, i.e. whether it is new for the market, new to the country, developed by the firm or was adopted, and thus provides information about the innovative value.

ICT usage/ E-Commerce Survey (ICTEC) The Community survey on ICT usage and e-commerce in enterprises is an annual survey conducted since 2002, which collects information on the use of information and communication technology, the internet, e-government, e-business and e-commerce in enterprises. Like the CIS, the EC survey contains mostly qualitative data. The ICT-usage survey measures various dimensions of firm technology use. Besides software and databases being considered as an integral part of intangibles, the adoption of certain technologies also provides information about firms' organizational capital and ICT capabilities both in the firms' internal operations and regarding the firms' supplier and buyer relationships. The qualitative information in the survey can be used to construct an ICT intensity index which allows for variation in the underlying source variables, thereby overcoming the issue with changing survey questions and the saturation of certain variables over time (Bartelsman et al. 2018).

International Trade Statistics Firm-level statistics concerning exports and imports are the International Trade in Goods Statistics (ITGS) and International Trade in Services Statistics (ITSS). International trade in goods statistics (ITGS) measure the value and quantity of goods traded between EU Member States (intra-EU trade) and goods traded by EU Member States with non-EU countries (extra-EU trade) broken down by types of goods (Combined Nomenclature) and by partner countries. The providers of statistical information differ between intra and extra EU-trade. In the first case, it corresponds to all taxable persons reporting transactions exceeding a certain threshold fixed by member states; in the second one, it corresponds to administrative data from the customs declarations lodged by natural or legal persons in the customs administration. International Trade in Services Statistics (ITSS) typically cover trade in services, i.e. transactions paid for the services that have taken place between the residents and non-residents.

Foreign Affiliate Statistics (FATS) The Foreign Affiliate Statistics is distinguished into inward FATS, i.e. the activity of foreign affiliates resident in the compiling country, and the outward FATS, that is, the activity of foreign affiliates abroad but controlled by the compiling country. The FATS allows to qualitatively assess the degree of economic activity of a domestic enterprise abroad and identify foreign-controlled firms.

Other sources Further data sources are available at the NSIs, but not yet included in the MDI due to being less harmonized. The sources and their possible contribution are briefly described in the following.

A promising and interesting source is **linked employer-employee data (LEED)** that cover the working populations' characteristics like employment relations, income and education and socio-demographic characteristics. For example, linked employer-employee data can be used to analyse complementarity between firm human capital and intangible assets (Piekkola 2016). The construction of such LEED data will necessarily vary across countries, but generally starts with a bridge between business units (firms) and individuals (workers). The bridge, for example, could be based on an administrative register established for the purpose of payroll tax collection. Using this bridge, the LEED can be augmented through linkages with other person-based sources, e.g. educational or health registers and linkages with the other firm-based sources described in this paragraph.

The **International Sourcing Survey (ISS)** gathers data on international organisations and sourcing of business functions in 16 European countries, covering the period 2014-2016 or 2015-2017, depending on the country. The survey results cover nearly 60,000 businesses each with more than 50 persons employed. However, since the survey is still in pilot stage, the survey design varies across countries. **Financial data** provides information on firms' financial assets and liabilities. While for nearly all pilot countries, firm financial data is available at the NSI, for some countries it is only available at the respective National Central Bank (NCB) (e.g. Germany). Balance sheet data contain an accounting measure which aims to capture the entire stock of intangible capital. However, intangibles can only appear on the balance sheet of a company if their value is clearly identifiable, with the shortcomings that (i) acquired assets are much more likely to enter the firm's balance sheet, (ii) the item covers only certain aspects of the economic concept of intangibles and (iii) does not necessarily reflect the economic value of the incorporated intangible assets due to accounting principles and depreciation rules (Bisztray et al. 2020). Conversely, the profit & loss statement includes information on expenditures on intangibles such as *Sales, General and Administrative Costs (SG&A)*.

2.2.3 Data Access

Depending on the legal framework and technical possibilities, there can be two modes of operation for accessing the firm-level data via the MDI:

Remote Access Under this modality - available to the MDI team for France and the Netherlands - the team can run independently the needed codes on the (previously harmonized) micro data, using existing facilities available respectively at CBS (Netherlands) and CASD (France). This of course implies incredibly lower costs for the NSI staff who is only responsible for maintaining up-to-date versions of the above mentioned source datasets, as well as providing up-to-date metadata describing their data.

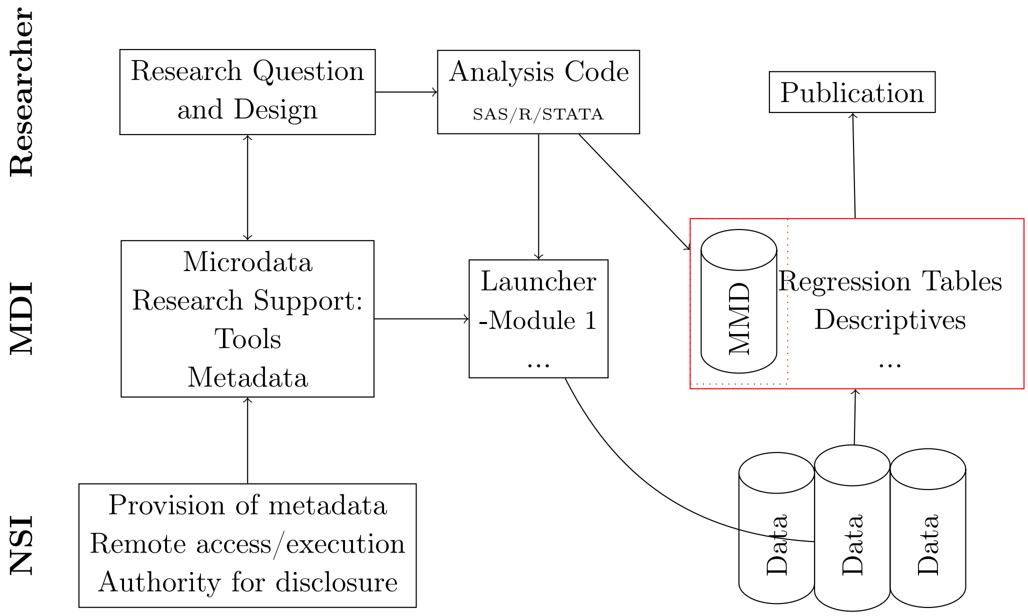
Remote Execution Under such modality, the codes are sent to the NSIs' staff who take care of running the codes and to return to the team the derived firm-level-based results. Under this modality, precise metadata is key to allow for a smooth execution of sent code. In addition, this modality implies a restriction of programming languages to those used within the NSI. At present, this is the only modality available for some due to legal concerns and technical possibilities.[8]

2.2.4 Audience

Current Applications National Productivity Boards (NPBs) only have sparingly used firm-level data for analysis, for a combination of issues including (i) trust and reliability

[8]For example, the legal framework in the Nordic countries does not allow for foreign-based researchers to directly access the data via their remote infrastructures.

Figure 6: Proposal of MDI Architecture



of the firm-level data especially when compared with macro aggregates, (ii) difficulty in accessing the relevant datasets, and (iii) lack of solid comparability of the information across countries. At best, when firm-level data are utilized, they refer to the national-level only, in the vast majority of cases. One application of the MDI will be to provide NPBs access to harmonized and easily comparable information based on firm-level data to increase the use of such micro based information as the basis of their analytical work on productivity. This will include the use of micro-aggregated data which is already currently available in disclosed form (CompNet), as well as more complex confidential information available through MDI. These forms of access are complementary. One offers ease of access, a pre-defined set of statistics, and a broad range of comparator countries. The other offers the opportunity for much more sophisticated analysis through the MDI.

User expansion Eventually, the MDI could be opened to the research community interested in working with cross-country comparable firm-level data. Figure 6 depicts the proposed MDI architecture, consisting of 3 actors: NSIs, external Researchers and the MDI in intermediary position. Researchers approach the MDI team with a specific research question and design, who in turn offer research support in terms of pre-programmed tools and comprehensive metadata allowing for a smooth usage of the micro data. Based on these tools and metadata, the researcher can draft analysis code that will be embedded in a launcher and run by MDI or NSI staff on the actual micro data. The output - checked for confidentiality by the NSIs - could then be provided to the user. The user could test the code on a mock sample database provided by the MDI/CompNet team.

To guarantee micro data access also to external researchers while avoiding overburdening the NSIs, we suggest that a consortium, for example CompNet, takes on an intermediary position between external researchers requiring cross-country comparative work and NSIs in filtering and assisting in the data application process.

In perspective, we strive to provide a user interface for potential users to search relevant metadata and aggregate statistics. In this way we could adapt to the needs of more advanced users, who have a very specific project in mind, and some more basic users or policy makers, who need more standard statistics.

2.3 Interim Conclusion

In this section we have presented the MDI and CompNet data infrastructures, discussing how they provide a useful asset in tackling relevant policy and research questions. CompNet is a more standardized tool, providing a variety of micro-aggregated moments for a large set of variables that have to do with firms' production process, finances and trade activity. Still, CompNet does not provide researchers with the flexibility of specifying a personalized analysis on firm level data, therefore the MDI provides a useful complement to it. Additionally, the MDI allows users to access a larger variety of indicators than the ones included in CompNet. In the next section we will present an application focused on the increasingly important role of intangible assets for productivity developments, firm performance and market competition.

3 Application: The Role of Intangibles in Explaining Productivity Development

In this section we focus on the impact of intangible assets on productivity developments, to illustrate an example of joint use of the CompNet and MDI dataset. Rising intensity in intangible assets is a trend that interests most advanced economies and that is likely to reinforce in the coming decades. Its impact on productivity is therefore relevant for ensuring long term economic growth and informing policy makers' decisions.

3.1 The Rise of Intangibles

In the last few decades, advanced economies have seen a shift in the relative importance of different types of productive assets. This phenomenon is generally framed around the so called "rise of intangibles", and captures the long term shift from tangible to intangible assets as key components of a country's productive capacity. This phenomenon is partly explained by the secular increase of the share of relatively intangible-intensive services in aggregate value added at the expense of manufacturing. But even within macro-sectors, there is an increase in the importance at the firm level of intangibles relative to tangible assets (see Figure 7).

Intangible assets refer to a relatively broad set of items providing productive services and having in common the feature of being non-physical and generally non-rival in productive use. The most important items in this broad set are software, followed by intellectual property, which in turn includes patents, licences, trademarks, etc, and capitalized R&D, managerial capital and know-how (Corrado and Hulten 2010).

Key Properties of Intangible Assets Intangible assets possess some key properties that relate them to the observed productivity puzzle outlined in section 1.

First, intangibles are to a large extent non-rival in use. Expanding production does not require 'more' of an intangible asset, and thus is associated with low marginal costs or *increasing returns to scale* (De Ridder 2019).[9] This implies that first mover advantage is key for gaining market shares. In industries that are intensive in intangibles, these properties imply a premium for within-firm (productivity) growth, but at the same time

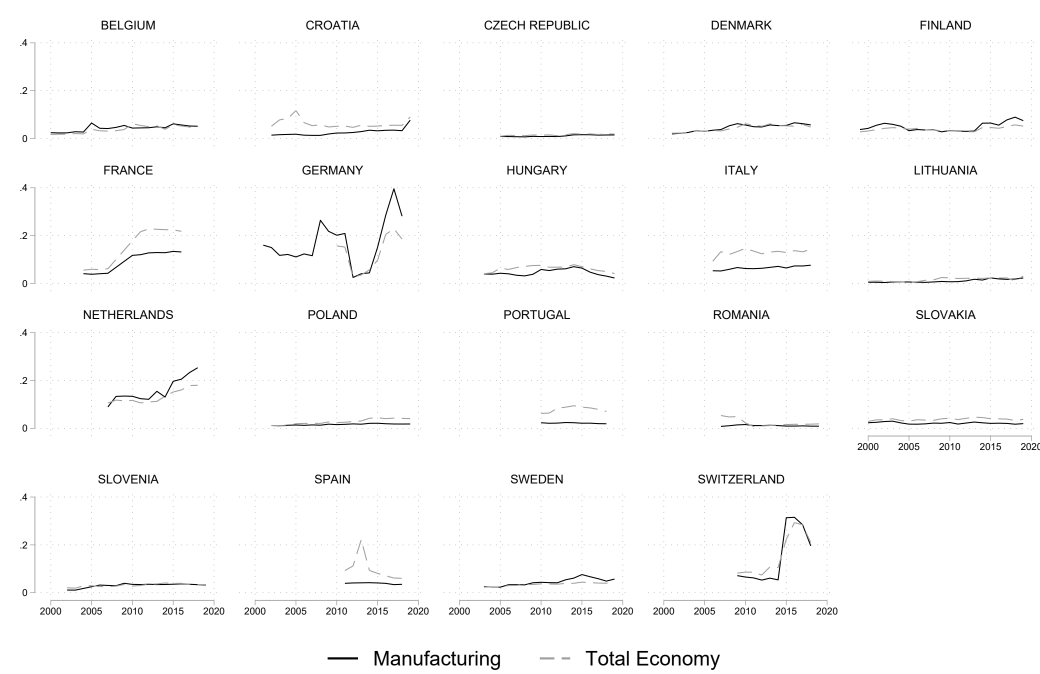
[9] For example, the cost of allowing one more customer to enjoy the intangible benefit of consuming a Justin Bieber song is essentially zero. Furthermore, some classes of intangible assets also provide an advantage when expanding sales 'extensively', eg through increasing the span of control of management in a firm's headquarter by increasing the number of production locations or via leveraging the brand reputation of a product through expansion into new markets.

can lead to increased concentration and lower business dynamism which are detrimental for long run productivity growth.

Second, the relative increase in intangible assets might imply lower levels of knowledge diffusion and technological spillovers, mainly via two channels. Either because the intangible asset embeds a technology that is harder to imitate per se (as it can be the case for software) or because they have a value that is firm specific, which limits the scope for imitation by competitors and increases the distance between the frontier innovators and the rest (Corrado et al. 2005; Corrado et al. 2009). Less knowledge diffusion implies less business stealing or technological spillovers, thereby favouring the position of incumbents and reducing competition. This can be reflected in more persistence in the position of leader firms and more sluggish aggregate productivity growth.

Third, there is growing evidence that industries that are intensive in intangible assets are less reliant on bank lending and more on retained earnings, venture capital and stock market (Dell'Ariccia et al. 2021; Döttling and Perotti 2020). This might be due to the non pledgeability of intangibles as collateral when applying for a loan, as their monetary value is more difficult to quantify and their value more difficult to secure following bankruptcy. Lower reliance on bank credit could also be due to more volatile returns from investing in

Figure 7: Intangible fixed assets over revenues.



Notes: Aggregate intangible intensity (intangible fixed assets over revenues) in firms with more than 20 employees by country. Source: CompNet 8th vintage.

intangibles, or more simply, to the fact that less cash in advance may be needed to develop intangibles. The consequences of this are mainly higher cost of financing for smaller firms that are intensive in intangibles, as they cannot access capital markets and bank loans as easily. This in turn results in stronger selection and in a firm population that includes a few large players, implying again stronger concentration and less dynamism, with a muting effect on aggregate productivity.

Thus, while intangible assets are associated with within-firm productivity gains for those that employ the assets successfully, aggregate (and long-run) productivity development may be distorted by their effect on market concentration and business dynamism.

3.2 Measurement of Intangibles

3.2.1 Literature Review

Due to their non-physical nature, the 'quantity' of intangible assets is hard to establish. Furthermore, for some intangibles even monetary values are highly imprecise, for example when these assets are developed and utilized in-house as part of ongoing operations.

Most research on the role of intangible assets was primarily concerned with quantifying sources of productive value within the firm such as managerial practices, know-how and intellectual property. For example, the FiMIAM method developed by Rodov and Leliaert (2002) allows to include a measure of intangibles inside firms' balance sheets. A different approach focuses on a set of soft indicators, including relationships and practices to deal with external and internal stakeholders of the company and on people's competencies (see Sveiby (1997)). However, in a seminal study, Kaplan and Norton (2004), note that the value of intangible assets varies with the the context they are used in and that they are hard to imitate, thereby reducing technology spillovers between firms. All these aspects further complicate quantifying firm intangible assets.

To this day, the issue of measuring intangible assets remains open, as multiple approaches are available, alternatively based on a monetary or on a non monetary approach (Egginton 1990). On this, a useful literature review is provided by Nichita et al. (2019), who conduct a meta-analysis on a set of articles written on this topic up until 2019. Their conclusion is that up to this point, while there is broad consensus on the fact that intangible assets such as intellectual property, know-how, ICT and managerial skills provide productive services alongside physical capital and labor, the literature has yet to agree on a unified optimal way of unified measurement, as each method has different advantages and disadvantages.

While early research on productivity growth mainly focused on technological assets built up through R&D expenditures or measured by patents (Griliches 1979), Corrado et al. (2005) developed a systematic framework to categorize the firm-level expenditures that account for investments into a complete stock of intangible capital. In this framework intangible capital comprises investments in research and development (R&D), software, patents, as well as branding and organizational capital (Corrado et al. 2005; Corrado et al. 2009). According to business accounting standards, such as IFRS or national GAAP, some components of what productivity researchers now consider as firm-level intangible investment are classified as expenditure. Further, comparisons of measures of intangible capital from public balance sheet filings show differences in interpretation of these standards across firms Covarrubias et al. (2019). According to national income accounting standards (*SNA 2008* and *ESA 2010*), only a limited range of investments are included in economy-wide intangible assets: R&D, mineral exploration, computer software and databases, and entertainment, literary and artistic originals.

3.2.2 Measuring intangibles using linked micro data

In this report, we triangulate between accounting standards, available data sources, and growth theory to experiment with proxies for intangible assets that can be used to study productivity developments. The following paragraphs present these practical experiments developed in MICROPROD that operationalize certain aspects of intangible measurement.

Intangibles from financial data Both balance sheet data and profit & loss statements can be consulted to calculate measures of intangibles. Bisztray et al. (2020) use the accounting measure for intangible fixed assets that consists of "...mineral exploration, computer software, entertainment, literary or artistic originals and other intangible fixed assets intended to be used for more than one year"[10]. While the accounting measure aims to capture the entire stock of intangible capital, this measure does not perfectly capture the economic concept of intangible capital. First, asset book values do not necessarily reflect the economic service value of the incorporated assets. Second, in order to enter the firm's balance sheet, the respective intangible asset's value and lifetime need to be quantifiable. This has the effect that assets developed in-house in contrast to acquired assets are seldom stated in the balance sheet, but rather show up in profit & loss statements as part of labor or intermediate expenses. Using income statements, Altomonte et al. (2020) derive firm intangible investments from firm expenditure on fixed costs, calculated as net revenues

[10] Eurostat, "European System of Accounts - ESA 1995", Office for Official Publications of the European Communities, Luxembourg, 1996

minus operating profits.[11] Finally, the classes of intangible assets that can be inserted in the balance sheet may not follow the same standards across countries, implying a challenge for cross-country studies.

Intangibles from investment data Using cost structure and investment surveys, Kaus et al. (2020) compute an intangible capital stock for each firm, consisting of expenditure for R&D, concessions, licenses, patents and trademarks and acquired software for 14,000 German manufacturing firms per year from 2009-2015. The authors use the Perpetual Inventory Method (PIM) to transform yearly investment flows into capital stocks as follows

$$K^{\theta}_{ijt} = (1 - \delta^{\theta}_{jt}) \times K^{\theta}_{i,j,t-1} + I^{\theta}_{ijt} \tag{1}$$

where δ^{θ}_{jt} denots the yearly depreciation rate and I^{θ}_{jt} yearly real investment for capital good $\theta \in$ (machines, buildings, software, patents, R&D) for firm i in industry j in year t. To transform nominal to real investment flows, the authors use price deflators provided by National Accounts, which also include separate deflators for investments in machines, buildings, and intellectual capital. While depreciation rates for tangible capital can be derived from the National Accounts, for intangible capital the authors use fixed rates for all industries and years, that is 33% for software, and 20% for patents and R&D (Corrado et al. 2009). The authors construct an initial capital stock using the average investment during the firm's first three years in the data

$$K^{\theta}_{i,j,t=0} = \frac{1}{3} \times \sum_{t=1}^{3} \frac{I^{\theta}_{ijt}}{\delta^{\theta}_{jt} + g^{\theta}_{j}} \tag{2}$$

where r^{θ}_{ij} is the geometric mean of the annual growth rates of the different investment types in the National Accounts. The results show that although the dispersion of productivity decreases slightly when intangible capital is accounted for in the production function, a large part of productivity dispersion remains. The authors conclude that other intangibles not contained in the investment data such as organisation and branding capital or management quality are additional factors explaining productivity dispersion.

Innovation, R&D and ICT usage surveys In order to complement the information derived from accounting statistics and administrative investment data, MICROPROD

[11] This approximation is related to measuring expenditures on intangibles based on *Selling, General and Administrative Expenses (SG&A)* which is – besides *Costs of Goods Sold (COGS)* – the second major component of costs and includes all intangible-building activities (e.g., R&D, Advertising and IT staff expense) (Gutiérrez and Philippon 2017; Covarrubias et al. 2019).

experiments with additional survey data, such as the CIS and ICT surveys mentioned in section 2.2.2. These data sources provide a rich set of indicators on qualitative and quantitative firm innovative activity and innovation output by category, and detailed qualitative data on ICT use, thereby capturing aspects of firm organizational capital. To get a comprehensive measure of firm innovative activity or technology use, this extensive information can be summarized for example using clustering algorithms, grouping firms based on innovation strategy or intensity in certain classes of inputs, or through other algorithmic tools for dimension reduction.

For example, Bisztray et al. (2020) classify ICT usage in six categories expected to be related to firm productivity: providing IT training to employees, ICT use in within-firm processes and in communication with buyers or suppliers, use of website, social media and cloud computing. For each of the categories, the authors create indices by counting positive answers to the related questions on the firm-year level. In addition, the authors use principal component analysis to further reduce the dimensionality of the data, resulting in one principal component capturing the intensity of firm ICT usage. Their results show that this measure of firm ICT capability is highly correlated with firm output, suggesting that firm capabilities captured by information technology provide additional information on firm intangible capital.

While the ICT use survey only contains qualitative information on firm ICT use, Smeets and Warzynski (2020) use a novel dataset on firms' ICT investment for Denmark, which allows to disentangle ICT investment into three categories—hardware, software and communication equipment—and analyse their respective effects on firm growth and productivity. Their findings show that all three components of ICT spending at the firm level correlate strongly with firm growth and productivity, but also suggest a strong selection effect and little variation over time in the spending heterogeneity across firms.

In this Report we rely on a large set of proxies of intangible capital, that we source either from the CompNet dataset or by linking the firm-level data sources available in the MDI.

- *Intangible assets* from the balance sheet. This indicator comes from the balance sheet of firms contained in the CompNet dataset and is available for a subset of CompNet countries (see next subsection).

- *Investment in intellectual property.* This variable is sourced directly from the SBS dataset available in the MDI and covers investment in purchased items of the type: concessions, patents, licences, trade marks and similar rights.

- *Intangible capital* estimated via the PIM method. This variable sums together investment in intellectual property (see above) and investment in software, to estimate a measure of capital stock by assuming a law of motion of capital as illustrated in the previous paragraphs. We assume a depreciation rate of 30%, in line with the literature (Corrado et al. 2009; Kaus et al. 2020).

- In house *expenditure in R&D* as a share of revenues (R&D intensity). For this variable we focus on intramural R&D expenditure as declared from the CIS survey available in the MDI and we take it as a share of revenues.

- Share of *employees using computers* regularly on the work place. This variable is a proxy of ICT intensity, sourced from the ICT survey available in the MDI.

- An aggregate *innovation score*, computed as a geometric mean over multiple "propensities to innovate" (Bartelsman et al. 2018). To compute this variable we focus on a list of binary indicators on whether in the last year (t) a firm has performed a certain type j of innovation: ι_{jt}. The innovation types are innovation in terms of products, processes, origianization or marketing, which in turn are thematic aggregations of indicators directly provided in the CIS survey. For each ι_{jt} we fit a Probit model on size, age and industry fixed effects. From the Probit estimate we predict a firm level probability of performing the innovation $\hat{p}_{ijt}(\iota_{jt})$. The final innovation score is the geometric mean across all predicted probabilities:

$$IS_{it} = (\Pi_J \hat{p}_{ijt}(\iota_{jt}))^{\frac{1}{n}} \tag{3}$$

  where J is the set of the n innovation indicators for which we estimate the Probit model.

The broad list of indicators used is motivated by the fact that each one of these taken singularly may only give a partial representation of firm level intangible assets, while a more complete picture can be reached through their joint use. Indicators from investment surveys or the balance sheet cover financial or "measurable" intangibles. Information about them is readily available in larger and more standard datasets, but they miss the large portion of intangibles that are developed in house and therefore seldom included in financial statements. That is why we also include variables related to innovative activity and ICT use, aggregated up by categorical indicators and survey based. We combine firm-level information by merging the Business Register, Structural Business Statistics, the CIS and ICTEC (surveys), thus linking a broad set of intangible asset indicators to a full set of firm-level covariates. In terms of country coverage, the MDI includes France, Netherlands, Denmark, Sweden, Finland and Norway[12].

Concerning the CompNet data, intangible assets are not available as a stand-alone variable for all countries, therefore we restrict the analysis to those countries that report these assets in the balance sheet, keeping in total 18 countries [13]. Such a variety of approaches to study intangibles is a unique feature of the presented data infrastructure. However, combining different surveys to get richer information comes at the cost of creating non-representative firm-samples due to country-specific sampling strategies and overlap between surveys. The next section will describe in detail the advantages and issues related to combining these data sources across multiple countries.

3.2.3 Potential issues

Selection of variables across countries While definitions of economic concepts are harmonized across the EU for aggregate statistics and some of the surveys, e.g. ICTEC, are harmonized to have identical variables at the firm level, potential issues remain. For the SBS, not all desired variables are available in all EU countries, and within countries some variables may differ across industries, or not be available for firms below certain size thresholds. This creates a trade-off between conducting cross-country research on a wide variety of harmonized indicators versus pre-selecting a limited set of variables that are available in all countries. The MDI gathered extensive metadata with information on the availability of a large set of variables across countries and over time, and thus gives flexibility to data users to make their own trade-off between richness of the dataset and country coverage.

Firm coverage The characteristics and selection of the sample of firms also may vary across countries. While by design the BR reflects the universe of firms, sampling for each individual survey varies as does the resulting sample of linked surveys and registers. Depending on the sample selection and stratification employed in each country, this may hamper the comparability of results across countries, and between CompNet and MDI.

In our analysis, the MDI sample obtained by joining BR and SBS is comparable with the firms underlying the CompNet dataset, as the BR covers the universe of firms, and SBS

[12]The process of harmonization of the data across countries does not always allow to replicate the same analysis across all countries, as it can be the case that a certain indicator is available in some, but not in other countries. For example among the Nordic countries only Finland reports investment in intangible assets in the SBS, while for the others this variable comes from a separate survey and therefore covers a different sample.

[13]these data are available in Belgium, Croatia, Czech Republic, Denmark, Finland, Germany, Hungary, Italy, Lithuania, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland.

is a representative survey covering the same industries that are covered in CompNet. When selecting the subsample of firms that are present also in the CIS and ICT survey, however, the number of firms can decline dramatically. The CIS and ICTEC surveys are carried out independently from each other and it is not given that a firm is included in both.[14] The sampling of both surveys is representative for the size and industry composition of a country. When we select only firms in common between the two surveys, we often tilt the distribution towards larger firms, which are more likely to be sampled in multiple statistical surveys due to their economic weight (both in terms of employment and value added). Comparing such subsamples in a given country with the results from CompNet for the same country could suffer from poor comparability, depending on the questions we are asking to the data.

Still, for our study we consider this to be a less relevant issue. As it will be clear in the next section intangible assets generally appear in larger firms and tend to be highly concentrated, therefore whenever we investigate the role of intangible assets within firms that do hold them, we would focus on a subsample of the economy. In this case, selecting a subsample where larger firms could be over-represented would not present an issue. Conversely, when we compare firms that hold intangibles to firms that do not, we will rely on more representative samples within the MDI (i.e. the overlap between BR and SBS, rather than the sample including also CIS and ICT).

Panel attrition Another potential issue to keep in my when using panels from linked statistical sources, such as SBS linked with CIS surveys, is that exit from the sample can result from real exit from the market, or exit from the joint sample. The latter is more likely to occur for small firms that have smaller likelihood of inclusion in a survey. We take this into account by considering the subsample of CIS and ICT as a repeated cross section, without following firms over time. This problem does not occur in the SBS survey in the countries currently under study, but will occur in countries where the firms in the SBS also derive from a (size-stratified) sample.

As a general conclusion, despite these challenges, the MDI structure is flexible enough to ensure users to choose the sample they want to focus on, and to maximize sample size and representativeness based on the analysis they need to carry.

[14] In some countries, having a small firm occur in multiple surveys it is explicitly ruled out to reduce administrative burden on firms.

3.3 Results

In the remaining part of this section, we present descriptive evidence on the link between the rising importance of intangible assets and productivity, and how gains in productivity are related to firm performance. Furthermore, we investigate whether the uneven distribution of firms that are able to successfully invest in intangibles may cause a rise in concentration and excessive market power concerns. We conclude by pointing at potential avenues for further research on this topic.

Higher intensity in intangibles coincides with higher productivity, but returns from investment in intangible assets are highly skewed. We first present evidence on the correlation between intangible assets and productivity at the industry level[15]. We define productivity as the log of value added per worker (labour productivity, hereafter). We start from the CompNet based indicators: in Figure 8 we plot the correlation between intensity in intangibles (intangible fixed assets over revenues) and labour productivity at the industry level, by pooling together all available CompNet countries.

We find a positive correlation, implying that industries that are more intensive in intangible assets also display higher aggregate productivity. From the figure, it is possible to notice that many points are clustered to the left of the chart, implying that many industries hardly report the use of any intangible assets. In fact, correlation between intangible intensity of an industry and aggregate industry productivity is driven by some specific industries, where the weight of intangibles such as intellectual property or software is higher. This is especially the case for intangible intensive sectors such as Information and Communication, Professional, scientific and technical activities, together with fewer cases of Manufacturing and Transportation and Storage. These are the sectors where most of the stock of intangibles is concentrated for the countries available in our data [16].

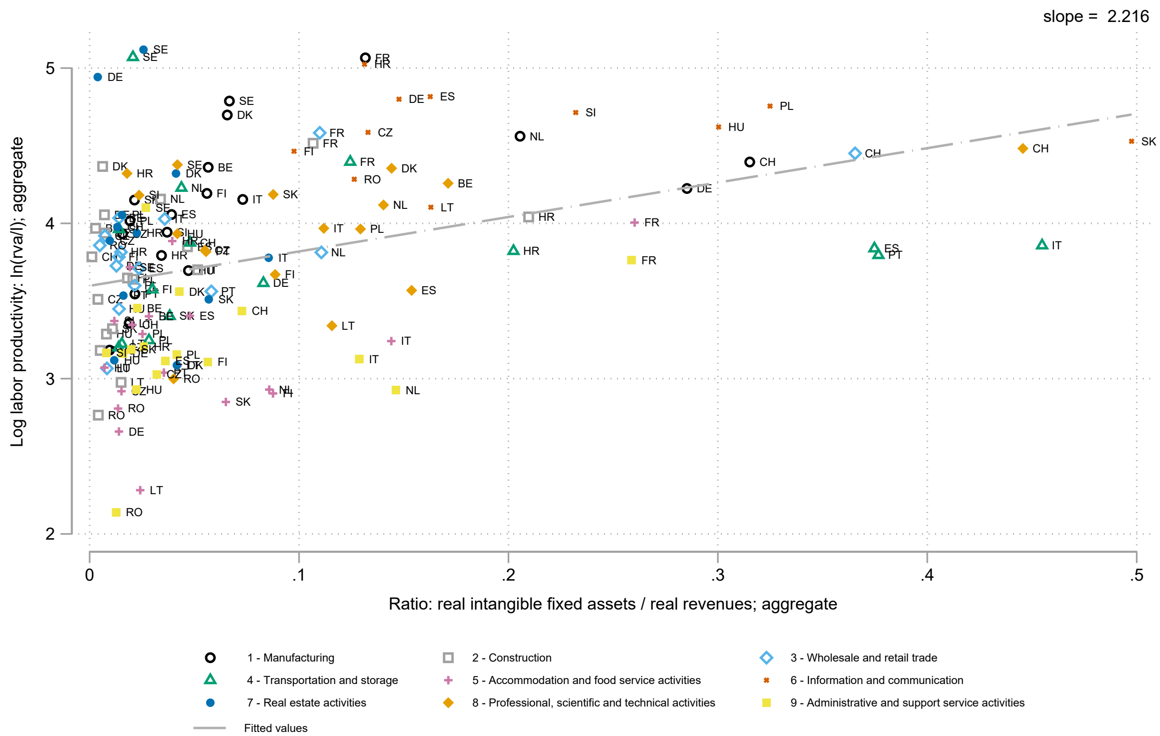
Turning to within-industry information in CompNet, we however do not find a higher average labor productivity for deciles of firms with higher average intangible assets (Figure 9). The same holds for alternative measures of intangibles: turning to firm-level information using the MDI, we find no clear positive association between average labor productivity and intangible capital, investment into intangibles, or innovative activity, ICT use and R&D spending (see Figure A.3, Figure A.4 and Figure A.5 available in the Appendix).

While seemingly a contradiction, the two different results can be reconciled with an

[15] We use as unit of observation averages in productivity and intangible intensity at the macro-industry level of the NACE 2 classification, for each country-year combination available in the data.

[16] Similar analysis based on the MDI evidence confirms this pattern.

Figure 8: Intangibles and productivity - CompNet



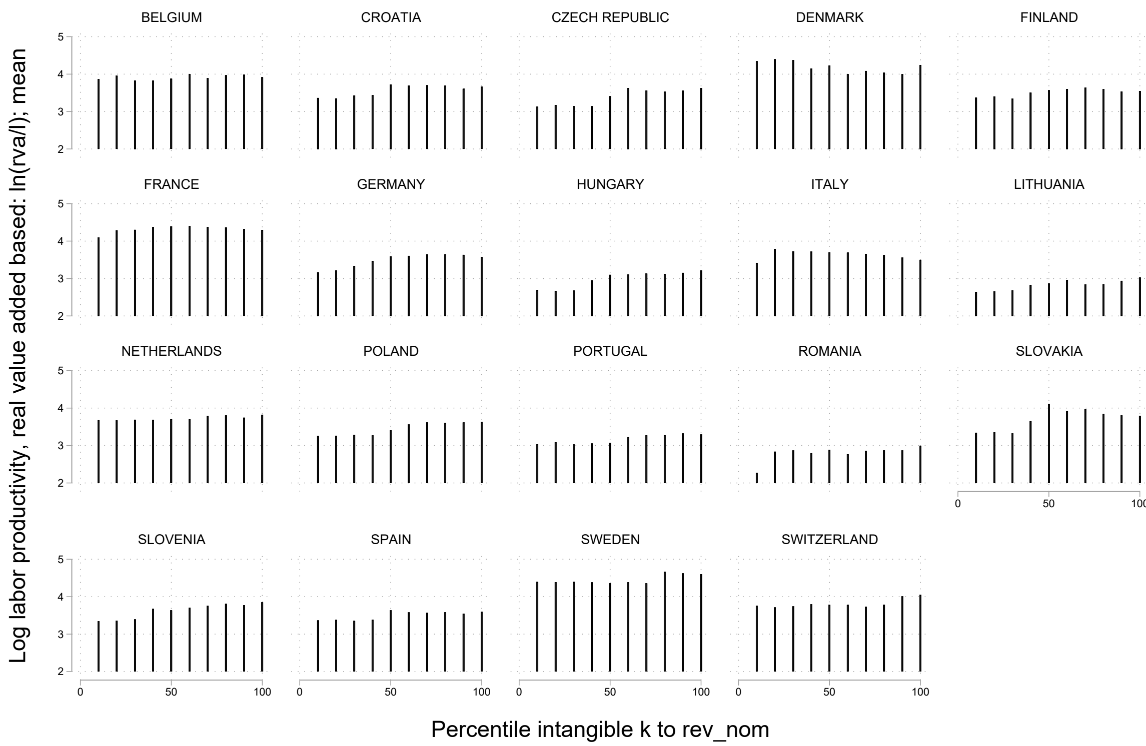
Notes: Results refer to 2016. Cross country correlation between aggregate intangible assets over revenues and aggregate labour productivity (value added per worker). Each point is a macro-sector country combination. Source: CompNet.

explanation that has some precedents in the literature (Bartelsman and Doms 2000; Bartelsman et al. 2018). The reason for this discrepancy lies in the different degree of uncertainty around expected gains from an investment in intangibles. In general, a firm investing in a certain type of assets expects a return in productivity with a certain degree of uncertainty. As mentioned in other sections of this report, intangibles differ from more traditional assets in two dimensions: first, there is higher uncertainty around the outcome of the investment[17]; secondly, the success of an investment in intangible assets hinges on reactions from the demand side: first mover advantage or other characteristics that trigger high demand interact with the lowered marginal costs of production and imply skewed returns across investing firms.

All this implies that on average, gains in productivity for successful investments are

[17] As argued already in the introduction of this section, this has to do with the fact that intangibles have a firm specific value, they may be linked with a hard to predict composition of the work force or managerial talent, or they may be determined by immaterial features difficult to acquire deterministically, such as reputation, trust, etc.

Figure 9: Intangibles and productivity - CompNet



Notes: Results refer to 2016. Average firm revenue and size by intangible intensity (intangible fixed assets over total revenues) in firms with more than 20 employees by country. Source: CompNet 8th vintage.

balanced by low returns to unsuccessful investments, resulting in a low or zero correlation, on average. At the same time, those firms that are successful in investing in intangibles scale up, especially in presence of increasing returns to scale or lower marginal costs, causing an industry level correlation to become positive. An implication of this is that those industries that are more intensive in intangibles will display higher dispersion in productivity, reflecting higher volatility of investment returns.

We test this implication in Table 6, where we regress productivity dispersion on intangible intensity. The results confirm a positive and significant correlation, mainly driven by the low tech industries[18]. This is likely motivated by the fact that in these industries dispersion in potential returns from investment in intangibles is highest. On the other hand, in the High Tech or Knowledge Intensive industries the use of these assets is more widespread and the associated technology is more mature, thereby reducing volatility in investment returns. Finally, we run the same regression using different indicators of dispersion in productivity as dependent variable, i.e. also the ratio between the p90 and

[18]see Table A.1 for a detailed definition.

Table 6: Dispersion of Labor Productivity and Intangible Intensity.

	Log labor productivity, real value added based ln(rva/l); SD			
	(1) All sectors	(2) HT	(3) KI	(4) Low
Share of intangible k to rev_nom; mean	0.081***	0.005	-0.000	0.189***
	(0.003)	(0.005)	(0.004)	(0.005)
Observations	13282	1763	3882	7637

Notes: Linear regression of standard deviation of log labor productivity (measured as real value added over worker) on average intangible intensity in each country-industry-year cell. Regressions are weighted by employment. Column (1) uses the full sample, while column (2), (3) and (4) restrict the sample to high-tech (HT), knowledge intensive (KI) and low tech industries (Low), respectively. See table A.1 for the classification of industries. All specifications include country, industry and year fixed effects. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: CompNet.

p10, as well as the interquartile range (IQR in the table). All results point at a positive and significant coefficient: an increase in intangible asset over revenues by an additional 1 basis point is associated to a 22% widening of the distance between the top and bottom 10% of the productivity distribution.

Overall, these results point towards a positive yet very skewed impact of intensity in intangibles on productivity. We will next investigate if these productivity gains also translate into better firm performance.

Table 7: Dispersion of Labor Productivity and Intangible Intensity.

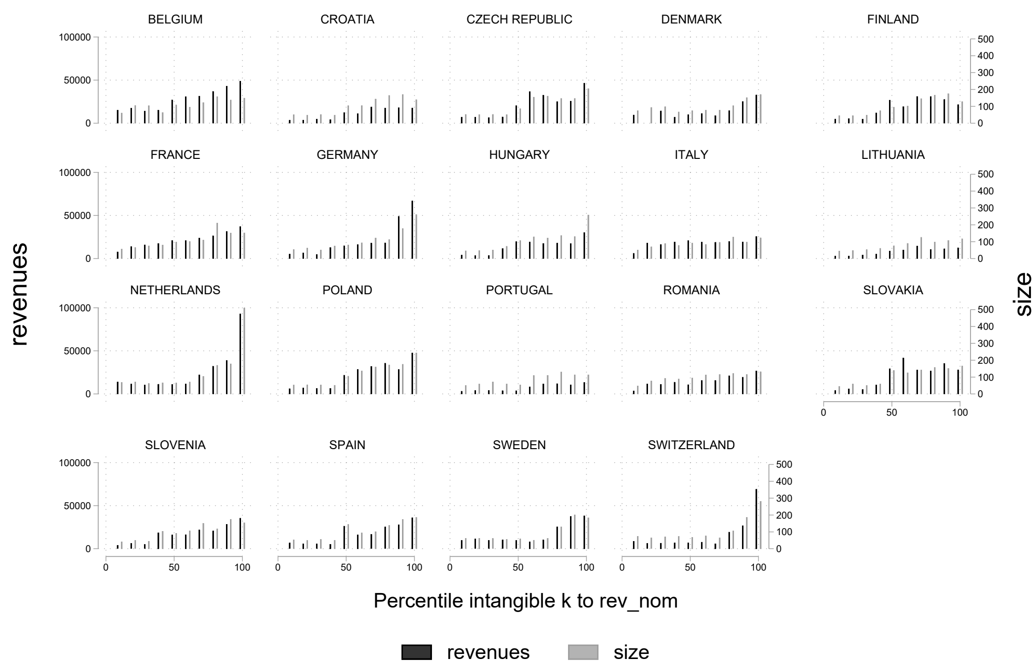
	Log labor productivity, real value added based: ln(rva/l)		
	(1) SD	(2) P90-P10	(3) IQR
Share of intangible k to rev_nom; mean	0.081***	0.224**	0.089**
	(0.031)	(0.088)	(0.039)
Observations	13282	13122	13122

Notes: Linear regression of different measures of log labor productivity (measured as real value added over worker) dispersion on average intangible intensity in each country-industry-year cell. Regressions are weighted by employment. Column (1) shows the standard deviation of log labor productivity, column (2) the difference between the 90th and 10th percentile, and column (3) the interquartile range (difference between 75th and 25th percentile). All specifications include country, industry and year fixed effects. Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: CompNet.

Intangibles are positively related to firm performance, but the strength of this relationship varies by asset type and country. We start by investigating the relationship between intangible assets and various indicators of firm performance, namely profit rate, revenue and employment.

We start again from the CompNet data. Figure10 depicts average firm size, as measured by revenue or employment, for each decile of intangible intensity, defined as intangible fixed assets over revenues. Firms at the top of the intangible assets distribution on average have higher revenues, and more employees. However, we see substantial heterogeneity across countries. While in the Netherlands and Germany, the most intangible-intensive firms are very large, in Denmark and France, the positive relationship between intangible-intensity is much weaker or non-existing.

Figure 10: Intangible fixed assets and firm performance.



Notes: Results refer to 2016. Average firm revenue and size by intangible intensity (intangible fixed assets over total revenues) in firms with more than 20 employees by country. Source: CompNet 8th vintage.

The MDI can give us a more nuanced picture of the types of intangibles used by the firm[19]. In Figure 11 we focus on two definitions of intangibles: either investment

[19]As outlined above, the CompNet measure for intangibles is based on the balance sheet item and captures the components of a firm's intangible assets that can be monetized. This is the most readily available source of information regarding intangibles that can be used for an initial cross-country comparison. Still, through the MDI, we can better capture those intangible assets that are not included in

in intellectual property or PIM-estimated stock of intangible assets[20]. We divide the distribution of each indicator of intangible intensity in quintiles, and for each quintile we report the level of each of the three outcome variables (from A to C, each panel reports the profit rate, revenues and employment, respectively). We do this for France and Netherlands in the top two rows, and Finland in the bottom row.

It is straightforward to notice that results are very similar in France and the Netherlands, while they substantially differ in Finland. Focusing on the first two countries, we conclude that intangibles are positively correlated with profits, revenues and size and results are mostly driven by the frontier of the distribution. In France, firms in the top quintile of the distribution report a profit rate that can be as high as 6 times that of the bottom quintile, while for the Netherlands more than 4 times. Similarly for revenues and size, firms that are most intensive in intangible investment and capital display revenues between 4.5 and 10 times higher than the least intensive ones, and are between 3 and almost 6 times larger. The skewness of the distributions could be driven by productivity gains resulting from investment in intangibles, which we have shown in the previous section are positive but volatile.

In Finland, the picture is almost reverted, with a correlation that is absent if not negative [21]. If we focus on revenues, for instance, firms that are mostly intensive in intangibles report between 50-25% less revenues than those that are the least intensive. These results could hint at a less skewed distribution of intangibles among firms of the Nordic countries, or at least to a different role of covariates such as firm age or size in predicting their concentration. Still, in these countries, firms that do report any intangibles are significantly more profitable and pay higher wages than those that do not report any.

We now turn to other measures of intangibles, that may be better able to capture the role of organizational capital, innovation and ICT intensity. We repeat the exercise from the previous figure. As mentioned earlier, these are all types of intangible assets that are harder to measure in monetary terms, therefore require an alternative measurement method. We therefore split the distribution of firm specific ICT intensity, innovation index and R&D rate (see Section 3.2). We summarize the results in Figure 12 for France and the Netherlands.

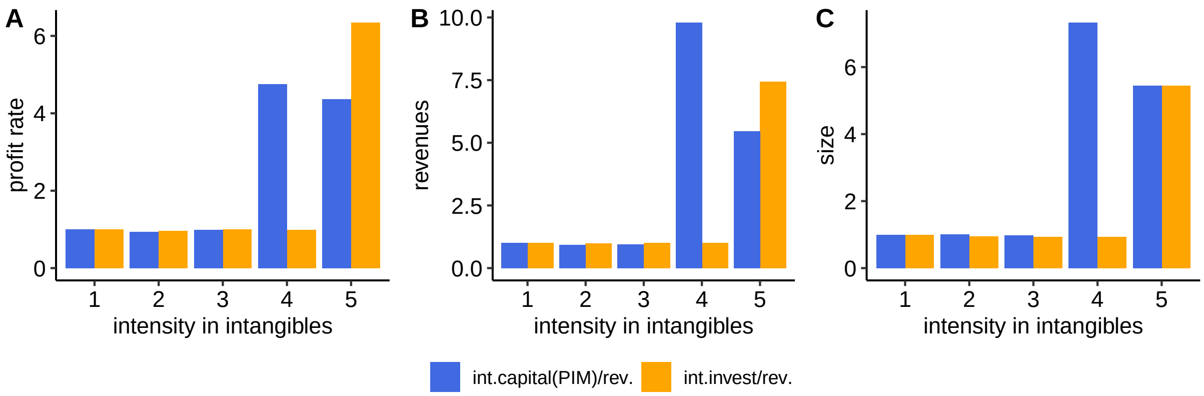
We find that ICT intensity is still positively correlated with the various measures of firm performance, in line with the literature. Still, the distribution is less skewed towards the

the balance sheet and that are harder to measure.

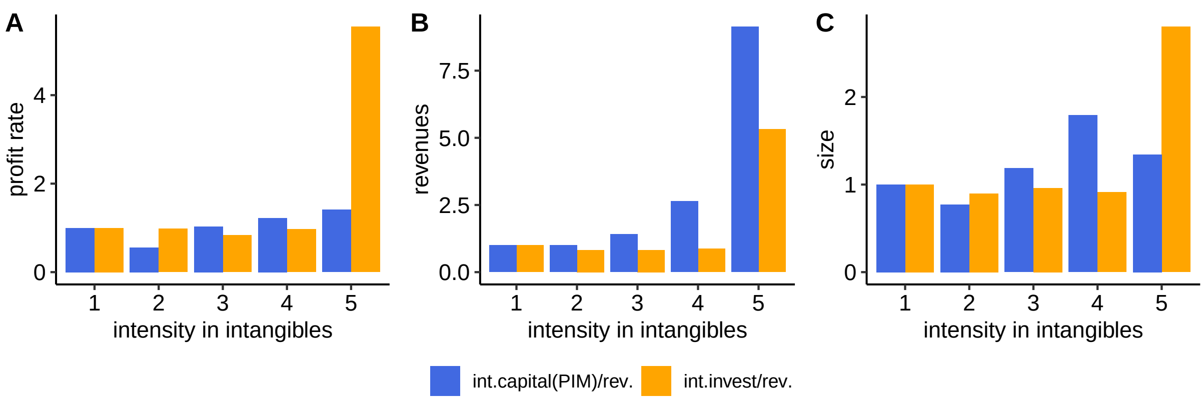
[20]see Section 3.2 for further details on how these variables are constructed.

[21]Additional analysis via a simple fixed-effect regression shows that all of the three dependent variables are not significantly correlated to intensity in intangibles, while this is not the case in France and Netherlands.

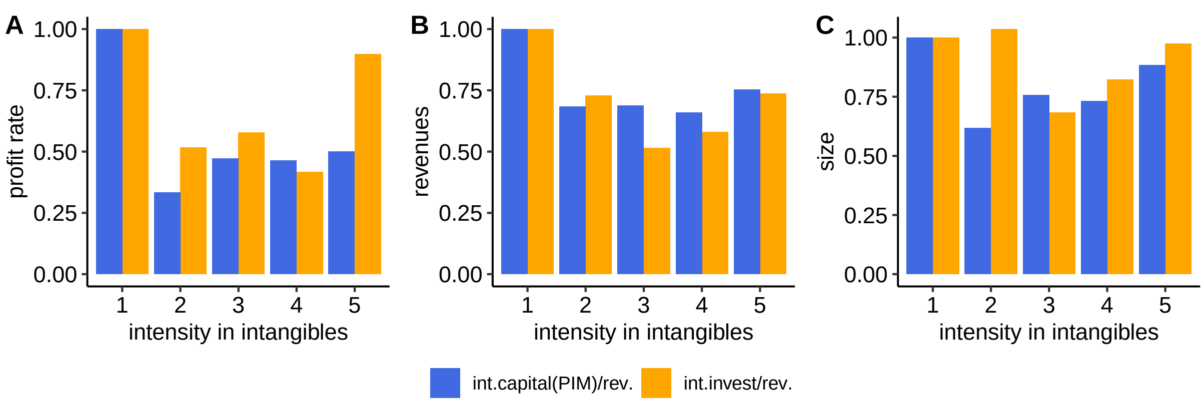
Figure 11: Intangible capital and firm performance.



(a) France



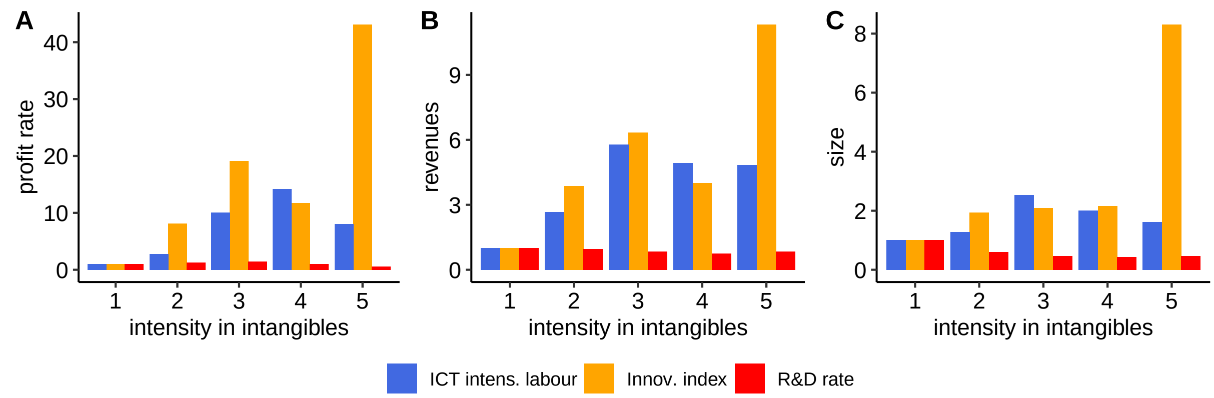
(b) Netherlands



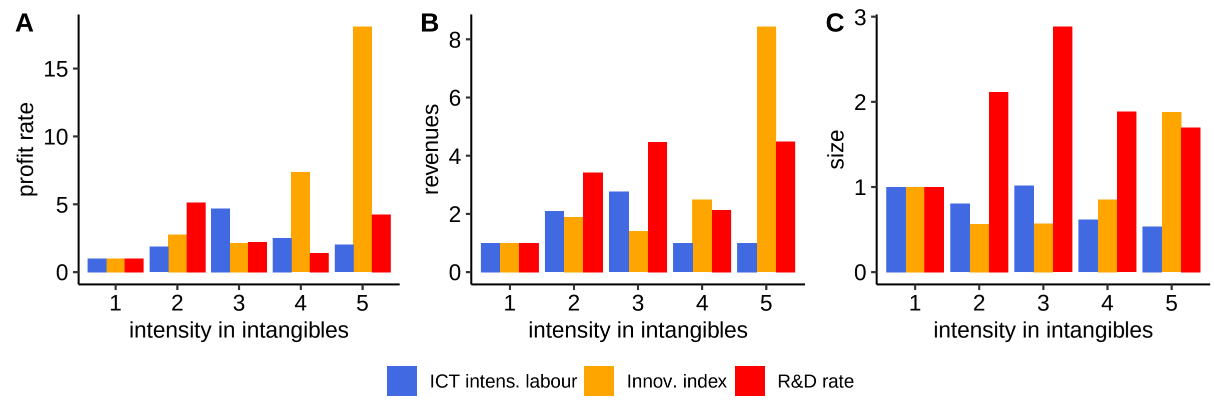
(c) Finland

Notes: Results refer to 2016. Profit rate (panel A), revenues (panel B) and size (panel C) by quintile of the distribution of intangibles. From left to right, blue bars refer to intangibles as intangible capital estimated via the PIM over revenues, yellow bar refer to investment in intellectual property as share of revenues. All values are presented in relative terms to the first quintile, which is normalized to 1. Source: MDI.

Figure 12: Intangible assets and firm performance



(a) France



(b) Netherlands

Notes: Results refer to 2016. Profit rate (panel A), revenues (panel B) and size (panel C) by quintile of the distribution of intangibles. From left to right, blue bars refer to ICT intensity, proxied by the share of employees who daily work with a computer; yellow bar refers to innovation capital, estimated starting from the CIS survey (see section 3.2); red bar refers to R&D expenditure as share of revenues. All values are presented in relative terms to the first quintile, which is normalized to 1. Source: MDI.

top quintile. This result can be explained by the fact that the economies we are studying are relatively mature and already with high intensity in ICT, on average, implying lower marginal returns of this asset. Different results could be obtained if we focus on the use of more advanced technologies, such as cloud computing, AI or use of big data, where dispersion and skewness of performance may increase together with ICT intensity to a greater extent.

If we move to the innovation index, we actually find higher skewness than in Figure 11. If we focus on panel A of Figure 12, for instance, we see that firms in the top quintile of the innovation index distribution can be as much as 40 (20) times more profitable than those in the bottom of the distribution in France (Netherlands). Similar levels of dispersion take place also for revenues and size, suggesting how firms that regularly perform product or process innovation, organization or marketing innovation outperform the rest of the economy. Some potential channels can be efficiency gains in the production process that unlock reduction in costs, ultimately leading to more competitiveness (Jona-Lasinio and Meliciani 2018). Additionally, lower prices or better quality of new or improved products can lead to higher revenues. Finally, more effective management practices and organizational experimentation can unlock gains in productivity and faster adoption of new technologies (Schivardi and Schmitz 2020). The latter are becoming especially relevant for determining firm performance and resilience to shocks (Lamorgese et al. 2021).

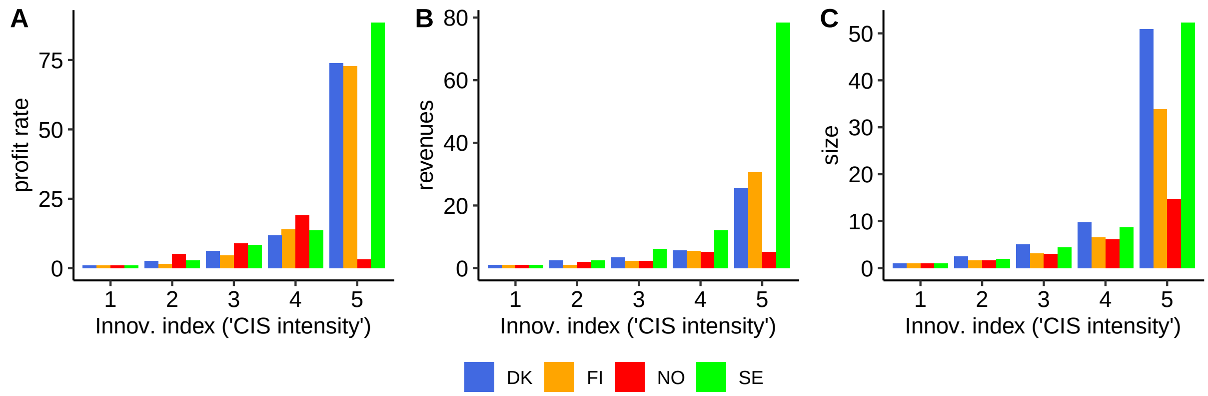
Finally, in the red column of Figure 12 we use R&D intensity (see section 3.2) as a proxy of intangibles. In this case we observe a much less pronounced correlation between intangibles and firm performance: higher R&D rates do not necessarily imply higher profits, revenues or size. This result may be determined by two factors: first, due to data availability, we restricted R&D to intramural R&D only. This may underestimate a larger portion of expenditure in innovation that could be more tightly linked to firm performance. Secondly, the CIS survey adopts as unit of observation a legal unit, therefore the entirety of several larger companies (made up by more than just one legal unit) is misrepresented when not all legal units that are part of a company are included in the survey. Consolidating innovation expenditure at the group level is therefore not trivial and is an aspect that the MDI team will further work on.

If we turn to the Nordic countries in the MDI, we are restricted in the type of analysis we can do, as R&D follows different reporting patterns than in France and Netherlands, requiring further harmonization. Still, in Figure 13 we present a cross country distribution of profit rate, revenues and employment conditional on the quintile of our innovation index ('CIS intensity') for Denmark, Finland, Norway and Sweden. Also in these countries we find a positive correlation, mainly skewed towards the highest quintiles of the innovation index. Such dispersion is in line with France and Netherlands, even if it is sometimes more pronounced in these countries.

In conclusion, from this initial analysis it is clear that, on average, intangibles correlate with higher profits, revenues and employment. Moreover, the dynamics seem to be largely driven by few firms that are the most intensive in intangibles. Different nuances emerge if we focus on different types of intangible assets, but all of them deliver this general conclusion[22]. High selectivity of returns from investment in intangibles do not only reflect

[22]Still, from Figure 11 we found quite peculiar dynamics in Finland that may hint at a different pattern for already more intangible intensive economies such as the Nordic countries when compared to the rest of our data.

Figure 13: Intangible assets and firm performance - Nordic countries



Notes: Results refer to 2016. Profit rate (panel A), revenues (panel B) and size (panel C) by quintile of the distribution of intangibles in Finland, Norway and Sweden proxied by the Innovation index ('CIS intensity'). All values are presented in relative terms to the first quintile, which is normalized to 1. Source: MDI.

in higher productivity dispersion, but also in higher distance between top firms and the rest of the economy. This could reinforce the phenomenon of 'superstar firms' (Autor et al. 2020), with potentially serious implications for concentration, market power and decline of the labour share. In the remainder of this section, we broadly investigate the concentration in ownership of intangible assets. Secondly, we investigate whether they are associated with higher concentration also in revenues and profits, and if they raise concerns for the labour share of income.

Ownership of intangible assets is highly concentrated. Table 8 shows the average ratio of intangibles over revenues for each decile of the distribution of intangible assets over revenues for the year 2016. We document that intangible assets are reported by relatively few firms and that they are highly concentrated. We can indeed see that in most countries the vast majority of firms (in most countries around 70%) do not report any intangible assets. Secondly, for those firms that do report some intangibles, these tend to be highly concentrated. Firms in the top 10% of the distribution are several times more intensive in intangible assets than the rest. It appears from the charts that intangible capital over revenues in the top 10% of the distribution is sometimes 10 times higher than the rest.[23]

We find similar numbers in the MDI, where in the countries for which we have data 10-15% of firms report any investment in intangible assets. Also in the MDI we find similar levels of skewness in the ratio of intangibles over revenues. Intangible asset creation

[23]Figure A.6 in the appendix further shows that while average intangible intensity stayed at a low level for the majority of firms from 2010 to 2016, it slightly increased for the 10% most intangible intensive firms in most countries.

Table 8: Concentration of intangible intensity.

	intangible k to rev_nom; mean				
	P10	P50	P70	P90	P100
BELGIUM	0.00	0.00	0.00	0.02	0.11
CROATIA	0.00	0.00	0.00	0.02	0.16
CZECH REPUBLIC	0.00	0.00	0.00	0.00	0.06
DENMARK	0.00	0.00	0.01	0.03	0.21
FINLAND	0.00	0.00	0.01	0.03	0.21
FRANCE	0.00	0.01	0.05	0.20	1.36
GERMANY	0.00	0.00	0.00	0.01	0.18
HUNGARY	0.00	0.00	0.00	0.01	0.13
ITALY	0.00	0.01	0.02	0.07	0.28
LITHUANIA	0.00	0.00	0.00	0.00	0.06
NETHERLANDS	0.00	0.00	0.00	0.02	0.35
POLAND	0.00	0.00	0.00	0.00	0.08
PORTUGAL	0.00	0.00	0.00	0.01	0.16
ROMANIA	0.00	0.00	0.00	0.01	0.08
SLOVAKIA	0.00	0.00	0.01	0.02	0.22
SLOVENIA	0.00	0.00	0.00	0.01	0.17
SPAIN	0.00	0.00	0.00	0.02	0.22
SWEDEN	0.00	0.00	0.00	0.01	0.11
SWITZERLAND	0.00	0.00	0.00	0.00	0.16

Notes: Results refer to 2016. Country level distribution of intangible assets over revenue. The table reports the firm average ratio for a decile of the distribution. Source: CompNet.

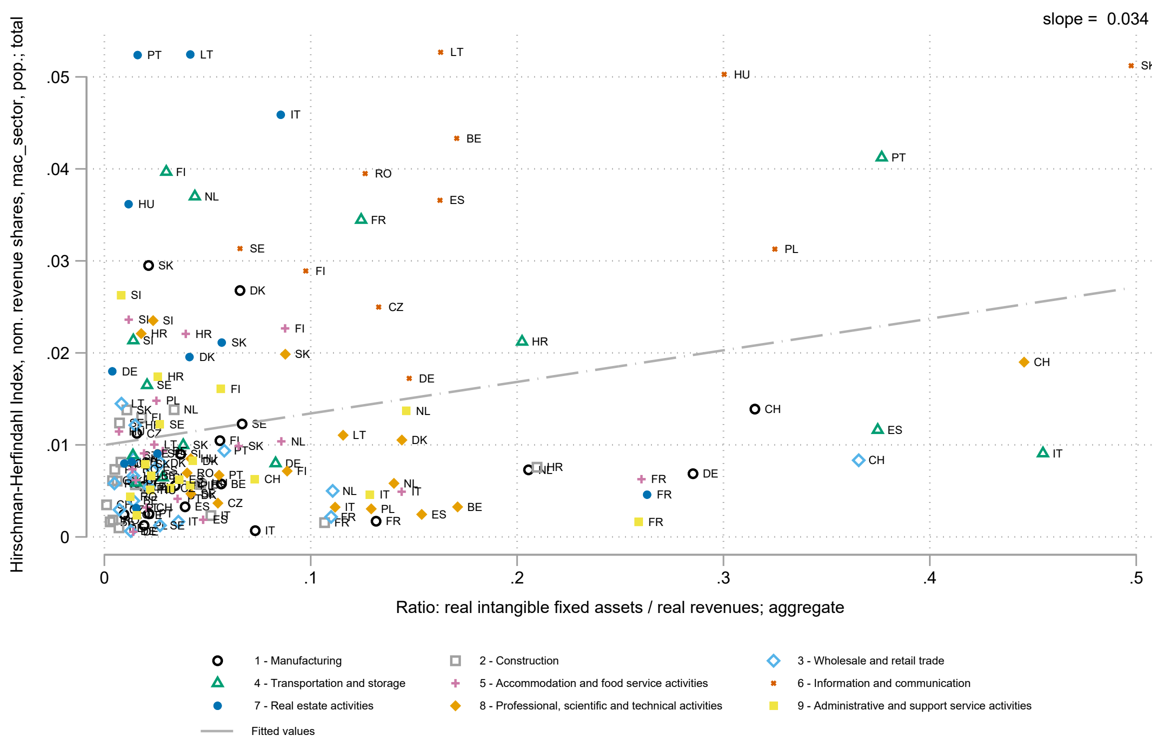
is also mostly concentrated in the Information and Communication sector, followed by Professional, Scientific and Technical activities and to a lesser degree, Manufacturing.

Industries that are characterized by high intensity in intangibles see higher revenue concentration and for some countries such concentration has been increasing over time. Further research should establish whether firms are paying back the sunk cost of investment in intangibles or if they are enjoying excess market power. There are several studies that associate intangible assets to higher concentration and market power (De Loecker et al. 2020; De Ridder 2019; Bajgar et al. 2021). The main motivation for this concern rests on the *scalability* of intangibles: valuable intangible assets display high economies of scale and once they are effectively deployed, they can support increased production at very low marginal cost. Moreover, intangible-intensive firms are more effective in raising entry barriers for potential competitors: as these assets have a firm specific value and are harder to imitate, knowledge diffusion is greatly subdued.

Over the long run, the theory implies an initial increase in productivity following the early phases of the rise in intangibles (Aghion et al. 2019; De Ridder 2019). Still, over time, the features mentioned above favor incumbents, reducing firm entry and business dynamism. Therefore, based on this theory we should observe higher market concentration in those industries that are more intensive in intangible assets.

We test this prediction in Figure 14 and in Figure 15, where we show the correlation at the industry level between intensity in intangibles and concentration in revenues and aggregate markups, respectively. We find a small positive correlation between intensity in intangibles and both revenues concentration (measured by HHI) and aggregate markups. We confirm these results through a regression adding industry and years fixed effects.

Figure 14: Intangibles and concentration

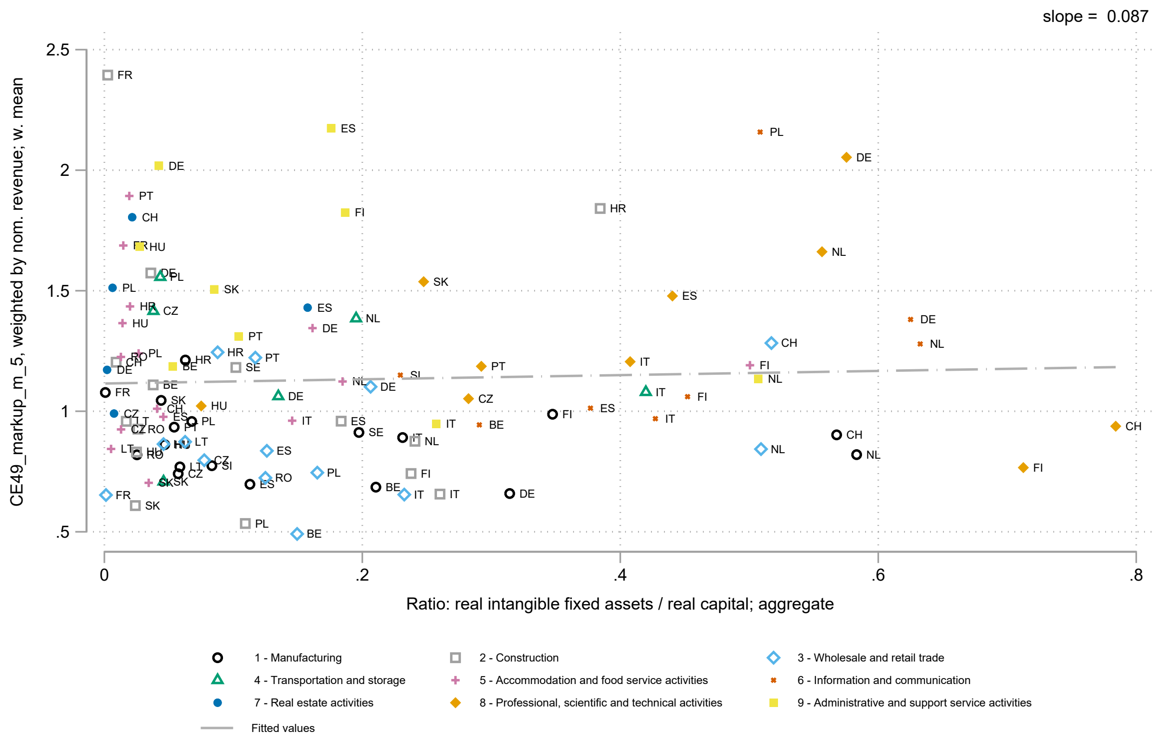


Notes: Cross country correlation between mean intangible assets over revenues and industry level HHI index of revenues concentration. Each point is a macro-sector country combination. Source: CompNet.

These results provide evidence in favour of a theory of intangibles increasing concentration and markups, but we remain agnostic on whether such concentration is determined by excess market power. It may indeed be that higher intensity in intangibles is associated with higher markups over marginal costs, as firms need to pay above their marginal cost to repay the sunk cost of investing in intangibles and not necessarily because they enjoy greater market power (Berry et al. 2019). At the same time, there are studies that seem to associate higher intensity in ICT to higher markups (Calligaris et al. 2018).

As a final result for this section, we investigate differences in trends in profit concen-

Figure 15: Intangibles and markups



Notes: Cross country correlation between mean intangible assets over revenues and average markups. Each point is a macro-sector country combination. Source: CompNet.

tration and average wages per employee between the knowledge intensive industries and the total economy. This investigation can provide initial evidence on whether gains from intangibles are shared evenly with the labour force, or if they mainly end up in the profit share of income.

We therefore plot trends of profit concentration and average wages in the knowledge intensive sectors vs the total economy. We define knowledge intensity using a Eurostat designed reclassification of the industry codes, based on R&D intensity and skill composition of the workforce [24].

We explore whether these sectors display both an increase in the HHI index for profit, which would be in line with intangibles fostering concentration, and an increase in average wages. If this is true, it could be a sign that intangibles favour the labour share of income and not only profits. Conversely, in the opposite case it could be that market power related to intangibles takes place in the labour market and not in the product market, as

[24]More details on the structure of the classification is available at: `https://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an3.pdf`.

suggested also by the previous section.

Results for the Netherlands and France are displayed in Figure 16, while for Finland in Figure 17. We run this analysis using the MDI data, and in panel A (first column from the left) we report trends in profit concentration while in panel B (second column from the left) trends in average wages. It is clear that in the first two countries the knowledge intensive industries present a rapidly increasing profit concentration and stagnating if not declining wages, while for the total economy profit concentration is mostly stable, as well as wages.

Such trends may signal policy issues, if intangibles disproportionally favour profits over labour income. This could be caused by skill premia widening and demand for labour reducing in intangible intensive economies, resulting in middle/low skilled workers receiving fewer employment opportunities and stagnating salaries.

At the same time, though, in Finland we do not observe a divergence between the knowledge intensive industries and the rest of the economy, with most trends progressing in parallel a part from some temporary deviations. Still, profits concentration and mean wages remain higher in the knowledge intensive economy for all the MDI countries (Table 9)[25].

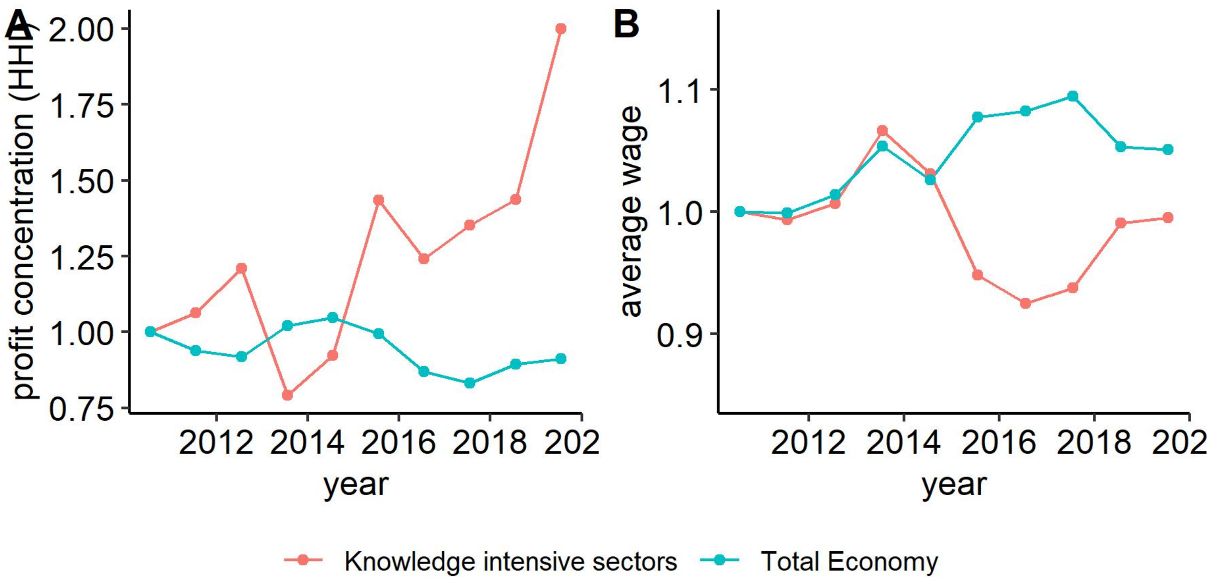
This last piece of evidence provides a more complex picture, with Finland and the other Nordic countries displaying lower disparities in profit concentration between intangible intensive industries and the rest of the economy. Also in terms of overall trends, there is no divergence in place between intangible intensive sectors and the rest of the economy.

Table 9: Time average of mean wages and profit concentration in the Knowledge Intensive sectors, as a ratio to the Total economy.

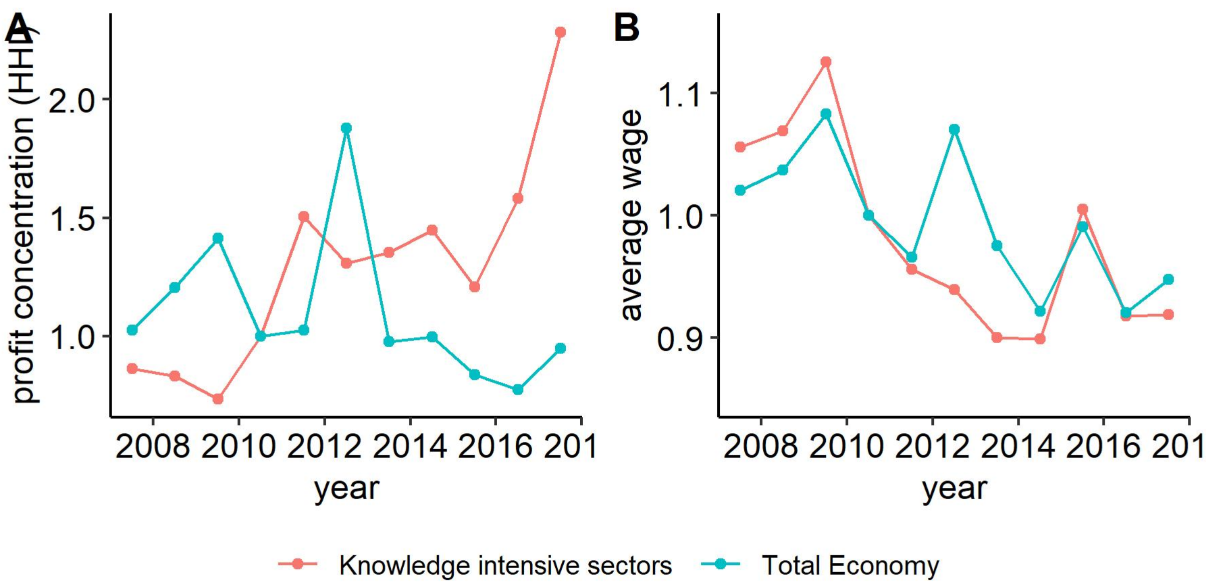
Country	Average wages	Profit concentration
Finland	0.92	0.94
France	0.99	1.17
Netherlands	0.96	1.50
Norway	0.91	1.46
Sweden	0.98	0.77
Denmark	0.97	0.23

[25] We provide results also for the other Nordic countries in Figure A.7. The picture for Denmark, Sweden and Norway resembles that of Finland, although the presence of outliers makes us more cautious in the interpretation of the results for these countries, and additional analysis may be required isolating from few very large enterprises that may drive the results.

Figure 16: Intangibles, concentration and wages



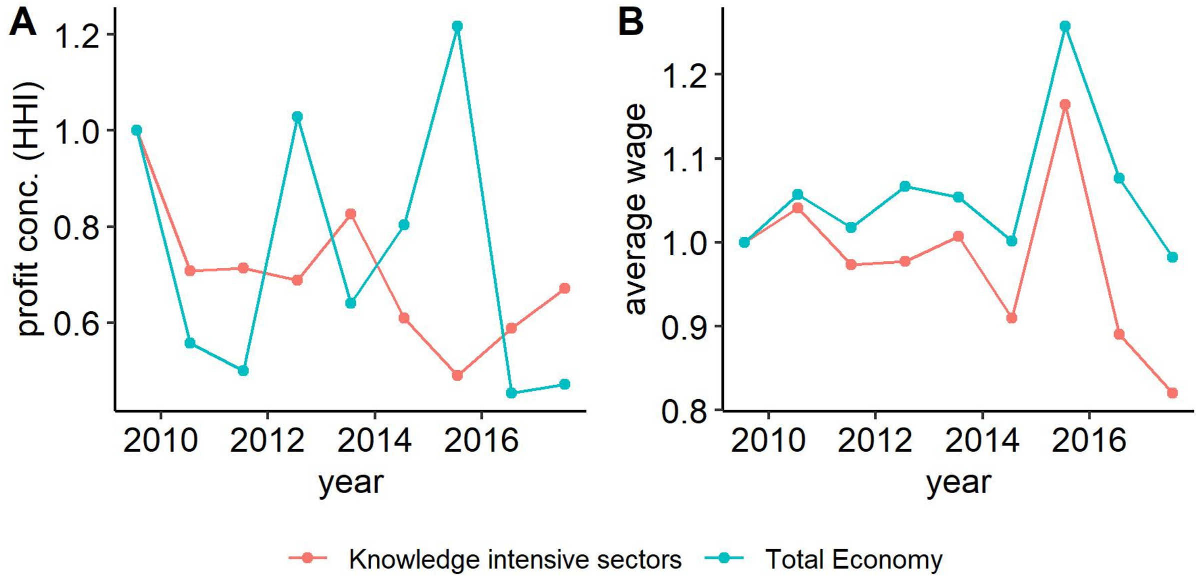
(a) France



(b) Netherlands

Notes: On the left (panel A) trend in HHI index of profits concentration for the knowledge intensive manufacturing and services and for the total economy. On the right (panel B), trend in average wage per employee, again for the knowledge intensive industries and for the total economy. Source: MDI. The time series for the Netherlands covers 2007-2017, France 2010-2019. The time point of 2013 for the Total Economy in the Netherlands has been interpolated, due to the presence of an undetected outlier.

Figure 17: Intangibles, concentration and wages



(a) Finland

Notes: On the left (panel A) trend in HHI index of profits concentration for the knowledge intensive manufacturing and services and for the total economy. On the right (panel B), trend in average wage per employee, again for the knowledge intensive industries and for the total economy. Source: MDI. The time series for Finland covers 2009-2018.

4 Discussion and Concluding Remarks

From the analysis carried out in the previous sections, we collect evidence in favour of intangibles correlating with better firm performance: firms that are more intensive in intangibles display higher profits, revenues and size, and the result is robust across multiple specifications of intensity in intangibles.

At the same time though, we present evidence in favour of intangibles being highly concentrated in the economy. The importance of the "top firms" is large in the intangible economy, and their distance from the rest of the economy is equally sizeable. We put forward as an explanation for this trend the higher dispersion across firms in returns associated with investing in intangible assets. Such higher dispersion may be motivated by multiple mechanisms, for example financial constraints or uncertainty. Concerning the first, access to credit may be harder for firms that want to invest in intangibles, as these assets provide poor collateral[26]. At the same time, macroeconomic uncertainty may push only few firms to invest, leading the economy in an "uncertainty trap" (Fajgelbaum et al.

[26]Note that this issue would then not be solved in conditions of "cheap" credit, i.e. with low interest rates or expansionary monetary policy.

2017).

In terms of trends, we document a diverse picture between the Nordic countries and France and the Netherlands, where the latter group experiences increasing profit concentration in time. There could be multiple explanations of this phenomenon. A first potential interpretation is related to the stage of development of intangible assets: the Nordic countries could be indeed at a more mature stage of diffusion and utilization of intangibles, thereby displaying more stable dynamics over time. Conversely, France and the Netherlands are still undergoing a more preliminary phase of development of these factors and technologies, resulting in a more unbalanced distribution of their benefits across firms. A different way of reading this result could be linked to policy: it is possible that the Nordic countries provide a regulatory environment that is less prone to profit concentration for industries that are more intensive in intangibles, or have intervened more actively in this sense, (for instance through fiscal policy). In either case, additional research using cross-country comparable micro data is needed to validate these findings and explore potential channels behind the phenomenon.

Rising concentration in intangible assets could contribute in explaining increasing dispersion in productivity, and if the diffusion of such assets becomes excessively unbalanced, it could also rise concerns about competition and the decline of the labour share. In the long run, such increasing concentration may in turn further jeopardize aggregate productivity growth as well, if cumulated market power by leading firms discourages them from innovating or leads to discriminatory practices affecting new potential entrants. We find preliminary evidence that this could operate through the labour market channel rather than through product market power, as markups are not correlated with intensity in intangibles, while the opposite is true for average wage growth.

At the same time though, we cannot rule out that the industry remains competitive, in the sense of free-entry with normal expected returns to investment. The higher markups found in the successful firms provide a return to their own initial investment in intangibles that is high enough to offset the losses of the unsuccessful firms for the economy as a whole. In this case, the high markups and skewed profits are the necessary conditions to induce firms in the market to innovate and invest in growth enhancing, yet risky, intangible assets.

In summary, these results call for more rigorous empirical analysis, both for determining what is the mechanism that brings intangibles to be associated with improved firm performance, but also on the broader consequences that this has on aggregate welfare. At the same time, it is worth stressing that the need of applied and cross country work in this field remains high, as within country dynamics oftentimes may be poorly representative of the overall trend in other contexts, even in an interconnected and overall economically developed geographical area such as Europe.

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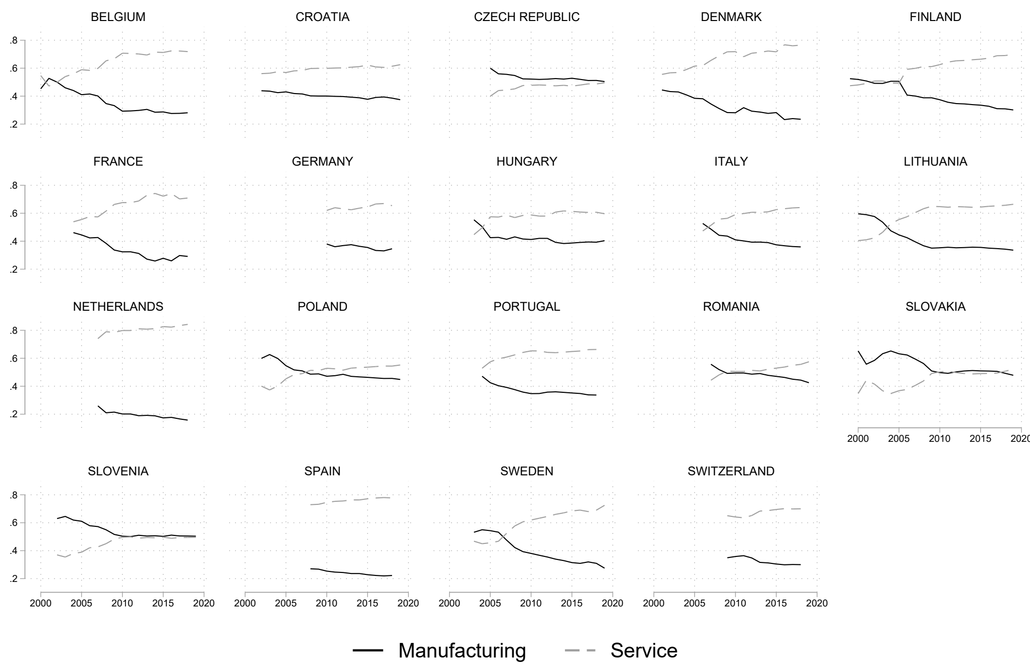
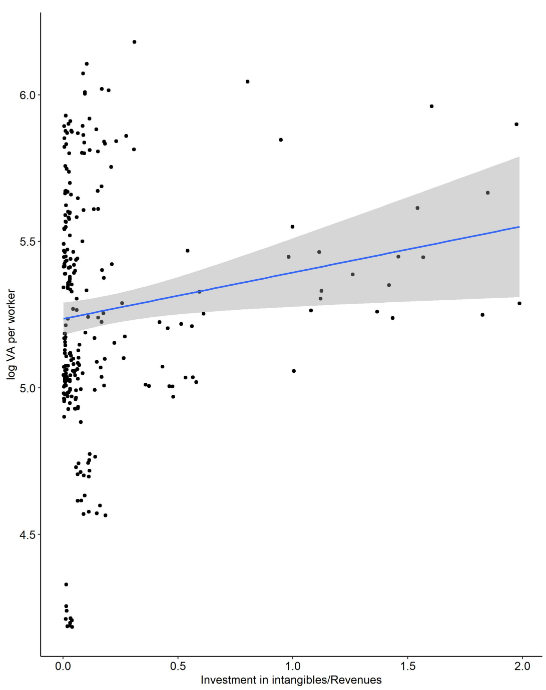
A Appendix

Figure A.1: Trends in Employment Shares.

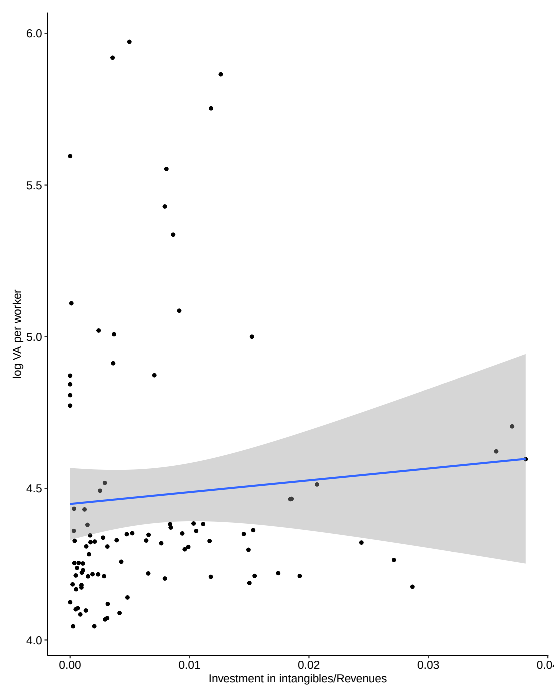


Notes: Share of employment in manufacturing and non-financial services (G-J & L-N) firms with more than 20 employees by country. Source: CompNet 8th vintage.

Figure A.2: Intangibles and productivity - MDI



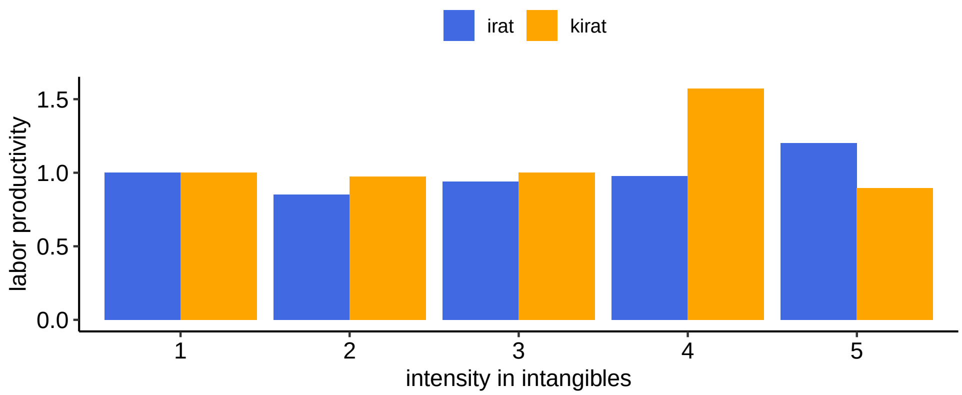
(a) France



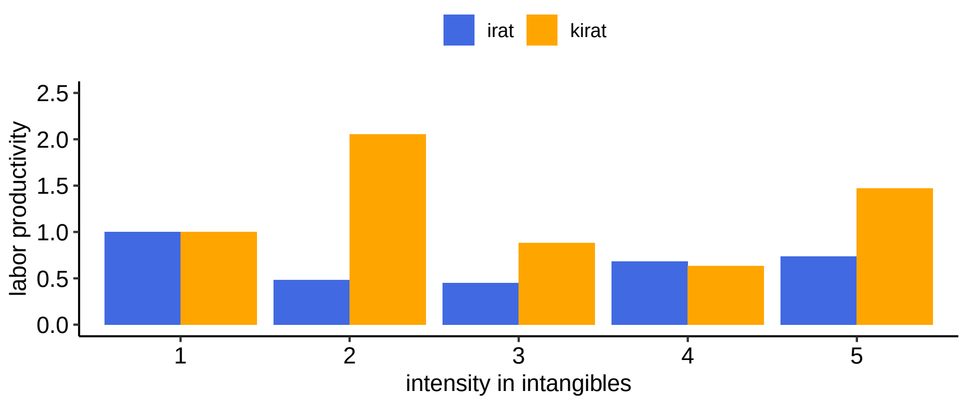
(b) Netherlands

Results refer to 2016. Each point refers to an industry within the country (aggregation based on 2-digit NACE code). Source: MDI.

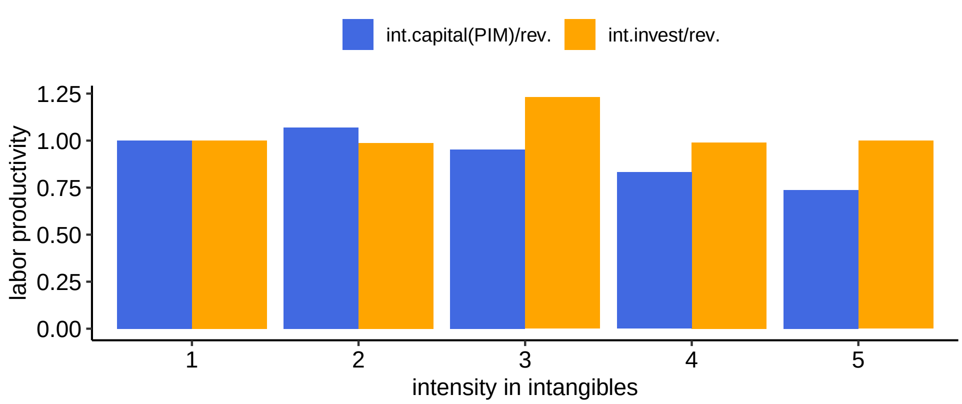
Figure A.3: Intangible capital and firm productivity.



(a) France



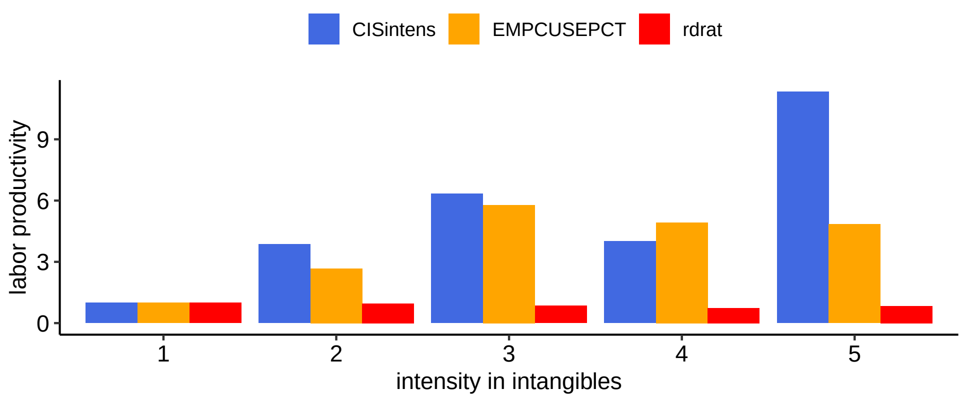
(b) Netherlands



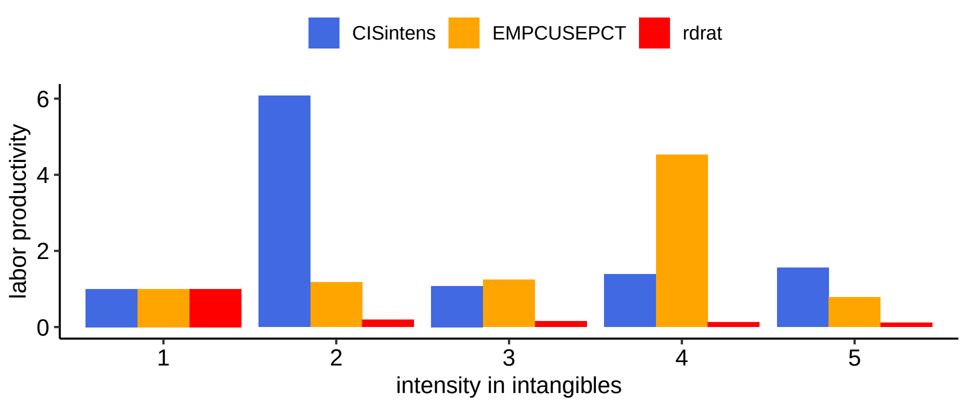
(c) Finland

Results refer to 2016. Labor productivity by quintile of the distribution of intangibles. From left to right, blue bars refer to intangibles as intangible capital estimated via the PIM over revenues, yellow bar refer to investment in intellectual property as share of revenues. All values are presented in relative terms to the first quintile, which is normalized to 1. Source: MDI.

Figure A.4: Intangible assets and firm productivity



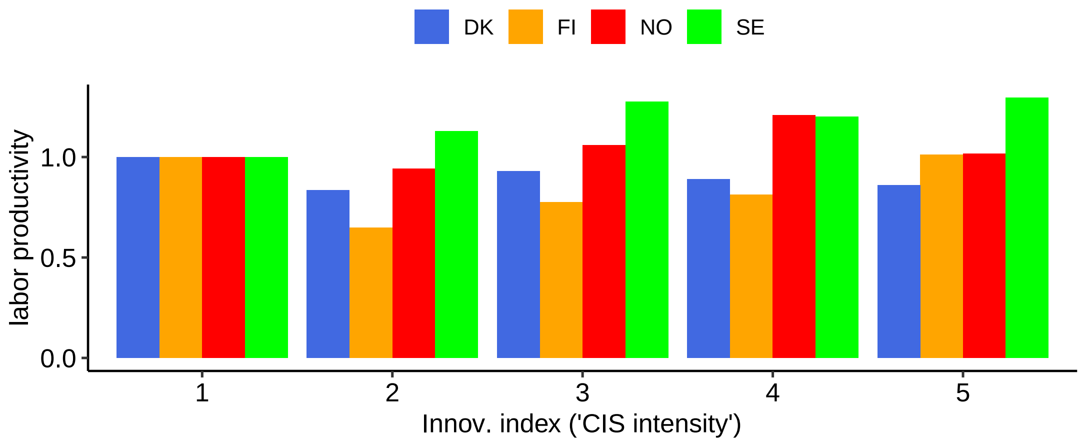
(a) France



(b) Netherlands

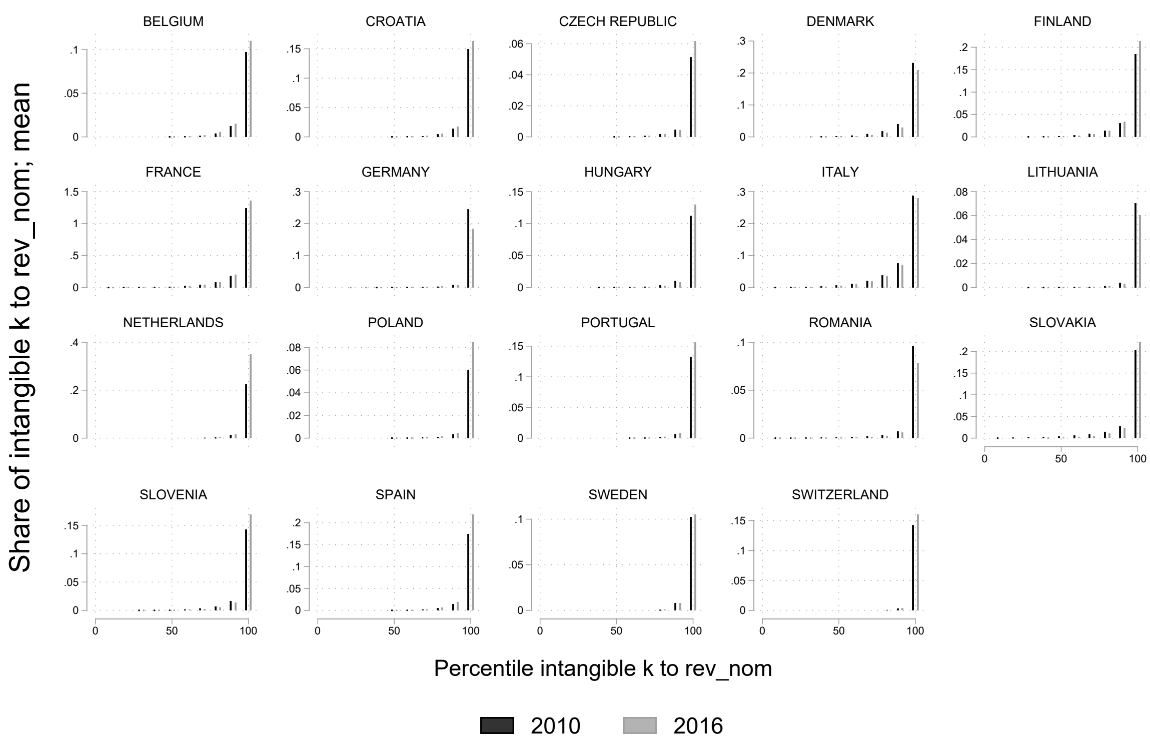
Results refer to 2016. Average labor productivity by quintile of the distribution of intangibles. From left to right, blue bars refer to ICT intensity, proxied by the share of employees who daily work with a computer; yellow bar refers to innovation capital, estimated starting from the CIS survey (see section 3.2); red bar refers to R&D expenditure as share of revenues. All values are presented in relative terms to the first quintile, which is normalized to 1. Source: MDI.

Figure A.5: Intangible assets and firm productivity - Nordic countries



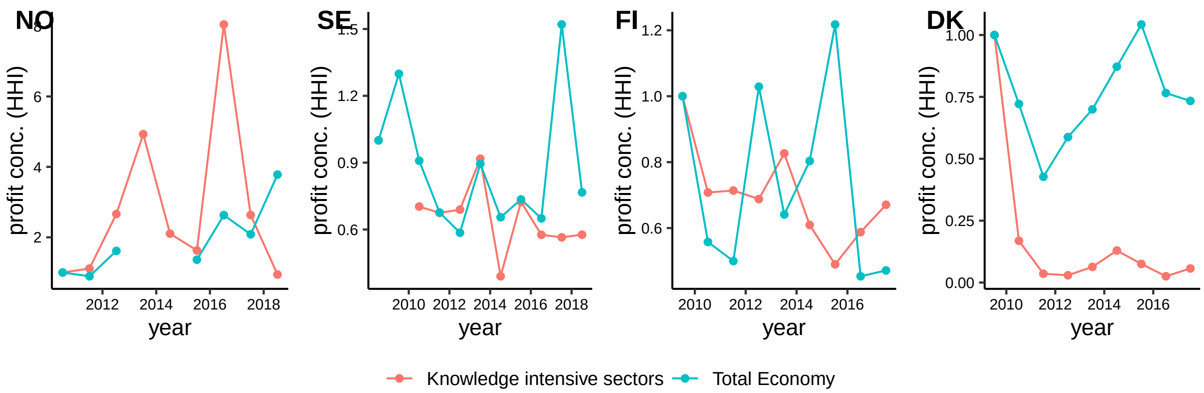
Results refer to 2016. Labor productivity by quintile of the distribution of intangibles in Finland, Norway, Sweden and Denmark proxied by the Innovation index ('CIS intensity'). All values are presented in relative terms to the first quintile, which is normalized to 1. Source: MDI.

Figure A.6: Country level concentration in reporting of intangible assets

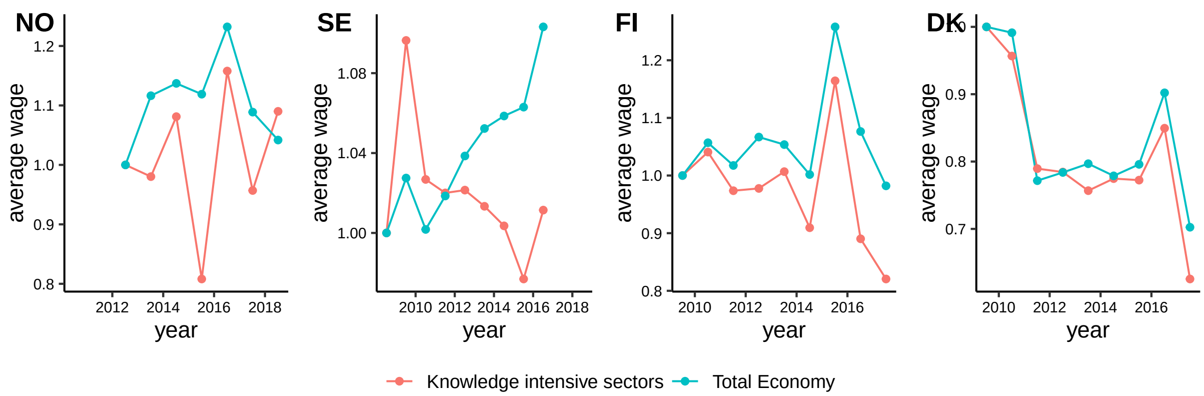


Country level distribution of intangible assets over revenue. Each bar reports the value of the ratio for a decile of the distribution. Source: CompNet.

Figure A.7: Intangibles, concentration and wages - Nordic countries



(a) Profit concentration



(b) Average wages

On the top row, trend in HHI index of profits concentration for the knowledge intensive manufacturing and services and for the total economy. On the bottom row, trend in average wage per employee, again for the knowledge intensive industries and for the total economy. In each row, results refer to Norway (left panel), Sweden (moddle panel) and Finland (right panel). The time series covers 2010-2018 for Norway, 2008-2018 for Sweden, 2009-2019 for Denmark and 2009-2017 for Finland.

Table A.1: Industry hierarchy by knowledge intensity.

nace	h_0	h_1	h_2
10	LTmfg	Low	TOTa
11	LTmfg	Low	TOTa
12	LTmfg	Low	TOTa
13	LTmfg	Low	TOTa
14	LTmfg	Low	TOTa
15	LTmfg	Low	TOTa
16	LTmfg	Low	TOTa
17	LTmfg	Low	TOTa
18	LTmfg	Low	TOTa
19	MLmfg	Low	TOTa
20	MHmfg	KI	TOTa
21	HTmfg	HT	TOTa
22	MLmfg	Low	TOTa
23	MLmfg	Low	TOTa
24	MLmfg	Low	TOTa
25	MLmfg	Low	TOTa
26	HTmfg	HT	TOTa
27	MHmfg	KI	TOTa
28	MHmfg	KI	TOTa
29	MHmfg	KI	TOTa
30	MHmfg	KI	TOTa
31	LTmfg	Low	TOTa
32	LTmfg	Low	TOTa
33	MLmfg	Low	TOTa
45	OTHmsv	Low	TOTa
46	OTHmsv	Low	TOTa
47	OTHmsv	Low	TOTa
49	OTHmsv	Low	TOTa
50	KImsv	KI	TOTa
51	KImsv	KI	TOTa
52	OTHmsv	Low	TOTa
55	OTHmsv	Low	TOTa
56	OTHmsv	Low	TOTa
58	KIoth	KI	TOTa
59	HTKIsv	HT	TOTa
60	HTKIsv	HT	TOTa
61	HTKIsv	HT	TOTa
62	HTKIsv	HT	TOTa
63	HTKIsv	HT	TOTa
64	KIfin	KI	TOTa
65	KIfin	KI	TOTa
66	KIfin	KI	TOTa
68	OTHmsv	Low	TOTa
69	KImsv	KI	TOTa
70	KImsv	KI	TOTa
71	KImsv	KI	TOTa
72	HTKIsv	HT	TOTa
73	KImsv	KI	TOTa
74	KImsv	KI	TOTa
75	KIoth	KI	TOTa
77	OTHmsv	Low	TOTa
78	KImsv	KI	TOTa
79	OTHmsv	Low	TOTa
80	KImsv	KI	TOTa
81	OTHmsv	Low	TOTa
82	OTHmsv	Low	TOTa
84	KIoth	KI	TOTa
85	KIoth	KI	TOTa
86	KIoth	KI	TOTa
87	KIoth	KI	TOTa
88	KIoth	KI	TOTa
90	KIoth	KI	TOTa
91	KIoth	KI	TOTa
92	KIoth	KI	TOTa
93	KIoth	KI	TOTa
95	OTHmsv	Low	TOTa

Notes: Classification of NACE Rev.2 industries (2-digit) by level of knowledge intensity / technology.