TESI
Territori
Economie
Società
Istituzioni

paper

07
2022

The age of intangibles: empirical evidences of the effects of intangible assets on firm's profitability, productivity and on the post COVID-19 recovery

The age of intangibles*: evidenze empiriche sugli effetti degli asset intangibili su profittabilità, produttività e ripresa post COVID-19 delle imprese*

di Marco Pini, Gaetano Fausto Esposito, Giuseppe Salonia

CENTRO STUDI DELLE CAMERE DI COMMERCIO GUGLIELMO TAGLIACARNE

Universitas Mercatorum
Università telematica delle Camere di Commercio Italiane

TESI | Territori Economie Società Istituzioni

paper

The age of intangibles: empirical evidences of the effects of intangible assets on firm's profitability, productivity and on the post COVID-19 recovery

The age of intangibles: *evidenze empiriche sugli effetti degli asset intangibili su profittabilità, produttività e ripresa post COVID-19 delle imprese*

di Marco Pini, Gaetano Fausto Esposito, Giuseppe Salonia

07
2022

CENTRO STUDI DELLE CAMERE DI COMMERCIO GUGLIELMO TAGLIACARNE

Universitas Mercatorum
Università telematica delle Camere di Commercio Italiane

Grafica della copertina e impaginazione: GIAPETO EDITORE srl con socio unico - Centro Direzionale Is. F2 - Napoli

Direttore Responsabile: Giovanni CANNATA e Gaetano Fausto ESPOSITO

Le linee editoriali congiunte Centro Studi Tagliacarne e Universitas Mercatorum
TESI (**T**erritorio, **E**conomia, **S**ocietà, **I**stituzioni). ***Instant Paper***, pubblicazione su blog con preliminare esame di coerenza;
TESI (**T**erritorio, **E**conomia, **S**ocietà, **I**stituzioni). ***Paper***, pubblicazione aperiodica priva di codifica caratterizzata da referaggio one side blind;
TESI (**T**erritorio, **E**conomia, **S**ocietà, **I**stituzioni). ***Discussion Paper***, pubblicazione aperiodica, dotata di ISBN rilasciato da Universitas Mercatorum, che viene pubblicata previo doppio referaggio blind;
TEMI (**T**erritorio, **E**conomia, **M**ercati, **I**stituzioni): raccoglie contributi teorici e analitici su call for papers tematici affini alle tematiche legate alla comunità scientifica di Universitas Mercatorum e del Centro Studi Tagliacarne.

Siti di distribuzione della pubblicazione:
www.tagliacarne.it/tesi_temi-30
https://www.unimercatorum.it/ricerca/tesi-e-temi.

Pubblicazione aperiodica

Centro Studi delle Camere di commercio G. Tagliacarne
Piazza Sallustio n. 9 – 00187 Roma
Universitas Mercatorum
Piazza Mattei, 10 – 00186 Roma

The age of intangibles: empirical evidences of the effects of intangible assets on firm's profitability, productivity and on the post COVID-19 recovery■

di Marco Pini*, Gaetano Fausto Esposito**, Giuseppe Salonia***

Abstract

We analyze at the firm level if the investments in the intangible assets boost profitability, productivity and accelerate the recovery post Covid-19 crisis. We considered four types of intangibles: i) intellectual property (including R&D); ii) organizational capital; iii) open innovation; iv) human capital. Through a mediation analysis on an integrated database (survey, balance sheet data, intellectual property data archive), we analyzed for around 2,000 manufacturing and service Italian firms the simultaneous relationship between the different types of intangible assets and their effects on firm's profitability (measured by gross operating margin), productivity (value added per employee), and on firm's resilience (in terms of the capacity to rise back to pre-Covid production level by 2021). The results show that especially intellectual property rights and organizational capital positively influence firm's profitability and productivity, while open innovation particularly firm's resilience. Moreover, we found that human capital exerts a direct, as well as an indirect effect on these performances via influencing the other three types of intangible assets. Thus, policies for the economic recovery should consider the investments in intangibles as key factors and especially in a organic way also through the role of the territorial institutions.

■ This paper is an advancement in research of the Position paper presented at the XIV COTEC Europe Summit, Malaga 17 November 2021: Unioncamere-COTEC (2021). *The effects of intangible assets on firm's profitability, productivity and on post-covid recovery: firm level empirical evidences from Italy*.

* Centro Studi delle Camere di Commercio Guglielmo Tagliacarne, Rome, Italy, e-mail: marco.pini@tagliacarne.it (corresponding author).

** Centro Studi delle Camere di Commercio Guglielmo Tagliacarne, Rome, Italy, e-mail: gfesposito@tagliacarne.it

*** Unioncamere (Italian Union of Chambers of Commerce), Rome, Italy, email: giuseppe.salonia@unioncamere.it.

The age of intangibles: evidenze empiriche sugli effetti degli asset intangibili su profittabilità, produttività e ripresa post COVID-19 delle imprese

Sommario

Si analizza a livello di impresa se gli investimenti negli asset intangibili aumentano la profittabilità, produttività e accelerano la ripresa post crisi Covid-19. Gli asset intangibili sono studiati prendendo in considerazione le seguenti quattro tipologie: i) proprietà industriale (inclusa la R&S); ii) capitale organizzativo; iii) open innovation; iv) capitale umano. Attraverso un'analisi della mediazione su un database integrato (risultati provenienti da un'indagine, dati di bilancio, archivio sui titoli della proprietà industriale), sono state analizzate per circa 2.000 imprese italiane manifatturiere e dei servizi, le relazioni simultanee tra le differenti tipologie di asset intangibili e i loro effetti sulla profittabilità (margine operativo lordo), sulla produttività (valore aggiunto per addetto) e sulla resilienza (in termini di capacità di ritornare ai livelli produttivi pre-Covid entro il 2021. I risultati evidenziano che sono soprattutto la proprietà industriale e il capitale organizzativo gli asset intangibili che influenzano maggiormente la profittabilità e la produttività dell'impresa, mentre l'open innovation influenza particolarmente la resilienza produttiva. Inoltre, i risultati mostrano che il capitale umano esercita un effetto su queste performance sia diretto che indiretto influenzando le altre tre tipologie di asset intangibili. Quindi, le politiche sulla ripresa produttiva dovrebbero considerare seriamente gli investimenti negli asset intangibili delle imprese come fattore chiave, e soprattutto in una maniera organica e strutturata anche facendo leva sul ruolo delle istituzioni territoriali.

Keywords: Intangible assets; Profitability; Productivity; COVID-19; Production recovery

Parole chiave: Asset intangibili; Profittabilità; Produttività; COVID-19; Ripresa produttiva

Classificazione JEL: D22; L20

1. Introduction

In 2014 Brynjolfsson and McAfee published "The Second Machine Age" underlining that «Production in the second machine age depends less on physical equipment and structures and more on the four categories of intangible assets: intellectual property, organizational capital, user-generated content, and human capital» (Brynjolfsson & McAfee, 2014).

In the new economic era characterized by

Knowledge economy, Fourth Industrial Revolution, environmental sustainability, global competition, and servitization, intangible assets became a key resource for the growth and the competitiveness all over the world (Haskel & Westlake, 2018; OECD, 2011). Despite the importance of the tangible assets, such as structures and equipment, that continues to be important for the production of good and services, their relative weight has declined over time in contrast to the raise of the intangible assets (Martins & Alves, 2010). In some countries the investments in intangible assets equals or surpassed tangible ones such as building, equipment and machinery (OECD, 2011).

This also because intangible assets touch all aspects of a company: both internally concerning human capital, R&D, organizational capital, involving the entire business model (Brynjolfsson & McAfee, 2014, 2002), and externally regarding the relationship with other actors according to the concept of the open innovation (Chesbrough, 2003). Indeed, intangible assets account for up to 80% of the company's value (Vodák, 2011). They are acknowledged as a key driver of firm competitiveness, also including the resilience to large shock such as the Covid-19 crisis, thanks to their complementarity with digital technologies that increases the flexibility and the speed of the reorganization (OECD, 2011). Recent empirical studies for the Italian case have demonstrated that digital reorganization accelerates the production recovery especially for less competitive firms (Unioncamere-Centro Studi delle Camere di Commercio Guglielmo Tagliacarne, 2021), and much more than the classical reorganization (Cugno et al., 2022).

Nevertheless, in the literature there are still controversial results about the impact of the intangible assets on firm's performance; furthermore at international level, including the Italian case, there is a lack of empirical studies investigating simultaneously the relationship between the various intangible assets and their effects on firm's performance. Overall, the existing studies investigated only some types of intangible assets: only R&D; only advertising intensity; just balance sheet intangible assets; difference between market value of equity and book value of equity; intellectual capital (for a literature review see, e.g., Bhatia & Aggarwal, 2018). Moreover, most studies investigate more large enterprises rather than Small and Medium Enterprises (SMEs) (Seo & Kim, 2020). Furthermore, according to our best knowledge, there are no contributes estimating at the firm level the effects of the intangible assets on the recovery post Covid-19 crisis.

The present study aims to fill this gap providing empirical evidences for the Italian case to policy makers. Considering the increasing importance of the intangible assets in the economy, on one hand, and the fact that they behave differently from tangible ones, on the other hand, empirically studying the intangible assets is crucial for the most effective policy reform for growth and competitiveness (OECD, 2011; Haskel & West-

lake, 2018). This is true in the Italian case for at least two reasons: firstly, in Italy the increase of the intangible assets was much greater than those referred to tangible ones (from 1995 to 2018, respectively, +39.3% vs 7.6%); secondly, the intangible assets-to-GDP ratio of Italy in 2018 (6.7%) is higher than other major European countries, such as Germany and Spain (Fundación Cotec-IVIE, 2021).

Although intangible assets remain a concept still difficult to define and measure, we adopted the approach defined by Brynjolfosson and MacAfee (2014) who identify four types of assets: i) intellectual property (including R&D); ii) organizational capital; iii) user-generated content (that we broadened to the concept of open innovation); and human capital. Through a mediation analysis, we analyzed simultaneously the relationship between the different types of intangible assets and their effects on firm's profitability (measured by gross operating margin), productivity (value added per employee), and on firm's resilience in terms of the capacity to rise back to pre-Covid production level by 2021. To do this, a database at the firm level was constructed bridging useful information (both qualitative and quantitative) of the Italian Chambers of Commerce system. Specifically, the database refers to a dataset collecting the results of a survey carried out by Centro Studi Guglielmo Tagliacarne (Italian Research Centre of the Chambers of Commerce) and Unioncamere (Italian Union of Chambers of Commerce) in 2020, integrated with other information about balance sheet data, certifications and intellectual property rights data. The integrated database is composed of around 2,000 Italian manufacturing and service firms between 10 and 499 employees.

Thus, the originality of the study is to investigate at the firm level the degree of diffusion of intangible assets, the effects of each category of intangible assets on firm's performances, with highly topical analysis concerning the speed of the post-Covid production recovery. The paper is structured as follows: Section 2 explains the theoretical framework and the research hypotheses; Section 3 describes data and variables description; Section 4 illustrates the econometric methodology; Section 5 reports results and discussion; Section 6 concludes.

2. Theoretical framework and research hypoteses

2.1 The definitions of intangible assets

As widely recognized, intangible assets are difficult to define and measure. So far there is no uniform definition and consistent data. Hulten et al. (2010, p. 6) define intangible assets as assets that «involve the development of specific products or processes, or are investments in organizational capabilities, creating or strengthening product platforms that position a firm at the top to compete in certain markets». However, there are different approaches to address this issue. Firstly, some authors focus on firm's stock market value (e.g., Hall, 1999). Secondly, others

(e.g., Arrighetti et al., 2014 in a study on Italian enterprises) use the value of the item "intangible fixed assets" reported in the balance sheet (that includes e.g., R&D and advertising, patents, copyrights, and original works, licenses, trademarks and similar rights, goodwill, etc.). Thirdly, others study intangible assets focusing on expenditures, such as those related to staff training and professional development, innovation, marketing, management expertise and workplace relations, including also patents, registered trademarks or simply goodwill (e.g., Webster, 2000), as well as expenditures on designs, software, blueprints, ideas, artistic expressions, for testing and marketing of new products (e.g., Nakamora, 2001). Lastly, some refer to intangible assets through the concept of Intellectual Capital considering intellectual property and human capital (e.g., Bontis et al., 2000).

The most established contributes at the macroeconomic level (Haskel & Westlake, 2018; Corrado et al., 2005, 2009, 2016, 2018) measure intangibles considering expenditures related to the three following categories: i) computerization and information (e.g. software and database); ii) innovative property (e.g., R&D, design, artistic originals); iii) economic competencies (e.g., advertising, marketing research, organizational capital, training). Adopting this last approach, EU-KLEMS estimates the value of intangible assets for European countries plus United Kingdom, United States and Japan.

Brynjolfsson and McAfee (2014) provide a wider definition identifying intangible assets through four categories: i) intellectual property (includes also R&D); ii) organizational capital; iii) user-generated content; iv) human capital. In this study we adopt this definition because it looks at this concept in a wider way taking into account also the innovation ecosystem (i.e. firm's relationship with external actors). Specifically, intellectual property mainly refers to patents and copyrights but also to R&D that is very valuable even if rarely formalized as intellectual property. Organizational capital refers to business processes, techniques of production, organizational forms, and business models, that often are required when we are dealing with the adoption of new technologies of the second machine age. Concerning user-generated content, given its nature, in this study we broadened the concept to open innovation since nowadays co-innovation regards not only users but also many other actors. Indeed, the open innovation concept emphasizes the fact that firms take competitiveness advantages not only from internal knowledge but, increasingly, from several external actors involving managed inflows and outflows of knowledge across organizational boundaries (Chesbrough, 2003; Chesbrough & Bogers, 2014). More specifically, open innovation concerns: firstly, cooperation with other firms, universities, clients, end-users (inbound); secondly, the transfer of ideas and technological knowledge from the firm to external environment for obtaining economic benefits (outbound); thirdly, coupling of these two activity types. Finally, hu-

man capital relates to schools learning skills and the additional learning that happens on the job and on our own. In this regard, Becker (1993) considers education and training the most important investment in human capital; Marimuthu et al. (2009, p. 266) state that «human capitals refer to processes that relate to training, education and other professional initiatives in order to increase the levels of knowledge, skills, abilities, values, and social assets of an employee»; Ballot et al. (2001) underline that firms increase human capital through training activities together with hiring educated workers.

2.2 Intangible assets and firm's performance

While in the past firm's profitability almost exclusively depended on tangible assets like land, infrastructure, and equipment, nowadays it increasingly depends on intangible ones (Haskel & Westlake, 2018). There is a broad consensus on the determinant role of the intangible assets for firm's survival and success (Seo & Kim, 2020). Specifically, intangible assets provide vital and valuable competitive advantages to the firm through several ways. Firstly, by creating corporate market value (Vodák, 2011). Secondly, by supporting innovation (OECD, 2008), also including the introduction of modern and flexible strategic planning and operation (Wheelen & Hunger, 2011) as well as involving the adoption of new business models. Thirdly, the competitive edge comes also from the fact that intangible assets are unique, rare and difficult for the competitors to imitate (Denicolai et al., 2015), allowing to firm to generate increasing returns over time in contrast to physical assets that may be most characterized by diminishing marginal returns (Denicolai et al., 2015). Fourthly, these greater persistence of the returns over time is sustained also by the fact the intangible assets improve customer attainment and preservation strengthening the brand image of the company (OECD, 2008); this also also because firm's success driven by the intangible assets is more believable in the market (e.g., Montresor & Vezzani, 2016).

Many empirical studies highlighted positive effects of the intangible assets investments on firm's performance. Zhang (2017), by studying listed telecommunication firms in China, found a positive impact of the intangible assets ratio (intangible assets divided by total assets) on Return on Assets (ROA). Adopting the same measurement of the intangible assets, Bubic and Susak (2015) tested the effects on several indicators besides ROA, such as Return on Equity (ROE), Net Profit Margin, and Gross Profit Margin. Dženopoljac et al. (2016) studied the effect of the intellectual capital on financial performance, in information communication technology (ICT) industry of Serbia, finding positive results. Gamayuni (2015), for Indonesians businesses, found a positive influence of the intangible assets on firm performance (ROA) and firm's value. Bhatia and Aggarwal (2018), for Indian companies, found a positive influence of intangible assets (taking into account data from the balance sheet and others

such as brands, customer and supplier relations, the organization management, individual skills) on firm performance (ROA, ROE, Tobin's Q). More recently, Qureshi and Siddiqui (2020), by analyzing sixteen countries in technological sectors from 2015 to 2018, found a positive impact of the intangible assets (measured by research and development, patents, concession rights, trademarks, software, etc.) on profitability (ROA, ROE, ROIC), efficiency and market value. On the same line, Seo and Kim (2020), for Korean SMEs, highlighted the positive influence of the intangible assets (human capital, R&D, advertising) in improving firm's profitability (gross profit margin) and value.

Besides profitability, several studies highlighted a positive impact of the intangible assets also on the productivity (e.g., Crouzet & Eberly, 2018; Añón Higón et al., 2017), by supporting the full exploitation of technology into improved productivity (Mohnen et al., 2018; Corrado et al., 2017).

Several studies investigated, but only separately, the impacts of the different types of intangible assets according to the definition of Brynjolfsson and McAfee (2014) – that we adopted – on firm's performance. For instance, regarding intellectual property (that may include also R&D) there is a large consensus on their positive influence on firm's performance. Several studies found a positive effect of account patents, copyrights, trademarks and licenses (e.g., Bloom & Van Reenen, 2002; Greenhalgh & Rogers, 2012;; Yuan et al. 2021; EPO-EUIPO, 2021) on firm's performance, as well as for R&D (e.g., Ehie & Olibe, 2010). Concerning organizational capital, since it relates to new business models (Brynjolfsson & McAfee, 2014, 2002), it may have a strong effect on firm's performance because, as highlighted by some scholars, the competition among firms – both at the national and international level – increasingly relies on innovative business models rather than, i.e., traditional forms of innovation (Gassmann et al., 2013; Schiavi & Behr, 2018; Ciriello et al. 2018). New business models, based on organizational capital, can generate competitive advantages in several ways: i) exploiting the full potential of the new technologies (Chesbrough, 2010); ii) making the existing business models obsolete (Johnson et al., 2008; Osiyevskyy & Dewald, 2015); iii) sustaining benefits over time because they are difficult to imitate (The Boston Consulting Group, 2009); iv) by lowering transactions costs; v) exploiting new business opportunities (Zhang et al., 2018).

Nowadays, in the current digital era, firms can compete only through open minds and open systems (Brynjolfsson & McAfee, 2014). Indeed, according to the concept of open innovation (Chesbrough, 2003), firms focusing on new business models are able to exploit and to make the best use of the innovation in the market. Clearly, the combination of internal and external knowledge supports economic performances (Zhang et al., 2018) through several ways: i) removing the inefficiencies (including that technological); ii) joining complementary expertise and skills; iii) reducing

the risk-aversion; iii) leveraging capabilities (of all actors) of generating increases of returns (for a review of studies on the effects of open innovation on firm's performance, see, Bigliardi et al., 2020). Indeed, several studies found a positive effect of open innovation on firm's performance (e.g., Crema et al., 2014). Recently, the importance of open innovation was further highlighted with the following question: «How might open innovation accelerate the coordination of business and other activities in the face of societal challenges?» (McGahan et al., 2021).

Finally, according to human capital theory (Becker, 1962; Schultz, 1961), human capital investments in training positively affects economic growth. At the firm level, many studies highlighted the positive influence of human capital on profitability (e.g., Del Valle & Castillo, 2009), since it: i) favours the absorption of new knowledge, technology and skills (Unger et al., 2011); ii) moves a tacit knowledge (Hatch & Dyer, 2004); iii) enables employees to absorb new missions quickly together to solve different assignment to achieve company's targets.

2.3 Hypoteses development

In the light of the arguments above reported, we state the following hypotheses:

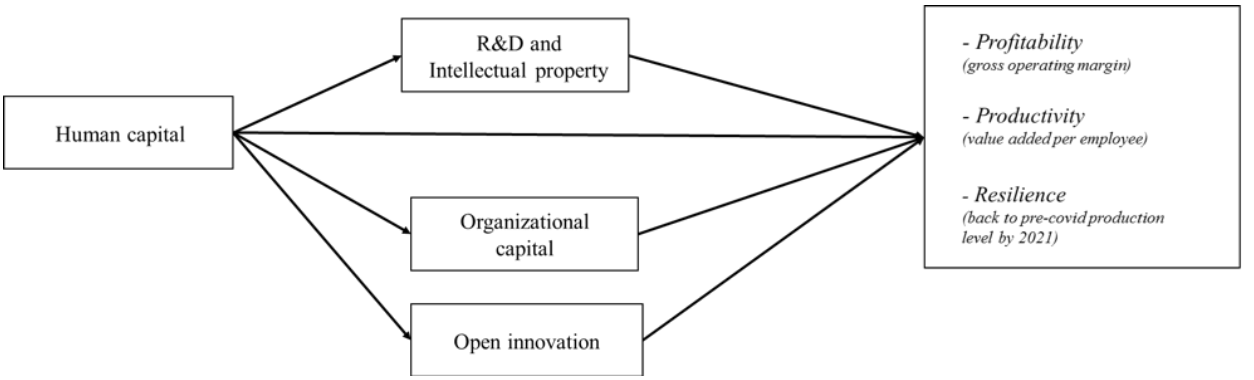
Hp1. Firms investing in intangible assets have a higher level of profitability

Hp2. Firms investing in intangible assets have a higher level of productivity

Hp3. Firms investing in intangible assets have a higher resilience in terms of the capacity to rise back before to pre-Covid production level

These hypotheses develop on the basis of a framework (Fig. 1) that: i) adopts the definition of intangible assets according to Brynjolfsson and McAfee (2014); ii) considers human capital an input of the innovation (Romer 1990; Nelson & Phelps, 1966) (in our case R&D and Intellectual property, and Open innovation) as well as of the organizational issues (Pasban & Nojedeh, 2016).

Figure 1 - Framework analysis



Thus, the human capital is as a factor influencing firm's performance and resilience both directly and indirectly via its influence on the other three types of intangible assets (R&D and Intellectual property, Organizational capital, Open innovation).

3. Data and variables description

3.1 Data

The analyses are conducted on a database built from the merge of different databases. The main datasource is a survey carried out by Centro Studi Gugliemo Tagliacarne and Unioncamere at the end of 2020 on a representative sample of 4,006 Italian manufacturing and services firms with a number of employees between 5 and 499. Nevertheless, the analyses focused on firms with at least 10 employees (until 499) for reasons of databases crossing. The sample of the survey is composed of 3,000 manufacturing firms, that represents 2.3% of the corresponding universe of Italian population in terms of firms, with an oversampling of 1,000 service firms representing 0.3% of the corresponding universe. The stratification of the sample considered three dimensions for each firm. i) industry according to seven sectors: food manufacturing; personal and households goods manufacturing; mechanical manufacturing; other manufacturing activities; trade; accomodation and food service activities; other service activities; ii) size class in terms of employees (5-9, 10-49, 50-249, 250-499). iii) geographical location (North-West, North-East, Center, South). The maximum sampling error is small (e=1.8%; α=0.95%). The survey is carried out by CATI (Computer-Assisted Telephone Interviewing) method by a professional contractor with the aim of gathering both qualitative and quantitative information on the firm. Several preliminary briefings are held with the contractor aiming to explain to interviewers the exact meaning of the questions. The quality of the data is subsequently validated. Furthermore, according to Dorling and Simpson (1999) the quality of data is also ensured by the fact that they come from a public agency confirming a high response rate and the representativeness of the population. The questionnaire of the survey contains several specific sections concerning the following issues: i) corporate governance; ii) internationalization; iii) Covid-19 crisis (the impact, the recovery time, and the business strategies for overcoming the crisis); iv) open innovation focusing on firm's relationship with internal and external actors for co-innovation activities; v) human capital (training activities and specific strategies on digital skills). Information about some firm's structural characteristics (e.g. age, number of employees, economic sector, geographical location) comes from administrative archive.

Industrial property rights data are provided

by Dintec[1] through the Unioncamere-Dintec Integrated Industrial Property (UDIIP) database[2]. Specifically, data on intellectual property used for the analyses include: i) patent applications published by the EPO (by Italian applicant or there is at least one Italian "owner") and applications submitted under the PCT (Patent Cooperation Treaty) that provides for the extension to Europe and the transmission at the EPO; ii) trademark filing at the EUIPO submitted by an Italian applicant; ii) design patent publications at the EUIPO submitted by an Italian applicant or there is at least one Italian "owner". The data about profitability (gross operating margin), productivity (value added per employee), and certifications are supplied by Innolva[3] elaborations on the basis of the official Infocamere (the IT Company for the Italian Chambers of Commerce) data.

Considering that the analysis about pre-Covid crisis time was carried out on the three-year period 2017-2019, the merge between the survey database and that of Innolva was based on companies that have filed their balance sheet at the Business Register of the Chamber of Commerce in all three years. From the merge we obtained a subsample of 2,300 firms. The analyses focused on firms with at least 10 employees (until 499) because in the integrated database there are too few firms in the size class 5-9 employees for assuring an adequate representativeness. Thus, the analyses were based on the subsample of 1,800 firms.

3.2 Variables description

Dependent variables

Table A1 in Appendix reports the variables description. To measure firm's profitability we used the gross operating margin that corresponds to the difference between value added (difference between revenues and external costs, in principle subject to VAT) and employed labor. Gross operating margin is a valid indicator of firm's profitability, used in financial analysis of annual accounts, which approximately refers to firms' capacity to create financial resources from the production process. Specifically, our dependent variable is the

1 Consortium for technological innovation between Unioncamere (Italian Union of Chambers of Commerce), several Italian Chambers of Commerce and ENEA (Italian national agency for New Technologies, Energy and Sustainable Economic Development) https://www.dintec.it/

2 The aim of the UDIIP databse is is to spread the culture of industrial property defence, investigating into the technological know-how available in Italy (by geographical area, sectors, kind of technology) by using data on patent, trademarks and design.

3 Innolva is part of the TiNexta group and manages and maintains every day an ecosystem of over 15 billion datapoints at the firm level sourced from official and public sources and integrated with proprietary data and algorithms. Data are processed by a dedicated team assuring the data quality through activities that translate into a continuous cycle of data maintenance, both in terms of single updates/changes and an activity of repeated and frequent reviews of the processes that regulate loading and management of the information. https://www.innolva.it

gross operating margin (*Profitability*) calculated as average value of the three-year period 2017-2019. We chose a period of more years to better capture firm's profitability in the mid-term period avoiding biases when considering only one year (possible outliers, high time-fluctuations, etc.). Furthermore, we measured productivity through a variable (*Productivity*) corresponding to the value added per employee, average value of the three-year period 2017-2019.

Besides firm's profitability in the pre-crisis period, we also investigated if intangible assets strengthen firm's resilience accelerating the production recovery to pre-Covid levels. To address this issue we used a binary variable (*Resilience*) taking value 1 if the firm expects to go back to pre Covid-19 production level by 2021 (according to firm's opinion resulting from the survey). We know that this type of measurement based on firm's opinion may be a limit, but currently it is the only way before referring to future studies in the next years when there will be the possibility to use the final data.

Main independent variables: Intangible assets

As explained above, we adopted the definition of intangible assets given by Brynjolfsson and McAfee (2014) that identify them in four typologies: i) intellectual property (includes also R&D); ii) organizational capital; iii) user-generated content; iv) human capital.

We measured these categories at the firm level through four variables. Concerning the intellectual property, we used a binary variable (*R&D and Intellectual property*) valued 1 if the firm has intellectual property rights: patents, trademarks or designs registered at the European Patent Office during the period 2009-2019. Regarding the organizational capital, since it relates to organizational practices including also corporate culture (Brynjolfsson & McAfee, 2014; Brynjolfsson et al. 2002), we measured this typology of intangible asset considering the certifications: specifically, we measured organizational capital through a binary variable (*Organizational capital*) equal to 1 if the firm has a certification (quality, energy and environmental management, etc.). Concerning the user-generated content, as just explained, we broadened the concept to open innovation. Since several previous studies on this issue take into account the openness toward partners, customers, suppliers, and universities (Bogers et al., 2010; Lichtenthaler, 2009; Enkel et al., 2009), we constructed a variable (*Open innovation*) taking value 1 if the firm carries out co-innovation with employees, customers, universities and supply chain firms. Finally, for the fourth typology, human capital, we used a binary variable (*Human capital*) taking value 1 if the firm invests in training activities including digital skills and recruitment of high-skill jobs.

Control variables

We included a set of control variables that might influence firm's economic performance in such a way as to better isolate the effects of the intangible assets.

Firm age is a determinant that might influence the performance according to literature (for a review, Coad, 2018). Indeed, if older firms may show higher performance than youngers ones thanks to more imbedded routines, a clearer strategic outlook, and better business processes, a greater knowledge of the market, greater networking and stable ties to customers, on the one hand, younger firms could outperform the older ones thanks to a greater ability to pick market opportunities being more agile and flexible in adapting to environmental change, on the other hand. Thus, we controlled for this characteristic inserting a continuous variable (*Age*) related to the number of years since the establishment of the firm.

Also size may impact on firm's performance: even if it could be evident that the larger firms outperform the smaller ones benefitting from economies of scale that reduce the cost per unit positively influencing the profitability, so far previous empirical studies show controversial results. In the light of this, we took into account this issue including a continuous variable (*Size*) based on the number of employees.

Moreover, also corporate governance may influence the performances. For instance, as is known, family firms behave differently from non-family ones (Chua et al., 1999; Miller & Le Breton-Miller, 2006; recently for the Italian case on Unioncamere survey data, Cucculelli et al., 2021). Thus, we controlled for this corporate factor including a variable (*Family*) taking value 1 if the family has the control of the ownership and manages the firm. In addition to this, we took into account also the foreign-ownership since inward FDI and the presence of multinational enterprises may boost economic performance through the diffusion of new knowledge and technologies, new organizational and managerial routines, the possibility to access new and distant markets (Ascani et al., 2020). Thus, we included a binary variable (*Foreign*) equals to 1 if the firm is a foreign-invested enterprise.

Furthermore, we included industry dummy variables to account for sectoral differences: Food manufacturing sector (*Food_m*) (reference category); Personal and Households goods manufacturing sector (*P&H_m*); Mechanical manufacturing sector (*Mechanical_m*); Other manufacturing activities (*Other_m*); Trade sector (*Trade_s*); Accomodation and Food service activities (*A&F_s*); Other services (*Other_s*).

Finally, to account for the fact that location is a factor potentially affecting firm's competitiveness – and this is particular relevant in Italy where socio-economic geographical differences are relevant (Territorial Cohesion Agency-Unioncamere, 2020) –, we controlled for the area in which the firm is located including two dummies: *Center*, *South* (*North* reference category).

Summary statistics

Table A2 in Appendix displays summary statistics. The average size of the firm is 68 employees and the average age is 37 years. The majority of the firms are family-owned (59.7%) while only a little

share (3.6%) refers to foreign invested enterprises. Almost one third of the sample operate in Mechanical manufacturing sector (31.9%); about 17% in the Personal and Households goods manufacturing sector; little more than 10% in the Food manufacturing sector; and around 20% in other manufacturing sectors; the shares of Trade sector and Accommodation, and Food service activities are less than 10% (respectively, 6.8% and 4.0%); other services represent 8.8% of total firms. In geographical terms, a large part of firms is located in Northern Italy (69.9%), while both in the Center (20.0%) and in the South (17.7%) the shares are smaller. Looking at the intangibles assets, 21.6% of firms has at least one intellectual property right, while almost the half of firms invests in human capital (46.0%), as well as in organizational capital (41.7%), and a little less than one-third in open innovation (29.4%). Regarding economic data: the average of gross operating margin is 2.1 billions of euro; the average of productivity is 74 thousands euro. Around 36% of firms expects to return back to pre Covid-19 production levels by 2021. Collinearity problem does not emerge since all values of Variance Inflation Factor (Table A3 in Appendix) are below of the critical value of 10 (Yoo et al., 2014).

4. Econometric methodology

We conducted a mediation analysis (Hayes, 2018) to measure simultaneously the relationship between the four intangible assets and their effects on firm's performance. Considering the human capital as input factor of the other three intangible assets, we measure the effect of the human capital (key variable: *Human capital*) on firm's profitability, productivity and resilience (dependent variables: *Profitability*, *Productivity*, *Resilience*) decomposing the direct effects from the indirect effects via three mediators: *R&D and Intellectual property*, *Capital organization*, and *Open innovation*. For this decomposition we applied the KHB method (command *khb* in STATA) providing an unbiased decomposition of total effects into direct and indirect effects (Breen et al., 2013; Kohler et al., 2011). Although KHB method is often used for binary models (e.g. logit, probit), it also applies to linear models. In the case of the model with dependent binary variable *Resilience*, however we apply a linear probability model[4].

The path explained in Figure 1 is estimated through the following four equations:

$$M_{1i} = i_{M_1} + a_1 X_i + d_1 C_i + \varepsilon_{M_1} \quad (1)$$

$$M_{2i} = i_{M_2} + a_2 X_i + d_2 C_i + \varepsilon_{M_2} \quad (2)$$

$$M_{3i} = i_{M_3} + a_3 X_i + d_3 C_i + \varepsilon_{M_3} \quad (3)$$

$$Y_i = i_Y + c' X_i + b_1 M_{1i} + b_2 M_{2i} + b_3 M_{3i} + d_4 C_i + \varepsilon_Y \quad (4)$$

where M_1, M_2 and M_3 are the mediators (respectively, *R&D and Intellectual property*, *Organizational capital*, and *Open innovation*), Y is the response variable corresponding to each type of analysis: *Profitability* (logarithm of gross operating

4 We applied also khb probit and we found similar results in terms of both magnitude and significance of the effects.

margin[5]); *Productivity* (logarithm of value added per employee); *Resilience* (binary = 1 if the firm expects to go back to pre-Covid crisis production level by 2021), *X* is the key variable (*Human capital*), and *C* is the vector including all control variables (see Table A1); ε is the random error term; i_{M_1}, i_{M_2}, i_{M_3}, i_Y are the regression constants.

The equations are estimated through the Seemingly Unrelated REgression (SURE) method (Zellner, 1962) to improve statistical efficiency allowing error terms to be correlated[6].

In Equations 1, 2 and 3 the coefficients a_1, a_2 and a_3 are the effects of the key variable *X* on each mediator (M_1, M_2, M_3). In Equation 3 the coefficient *c'* is the direct effect (that is unmediated) of the key variable *X* on the response variable *Y* when adjusted for the mediators; coefficients b_1, b_2, b_3 are the effects of each mediator M_1, M_2, M_3 on *Y* when adjusted for *X*.

The indirect effect measures the effect of *X* on *Y* that is explained (mediated) by the mediators. Specifically, in presence of three mediators (M_1, M_2, M_3) we have three indirect effects: one related to the *R&D and Intellectual property* (a_1b_1); one related to the *Organizational capital* (a_2b_2); one related to the *Open innovation* (a_3b_3): the sum of these three effects constitutes the total indirect effect. Thus, the total effect (*c*) of *X* on *Y* corresponds to the sum of the direct effect (*c'*) and the total indirect effect ($a_1b_1 + a_2b_2 + a_3b_3$): analitically, $c = c' + (a_1b_1 + a_2b_2 + a_3b_3)$. Stata version 15 was used for all the estimates. However, any conclusion regarding causality is limited when working on a cross-section analysis. Nevertheless, we used in some cases independent variables (concerning the main ones) covering a longer period in the past in comparison to the dependent variable.

5. Results and discussion

5.1 The effects on firm's profitability

The results of the entire study are reported in Figures 2-10 and in Tables 1-5. The findings show that, given the same conditions (firm's age, type of governance, size, sector, geographical location, see the sub-section "Control variables"), intangible assets positively influence firm's profitability. The coefficients of *R&D and Intellectual property*, and *Organizational capital* are positive and highly statistically significant ($p<0.01$), while those related to *Open innovation* is significant but a bit less ($p<0.10$) (Figure 2). Also the coefficients of *Human capital* are statistically significant ($p<0.01$): both direct and indirect effect (Figure 2 and Table 1).

Thus, the *Hypothesis 1 Firms investing in intangible assets have a higher level of profitability* is confirmed.

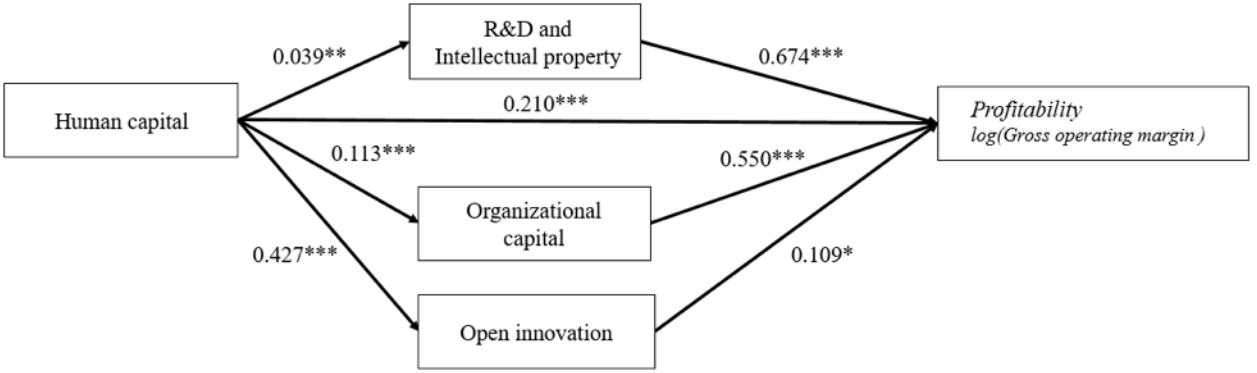
Looking at the magnitude of the coefficients, the intellectual property is the asset that pushes

5 Even if the logharithmic transformation excludes negative values, we precise that only a little number of firm (57) registered negative values of gross operating margin.

6 In our case, the Breusch–Pagan test of independence shows the presence of correlation between the errors with regard to all three types of analyses according to the different outcomes.

further gross operating margin: a firm having an intellectual property right (such as patents, designs, trademarks) has a level of gross operating margin higher by 67.4% than one that does not have any intellectual property right. This high effect confirms the strong impact of intellectual property right on firm's performance (in line also with other studies, recently EPO-EUIPO, 2021), likely explained by the possibility to monetize the intellectual property right through the increase of sales (boosted also by new business opportunities), as well as by a better competitive position in the market through a strengthened of the brand and reputation.

Figure 2 - The effects of the intangible assets on the level of Profitability



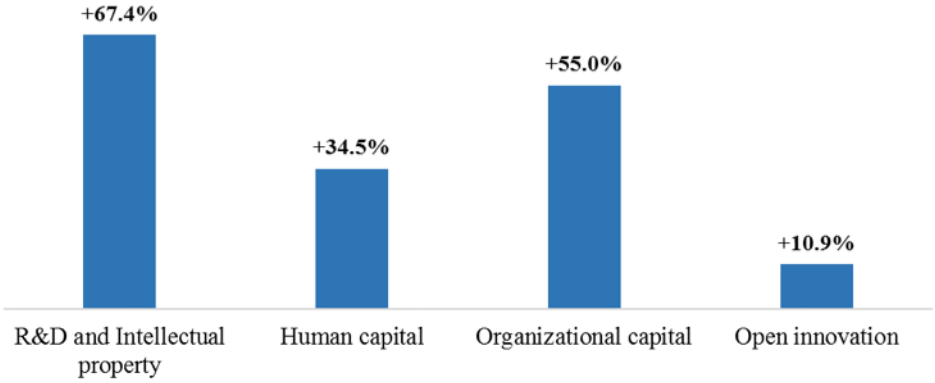
The figure reports the coefficients of the seemingly unrelated regression including the control variables (see Table A1).
*** p<0.01; ** p<0.05; * p<0.1

Table 1 - Effects of Human capital on the level of Profitability

	Coefficient	*Standard error*
Direct effect		
Human capital → Profitability	0.210***	0.062
Indirect effect		
Human capital → IP & OC & OI → Profitability	0.135***	0.034
Total effect	0.345***	0.054

Control variables included (see Table A1).
*** p<0.01; ** p<0.05; * p<0.1

Figure 3 - The effects of intangible assets on the level of Profitability (gross operating margin)



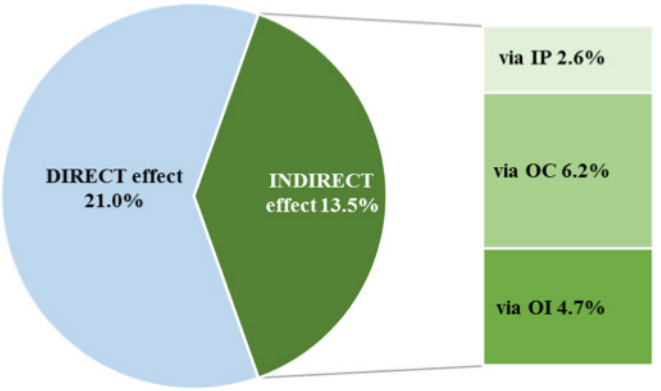
N.B. All values are statistically significant (for details see Figure 2).

The second intangible asset that most boosts the profitability is the organizational capital: a firm investing in organizational capital (in terms of certifications) has a level of gross operating margin higher by 55.0% than a firm which does not invest in this asset. This empirically confirms the understanding that nowadays competition among firms is mostly based on innovative business organizational models because they can generate competitive advantages (Gassmann et al., 2013; Schiavi & Behr, 2018; Ciriello et al. 2018).

Human capital exerts an important effect on the profitability: a firm investing in human capital (training and/or hiring high-skill jobs) has a level of gross operating margin higher by 34.5% than a firm which does not invest in this asset. We specify that this effect is the total effect including both those direct and indirect. Indeed, according to our framework analysis (Figure 1), human capital can influence firm's performance not only directly, but also indirectly as input of the other three types of assets (intellectual property, organizational capital, open innovation) which in turn raise firm's performance. By exploring this issue, we discover that although the larger part of the effect is direct (21.0% out of 34.5%), there is an evident indirect effect (13.5% out of 34.5%) generated by the influence of human capital on firm's profitability via the other three assets. This confirms the key role of the human capital as input factor in line with Romer 1990, and Nelson and Phelps (1966). Specifically, human capital exerts an indirect effect on firm's profitability mainly via influencing organizational capital (6.2% out of 13.5%) and open innovation (4.7% out of 13.5%) (Figure 4). This evidence supports the

idea that human capital enable employees to absorb new missions quickly together to solve different assignments to achieve the company's goals within the organizational scheme, on one hand, and it favors the pursuit and the absorption of new knowledge, technology and skills by triggering external relations, on the other hand.

Figure 4 - The total effect of 34.5% of Human capital on the level of Profitability divided between direct and indirect effect



IP: R&D and Intellectual property. OC: Organizational capital. OI: Open innovation.

Also open innovation significantly affects firm's profitability although to a lesser extent: a firm investing in open innovation (in terms of co-innovation through the relationship with employees, customers, universities and supply chain firms) has a level of gross operating margin higher by 10.9% than a firm that does not invest in this asset. This empirically confirms that the combination of internal and external knowledge supports economic performances through, for instance, removing inefficiencies (including technological ones), joining complementary expertise and skills, reducing the risk-aversion, and leveraging the capabilities (of all actors) of generating increases of returns (Chesbrough, 2003, 2010; Bigliardi et al., 2020).

5.2 The effects on firm's productivity

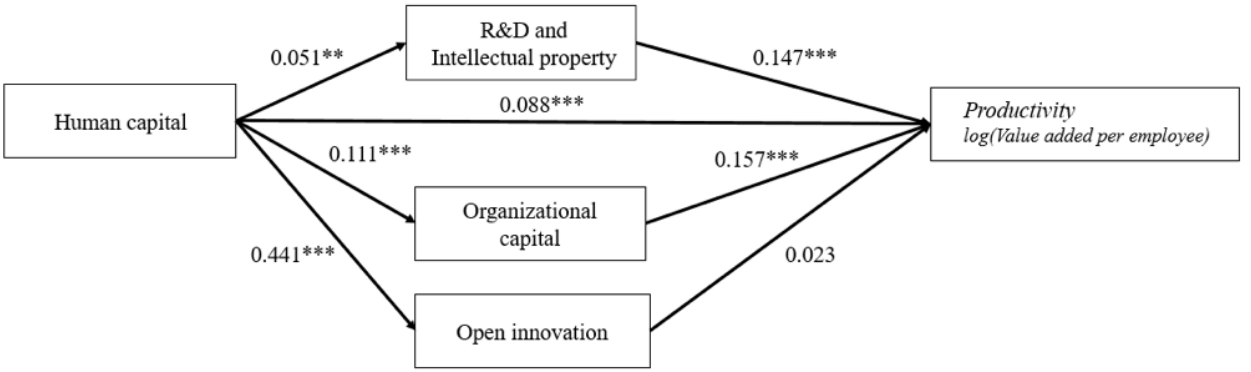
The intangible assets play a key role not only in raising profitability, but also by improving productivity. In this case, we find positive and significant effects with regard to *R&D and Intellectual property*, *Organizational capital* (both $p<0.01$) (Figure 5), and *Human capital* (direct effect $p<0.01$; indirect effect $p<0.05$, Figure 5 and Table 2), while

any effects emerges from *Open innovation*.

Thus, the *Hypotesis 2 Firms investing in intangible assets have a higher level of productivity* is confirmed except for the intangible asset related to the open innovation.

The magnitude of the coefficients indicate that organizational capital is the asset that mostly influences the productivity: a firm investing in organizational capital has a level of productivity (value added per employee) higher by 15.7% than a firm which does not invest in this asset. Even the intellectual property rights asset shows a positive impact on productivity (in line with, e.g., Bloom & Van Reenen, 2002; Yuan et al., 2021) close to 15% (14.7%).

Figure 5 - The effects of the intangible assets on the level of Productivity



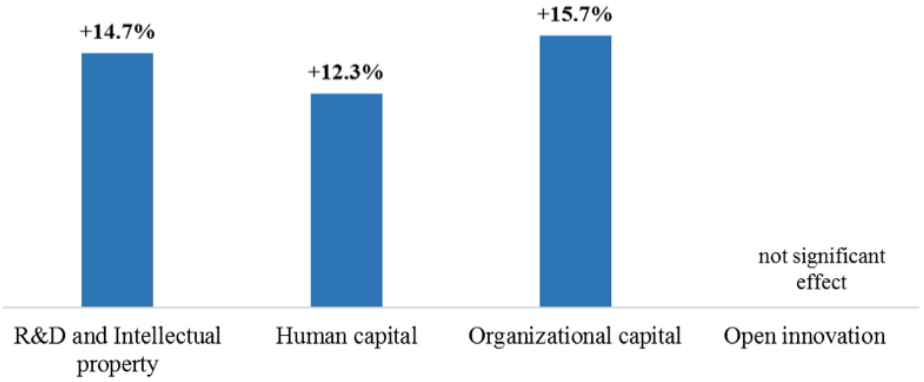
The figure reports the coefficients of the seemingly unrelated regression including the control variables (see Table A1).
*** p<0.01; ** p<0.05; * p<0.1

Table 2 - Effects of Human capital on the level of Productivity

	Coefficient	*Standard error*
Direct effect Human capital → Productivity	0.088***	0.028
Indirect Human capital → IP & OC & OI → Productivity	0.035**	0.015
Total effect	0.123***	0.025

Control variables included (see Table A1).
*** p<0.01; ** p<0.05; * p<0.1

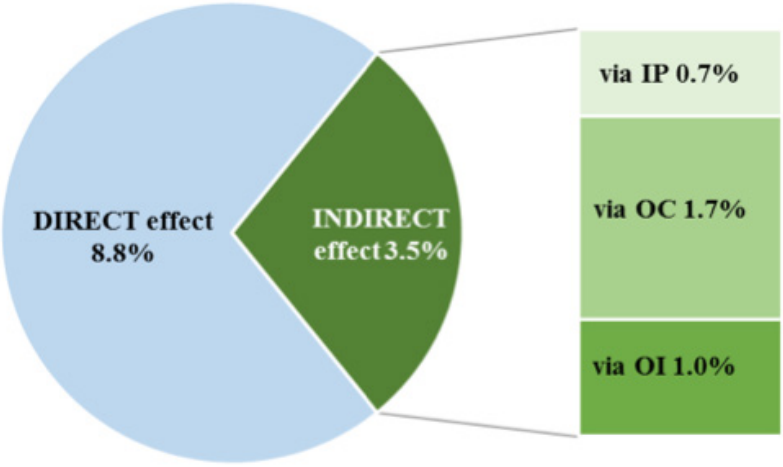
Figure 6 - The effects of the intangible assets on the level of Productivity (value added per employee)



N.B. All values are statistically significant except for Open innovation (for details see Figure 5).

Concerning human capital, it exerts an important role: a firm investing in human capital has a level of productivity higher by 12.3% than a firm which does not invest in this asset. This total effect is composed for a large part of direct effect (8.8%) but also for a significant part of indirect one (3.5%) through the influence of the human capital on the other three types of assets (that which in turn increase firm's productivity) (Table 2). In particular, also in this case, indirect effect of the human capital on productivity is mostly related to its influence on organizational capital (1.7% out of 3.5%) (Figure 7).

Figure 7 - The total effect of 12.3% of Human capital on the level of Productivity divided between direct and indirect effect



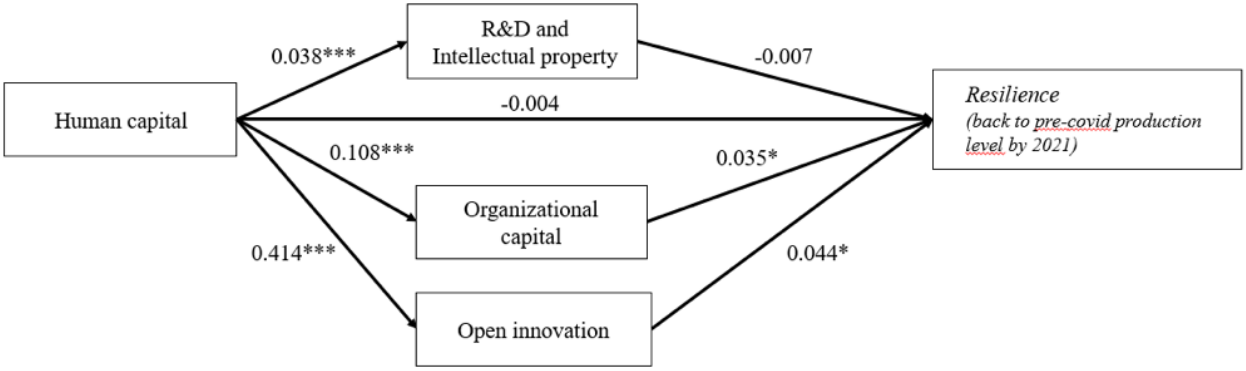
IP: R&D and Intellectual property. OC: Organizational capital. OI: Open innovation.

This confirms the close connection between these two assets underlining the importance of embedding the skills within the organizational schemes to improve the competitiveness (analyses for the Italian case, Cassetta et al., 2020; Pini et al., 2018); explained also by the fact that organizational capital mainly refers to working methods and practices that often require skills and competencies for their best effectiveness on firm's performances.

5.3 The effects on firm's resilience

Intangible assets also play a key role in the current context of the post-Covid economic recovery. We find that open innovation proves to be the prominent asset: a firm investing in open innovation (co-innovation with university, clients, and other supply chain firms) is more likely (by 4.4%, $p<0.10$) than a firm which does not invest in this asset to go back to pre-Covid production level by 2021 (Figure 8). This highlights that having open mind and open system is determinant to accelerate the recovery because the relationship with external actors allows firms to find more rapidly the best solutions and knowledge to increase their performances in a new scenario. Our results confirm the important role of open innovation that was reaffirmed in the Covid-19 pandemic (McGahan et al., 2021).

Figure 8 - The effects of the intangible assets on firm's resilience



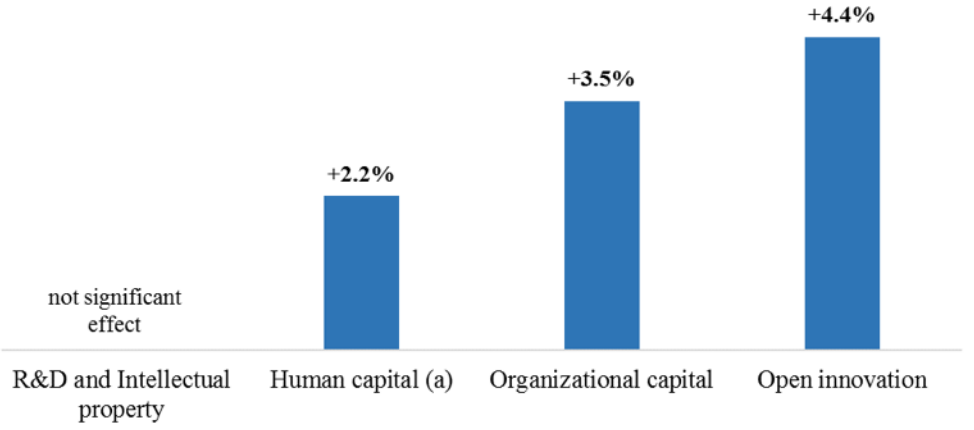
The figure reports the coefficients of the seemingly unrelated regression including the control variables (see Table A1).
*** p<0.01; ** p<0.05; * p<0.1

Table 3 - Effects of Human capital on firm's resilience

	Coefficient	Standard error
Direct effect		
Human capital → Resilience	-0.004	0.022
Indirect effect		
Human capital → IP & OC & OI → Resilience	0.022**	0.011
Total effect	0.018	0.020

Control variables included (see Table A1).
*** p<0.01; ** p<0.05; * p<0.1

*Figure 9. The effects of the intangible assets on firm's resilience**



* For each type of intangible asset, the value indicates the greater probability to go back to pre-Covid crisis production level by 2021 for a firm investing in that asset in comparison to a firm that does not invest. All values are statistically significant except for R&D and Intellectual property.

(a) The value only refers to indirect effect since the direct effect is not statistically significant (for details see Table 3).

Also organizational capital is a significant factor supporting production recovery (the effect is 3.5%, $p<0.10$): in this regard, the Covid crisis has revolutionized business processes, so that only the firms that have invested in the organizational capital succeeded in boosting their performances in the post-crisis period.

We found that human capital plays a role in accelerating the recovery only indirectly. Indeed, only the indirect effect is significant ($p<0.05$, Table 3) and indicates that investing in human capital increases the probability (by 2.2%) to go back to pre-Covid production level by 2021. The larger part (1.8% out of 2.2%) of this indirect effect exerted by the human capital passes via its influence on open innovation (that which in turn raises the probability to go back to pre-Covid production level by 2021).

Thus, the *Hypothesis 3 Firms investing in intangible assets have a higher resilience in terms of the capacity to rise back before to pre-Covid production level* is confirmed except for the intangible asset related to the intellectual property.

5.4 Robustness check

We conducted two types of analyses as robustness check. Firstly, we used as variable measuring the intangible assets the corresponding value from the

balance sheet data (in line with, e.g., Arrighetti et al., 2014). Specifically, we calculated the value of intangible assets per employee (average 2017-19 in line with the period referred to the dependent variables). Using Ordinary Least Square (OLS) regression, we found that the coefficient of this new variable measuring intangible assets (*IA balance sheet*) is positive and statistically significant in explaining the profitability, the productivity and the resilience (Table 4).

Secondly, we run the mediation analysis on a different sample using a large pool dataset as merge of the two previous waves (non panel) carried out by Unioncamere and Centro Studi Guglielmo Tagliacarne in the years 2018 and 2019. The variables *R&D & intellectual property* and *Capital organization* were constructed in the same way, as well as the dependent variables *Profitability* and *Productivity*; while *Human capital* and *Open innovation* were calculated in a little different way because of the lack of some questions in the questionnaires of the surveys 2018 and 2019. We were not able to calculate the variable *Resilience* beacause there was not the corresponding question in the previous two surveys. Nevertheless, the results (Table 5) show positive and significant effects of all four intangible assets both on firm's profitability and productivity. These two kinds of analyses confirm that the positive impact of intangible assets on firm's performance is robust.

Table 4 - Robustness check: intangible assets measured from the balance sheet data

	Profitability	Productivity	Resilience
	OLS	OLS	Probit
	(A)	(B)	(C)
IA balance sheet	0.041***	0.016***	0.021**
	(0.007)	(0.003)	(0.010)
+ *controls*			
F-statistic	85.18***	14.33***	
R^2	0.441	0.114	
LR chi2			23.30**
Pseudo R^2			0.012
Obs	1,417	1,464	1,465

N.B. IA balance sheet: value of intangible assets from the balance sheet per employee (/10,000). The title of the column reports the dependent variable (logarithmic value). Control variables (see Table A1). The coefficients are estimated with OLS regression. Standard errors in parentheses. *** p<0.01; ** p<0.05; * p<0.1

Table 5 - Robustness check: mediation analysis on the pool dataset 2018-2019

	Profitability	Productivity
	(A)	(B)
IP	0.797***	0.152***
	(0.059)	(0.023)
OC	0.703***	0.169***
	(0.049)	(0.021)
OI	0.221***	0.075***
	(0.051)	(0.021)
#HC	0.443***	0.102***
	(0.051)	(0.021)
+ *controls*		
Obs	2,558	2,130

N.B. The title of the column reports the dependent variable (logarithmic value). #HC reports the total effect (direct + indirect) of the *Human capital*. Control variables are the same of the main results (see Table A1) excluding only the variable *Foreign* due to the lack of the corresponding question on the questionnaires. Standard errors in parentheses. *** p<0.01; ** p<0.05; * p<0.1

6. Conclusion

The increasing importance of intangible assets in the new growth paradigm makes it necessary to investigate how these are diffused among the economy and the extent to which they influence the development. Although there are several studies on this field, there is still a gap in understanding how the different types of intangible assets, also considering the relationship between them, foster economic performances. All this with particular reference to the current post-Covid recovery. With this in mind, the present study, adopting the definition of intangible assets given by Brynjolfsson and McAfee (2014), we investigated the effects of each intangible asset (R&D and intellectual property, human capital, organizational capital, user-generated content broadened to the concept of open innovation) on firm's profitability (level of gross operating margin), productivity (level of value added per employee) and resilience (capacity to go back to pre-Covid production level by 2021), analyzing at the same time the relationship between the different types of intangible assets. In doing so, the study exploited an integrated database composed of around 2,000 Italian manufacturing and service firms gathering

all useful information from the Italian Chambers of Commerce system. Empirical results show that intangible assets play a key role in increasing the level of profitability, productivity as well as the probability to go back to pre-Covid production level by 2021. Moreover, human capital exerts an important role boosting firm's performance not only directly but also indirectly influencing the other three types of assets (that in turn positively affect performances). More robustness checks confirm these findings.

Our results highlight the importance of designing policies aimed at developing knowledge also through its circulation inside and outside the business environment favoring the effectiveness of firm's learning according to the new approach of industrial policies (Greenwald & Stiglitz, 2013).

Since human capital proves to be the factor triggering the other types of intangible assets, policies should primarily concentrate on this issue. Firstly, policy should support life-long learning (training in adulthood leveraging also on technologies that offer low-cost and convenient ways of learning) favoring the entry of people in the workforce, and, in doing so, avoiding problematic guessing of what skills will be the more valuable in the next decades. Secondly, they should support education of young people focusing more on *what we teach* than *how much we teach*. Specifically, it is crucial to encourage students and workers to learn not only occupation-specific skills but also soft-skills to stimulate creativity and innovation, with particular regard to collaborative problem-solving skills that are useful in the new economic models based on networking (Haskel & Westlake, 2018).

Indeed, these policies for learning and knowledge accumulation should be combined with those supporting open innovation, because a large part of the increase of knowledge goes through inbound and outbound flows along the firm's relationships with external actors. Nowadays the complexity of the new innovation patterns (4.0 technologies, green technologies, etc.) requires a combination of much expertise to be competitive. So, it may be essential to strengthen the business networks concerning not only those referred to supply chain, but also those related to other kinds of relationships (e.g. for innovation, internationalization, environmental sustainability, etc.); for the Italian case, eventually by strengthening and improving some existing tools (such as "Contratti di rete", Contratti di sviluppo"). Thus, policy should look to the networks where the firm operates instead of relying solely on its economic sector. This is crucial issue because the "optimal dimension of a firm" relates with the type of production model and in particular way with the relationship between firm and society, firm and market (Becattini, 2007). At the same time, to facilitate open innovation strategies is also necessary to remove all negative externalities on bureaucratic matter as well as on infrastructural ones. Regarding the latter, there are at least two types of infrastructure on which to focus attention: i) digital infrastructure particularly on the development of broadband in the light of the Italy's gap within the European

context (European Commission, 2020a); soft infrastructure consisted of norms, values, and social capital that enhance the share of spillovers as well as exploit synergies and cooperation.

Furthermore, open innovation relates to a new corporate culture able to get the most benefits from the networking. In doing so, the organizational capital plays a key role. Indeed, the current digital and green transitions require an in-depth innovation of business models based also on the relationship with external actors (clients, suppliers, etc.) to get the most effective exploitation of 4.0 technologies, knowledge and skills (Müller et al., 2018). For this reasons, besides various classical forms di incentives, policies should affect the corporate culture in adopting business processes in line with what competition requires (e.g., quality and sustainability standards).

Concerning Intellectual property, policies should work in at least two directions. The first aimed at protecting the intellectual property rights through a clear intellectual property law (rejecting vague patents that increases uncertainty) together with a clear jurisdiction (consistent Intellectual property courts); with regards to which it is important to achieve a stable social consensus about how things should work (that however requires high investments in social capital). The second, favoring the usage of the inventions by others through open source methods according to the concept of knowledge as "public good" (Greenwald & Stiglitz, 2013).

Intangible assets touch many and different aspects of the life of the enterprise. For this reason, a coordination of policies supporting intangible assets should be necessary, even considering the existing relationship between the various types of assets as empirically demonstrated. In other words, policy on intangible assets require a strong nexus between institutional settings and industrial policy (Rodrik, 2004; 2008), because nowadays we are shaping a new model of economy where the target is not only the growth of the tangible production, but the way in which we produce looking at a sustainable growth resulting from a broader institutional strategy (Haussman & Rodrik, 2006; Haussman et al., 2008; Rodrik, 2004; for empirical evidences for the Italian case see Dileo & Pini, 2021). In addition, it is critical to take into account the features of the local production systems since the best industrial policies should be both firm-oriented and regional system oriented (Nauwelaers & Wintjes, 2003) also taking into account local capacity to absorb the public interventions. Thus, within the policies supporting intangible assets the institutions, and in particular the territorial institutions, play a key role in several ways such as: increasing the awareness and the trust with respect to these issues; providing support services also including the training to entrepreneurs; providing financial resources and facilitating credit access to firms; favoring the networks between actors; all this is especially true for the small firms which face major obstacles in improving their competitiveness.

This study presents some limitations, such as:

cross section analysis; do not investigate the differences at the regional level; dot not investigate the micro firms (less than 10 employees); the expectation to return to pre-Covid production levels are based on firm's opinion instead of final data. Nevertheless, this study represents a first empirical analysis on intangible assets by a different perspective, potentially fruitful for future research (one of this could be deepening if some moderation effect exists about human capital with regard to other three types of intangible asset).

Acknowledgments

We are grateful to Giuseppe Tripoli for valuable suggestions. Special thanks to Luigi Nicolais. We wish to thank for the collaboration and useful advice: Fabio Boiani, Giacomo Büchi, Flavio Burlizzi, Monica Cugno, Matteo Gatti, Debora Giannini, Diana Marcello, Alessio Misuri, Valentina Meliciani, Sandro Pettinato, Alessandro Rinaldi, Raffaele Rinaldi, Antonio Romeo, Giovanni Riva, and the Research office of AIFI (Italian Private Equity, Venture Capital and Private Debt Association).

Disclosure

The views expressed in the article are those of the authors and do not necessarily reflect those of the institutions to which they belong.

References

Añón Higón, D., Gómez, J., & Vargas, P. (2017). Complementarities in innovation strategy: Do intangibles play a role in enhancing firm performance? *Industrial and Corporate Change*, *26*(5), 865–886.

Arrighetti, A., Landini, F., & Lasagni, A. (2014). Intangible assets and firm heterogeneity: Evidence from Italy. *Research Policy*, *43*(1), 202-213.

Ascani, A., Balland, P. A., & Morrison, A. (2020). Heterogeneous foreign direct investment and local innovation in Italian provinces. *Structural Change and Economic Dynamics*, *53*(2020), 388–401.

Ballot, G., Fakhfakh, F., & Taymaz, E. (2001). Firms' human capital, R&D and performance: a study on French and Swedish firms. *Labour economics*, *8*(4), 443-462.

Becattini, G. (2007). *Il calabrone Italia: Ricerche e ragionamenti sulla peculiarità economica italiana*, Bologna: Il Mulino

Becker, G. S. (1993). *Human capital: A theoretical and empirical analysis with special reference to education* (3rd ed.). Chicago: The University of Chicago Press.

Becker, G. S. (1962). Investment in human capital: A theoretical analysis. *Journal of political economy*, *70*(5, Part 2), 9-49.

Bigliardi, B., Ferraro, G., Filippelli, S., & Galati, F. (2020). The influence of open innovation on firm performance. *International Journal of Engineering Business Management*, *12*, 1-14

Bogers, M., Afuah, A., & Bastian, B. (2010). Users as innovators: a review, critique, and future research directions. *Journal of management*, *36*(4), 857-875.

Bhatia, A., & Aggarwal, K. (2018). Impact of investment in intangible assets on corporate performance in India. *International Journal of Law and Management.*, *60*(5), 1058-1073.

Bloom, N., & Van Reenen, J. (2002). Patents, real options and firm performance. *The Economic Journal*, *112*(478), C97-C116.

Bontis, N., Keow, W. C. C., & Richardson, S. (2000). Intellectual capital and business performance in Malaysian industries. *Journal of intellectual capital*, *1*(1), 85-100

Breen, R., Karlson, K. B., & Holm, A. (2013). Total, direct, and indirect effects in logit and probit models. *Sociological Methods & Research*, *42*(2), 164-191.

Brynjolfsson, E., McAfee, A. (2014). *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*, New York: W. W. Norton & Co.

Brynjolfsson, E., Hitt, L. M., & Yang, S. (2002). Intangible assets: Computers and organizational capital. *Brookings papers on economic activity*, *2002*(1), 137-181.

Bubic, J., & Susak, T. (2015). Detecting optimal financial and capital structure: The case of small and medium enterprises (SME) in Republic of Croatia. *Economic and Social Development: Book of Proceedings*, 324.

Cassetta, E., Monarca, U., Dileo, I., Di Berardino, C., & Pini, M. (2020). The relationship between digital technologies and internationalisation. Evidence from Italian SMEs. *Industry and Innovation*, *27*(4), 311-339.

Chesbrough, H. (2010). Business model innovation: opportunities and barriers. *Long range planning*, *43*(2-3), 354-363.

Chesbrough, H. W. (2003). *Open innovation: The new imperative for creating and profiting from technology*. Boston (MA): Harvard Business Press.

Chesbrough, H., & Bogers, M. (2014). Explicating open innovation: Clarifying an emerging paradigm for understanding innovation. *New Frontiers in Open Innovation. Oxford: Oxford University Press, Forthcoming*, 3-28. In H. Chesbrough, W. Vanhaverbeke, and J. West (eds). New Frontiers in Open Innovation. Oxford: Oxford University Press, Forthcoming (pp. 3-28).

Chua, J. H., Chrisman, J. J., & Sharma, P. (1999). Defining the family business by behavior. *Entrepreneurship theory and practice*, *23*(4), 19-39.

Ciriello, R. F., Richter, A., & Schwabe, G. (2018). Digital innovation. *Business & Information Systems Engineering*, *60*(6), 563-569.

Coad, A. (2018). Firm age: a survey. *Journal of Evolutionary Economics*, *28*(1), 13-43.

Corrado, C., Haskel, J., Iommi, M., Jona-Lasinio, C., Mas, M., & O'Mahony, M. (2018). *Advancements in measuring intangibles for European economies*. *EUROSTAT Review On National Accounts And Macroeconomic*, Luxembourg: Publications Office of the European Union, 89-106.

Corrado, C., Haskel, J., & Jona-Lasinio, C. (2017). Knowledge spillovers, ICT and productivity growth. *Oxford Bulletin of Economics and Statistics*, *79*(4), 592-618.

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

Corrado, C., Hulten, C., & Sichel, D. (2009). Intangible capital and US economic growth. *Review of income and wealth*, *55*(3), 661-685.

Corrado, Carol, Charles Hulten, and Daniel Sichel (2005). "Measuring Capital and Technology: An Expanded Framework." In *Measuring Capital in the New Economy*, C. Corrado, J. Haltiwanger, and D. Sichel (eds.), Studies in Income and Wealth, Vol. 65. Chicago: The University of Chicago Press.

Crema, M., Verbano, C., & Venturini, K. (2014). Linking strategy with open innovation and performance in SMEs. *Measuring Business Excellence*, *18*(2), 14-27.

Crouzet, N., & Eberly, J. (2018, May). Intangibles, investment, and efficiency. In *AEA Papers and Proceedings* (Vol. 108, pp. 426-31). Retrieved from http://dx.doi.org/10.1257/pandp.20181007.

Cucculelli, M., Dileo, I., & Pini, M. (2021). Filling the void of family leadership: institutional support to business model changes in the Italian Industry 4.0 experience. *The Journal of Technology Transfer*, 1-29.

Cugno, M., Castagnoli, R., Büchi, G., & Pini, M. (2022). Industry 4.0 and production recovery in the covid era. *Technovation*, *114* on-line. https://doi.org/10.1016/j.technovation.2021.102443

Del Valle, I. D., & Castillo, M. A. S. (2009). Human capital and sustainable competitive advantage: an analysis of the relationship between training and performance. *International Entrepreneurship and Management Journal*, *5*(2), 139-163.

Denicolai, S., Cotta Ramusino, E., & Sotti, F. (2015). The impact of intangibles on firm growth. *Technology Analysis & Strategic Management*, *27*(2), 219-236.

Dileo, I., & Pini, M. (2021). The Quadruple Helix Partnerships for Enterprise Eco-Innovation in Italian Macro-Regions Under the Lens of Smart Specialization Strategy. In M. Gancarczyk, A. Ujwary-Gil, and M. González-López (Eds.), *Partnerships for Regional Innovation and Development: Implementing Smart Specialization in Europe* (pp. 193-217). London, England: Routledge.

Dorling, D. F. L., Simpson, S., (1999). *Statistics in society: the arithmetic of politics*. London, England: Arnold publisher.

Dženopoljac, V., Janoševic, S., & Bontis, N. (2016). Intellectual capital and financial performance in the Serbian ICT industry. *Journal of Intellectual Capital*, *17*(2), 373-396.

Ehie, I. C., & Olibe, K. (2010). The effect of R&D investment on firm value: An examination of US manufacturing and service industries. *International Journal of Production Economics*, *128*(1), 127-135.

Enkel, E., Gassmann, O., & Chesbrough, H. (2009). Open R&D and open innovation: exploring the phenomenon. *R&d Management*, *39*(4), 311-316.

EPO-EUIPO (2021). *Intellectual property rights and firm performance in the European Union*, Firm-level analysis report, February 2021.

European Commission (2020a). *Europe's moment: Repair and Prepare for the Next Generation*, COM(2020) 456 final, Brussels, 27.5.2020

European Commission (2020b). *Broadband Coverage in Europe 2019: Mapping progress towards the coverage objectives of the Digital Agenda*, Luxembourg: Publication Office of the European Union.

Fundación Cotec-IVIE (2021). *The intangible economy in Italy, Portugal and Spain*.

Gassmann, O., Frankenberger, K., & Csik, M. (2013). *The St. Gallen business model navigator* (Working paper), Institute of Technology Management, University of St. Gallen.

Greenhalgh, C., & Rogers, M. (2012). Trade marks and performance in services and manufacturing firms: evidence of Schumpeterian competition through innovation. *Australian Economic Review*, *45*(1), 50-76.

Greenwald, B. & Stiglitz, J. E. (2013). *Industrial Policies, the Creation of a Learning Society and Economic Development*, in Stiglitz J.E., Lin J.Y. (ed. by), *The Industrial Policy Revolution. The Role of Government Beyond Ideology*, New York Palgrave-Mc Millan.

Hall, B. J. (1999). *Innovation and Market Value*. NBER Working Paper 6984, National Bureau of Economic and Research, Cambridge, MA.

Haskel, J. & Westlake, S. (2018). *Capitalism without Capital: The Rise of the Intangible Economy*, Princeton & Oxford: Priceton University Press.

Hatch, N. W., & Dyer, J. H. (2004). Human capital and learning as a source of sustainable competitive advantage. *Strategic Management Journal*, *25*(12), 1155–1178.

Hayes, A. F. (2018). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. Guilford publications.

Hausmann R., Rodrik D., & Sabel C. S. (2008). Reconfiguring Industrial Policy: A Framework With An Application To South Africa, Center for International Development, at Harvard University, may.

Haussman R. & Rodrik D. (2006). Doomed to Choose: Industrial policy as Predicament, *John F. Kennedy School of Government*, sept. 2.

Hulten, C. R. (2010). *Decoding Microsoft: intangible*

capital as a source of company growth, NBER Working Paper 1579, National Bureau of Economic Research, Cambridge, MA.

Johnson, M. W., Christensen, C. M., & Kagermann, H. (2008). Reinventing your business model. *Harvard business review*, *86*(12), 57-68.

Kohler, U., Karlson, K. B., & Holm, A. (2011). Comparing coefficients of nested nonlinear probability models. *The Stata Journal*, *11*(3), 420-438.

Lichtenthaler, U. (2009). Outbound open innovation and its effect on firm performance: examining environmental influences. *R&D Management*, *39*(4), 317-330.

Marimuthu, M., Arokiasamy, L., & Ismail, M. (2009). Human capital development and its impact on firm performance: Evidence from developmental economics. *Journal of international social research*, *2*(8), 265-272.

Martins, J., & Alves, S. (2010). The impact of intangible assets on financial and governance policies: A literature review. *Portuguese Journal of Management Studies*, *15*(1), 87-107.

McGahan, A. M., Bogers, M. L., Chesbrough, H., & Holgersson, M. (2021). Tackling Societal Challenges with Open Innovation. *California Management Review*, *63*(2), 49-61.

Miller, D., & Le Breton-Miller, I. (2006). Family governance and firm performance: Agency, stewardship, and capabilities. *Family business review*, *19*(1), 73-87.

Mishra, R.K. and Jhunjhunwala, S. (2009). *Valuation of intangibles*, Study Sponsored by ICAI, Accounting Research Foundation, Institute of Public Enterprise, Hyderabad.

Mohnen, P., Polder, M., & Van Leeuwen G. (2018), *R&D and Organizational Innovation: Exploring Complementarities in Investment and Production* (NBER Working Paper, No. 25044), National Bureau of Economic Research, Cambridge (MA). Retrieved from http://www.nber.org/papers/w25044

Montresor, S., & Vezzani, A. (2016). Intangible investments and innovation propensity: Evidence from the Innobarometer 2013. *Industry and Innovation*, *23*(4), 331–352.

Müller, J. M., Buliga, O., & Voigt, K. I. (2018). Fortune favors the prepared: How SMEs approach business model innovations in Industry 4.0. *Technological Forecasting and Social Change*, *132*, 2-17.

Nakamora, L. (2001). *What is the US gross investment in intangibles?*, Working paper 01-15, Federal Reserve Bank of Philadelphia.

Nauwelaers, C., & Wintjes, R. (2003). Towards a new paradigm for innovation policy. In B. T. Asheim, A. Isaksen, C. Nauwelaers, & F. Tödling (Eds.), *Regional Innovation Policy for Small-medium Enterprises* (pp. 193-220). Cheltenham, UK: Edward Elgar.

Nelson, R. R., & Phelps, E. S. (1966). Investment in humans, technological diffusion, and economic growth. *American Economic Review*, *56*, 69-75.

OECD (2011). *New sources of growth: intangible assets*, https://www.oecd.org/sti/inno/46349020.pdf

OECD (2008). *Intellectual assets and value creation: Synthesis report*. www.oecd.org/ dataoecd/36/35/40637101.pdf

Osiyevskyy, O., & Dewald, J. (2015). Explorative versus exploitative business model change: the cognitive antecedents of firm-level responses to disruptive innovation. *Strategic Entrepreneurship Journal*,

9(1), 58-78.

Pasban, M., & Nojedeh, S. H. (2016). A Review of the Role of Human Capital in the Organization. *Procedia-social and behavioral sciences*, *230*, 249-253.

Pini, M., Dileo, I., & Cassetta, E. (2018). Digital Reorganization as a Driver of the Export Growth of Italian Manufacturing Small and Medium Sized Enterprises. *Journal of Applied Economic Sciences*, *13*(5), 1373-1385.

Qureshi, J., & Siddiqui, D. A. (2020). Impact of Intangible Assets on Profitability, Efficiency, Capital Structure and Dividend Policy, and Market Value of Technology Firms: A Global Comparative Analysis. (August 26, 2020). Available at SSRN: https://ssrn.com/abstract=3681254

Rodrik D. (2008). Industrial Policy: Don't ask Why, Ask How**,** *Middle East Development Journal,* Demo Issue, 1-29

Rodrik D. (2004). Industrial Policy for the Twenty-First Century, *John F. Kennedy School of Government*, sept.

Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, *98*, S71–S102.

Seo, H. S., & Kim, Y. (2020). Intangible assets investment and firms' performance: Evidence from small and medium-sized enterprises in Korea. *Journal of Business Economics and Management*, *21*(2), 421-445.

Schiavi, G. S., & Behr, A. (2018). Emerging technologies and new business models: a review on disruptive business models. *Innovation & Management Review*, *15*(4), 338-355.

Schultz, T. W. (1961). Investment in human capital. *The American economic review*, *51*(1), 1-17.

Territorial Cohesion Agency-Unioncamere (2020). *Data and information on the socio-economic situation and trend: Regional reports*, Retrieved from https://www.agenziacoesione.gov.it ; https://www.unioncamere.gov.it.

The Boston Consulting Group (2009). Business model innovation. Retrieved from https://image-src.bcg.com/Images/BCG_Business_Model_Innovation_Dec_09_tcm56-121706.pdf

Unger, J. M., Rauch, A., Frese, M., & Rosenbusch, N. (2011). Human capital and entrepreneurial success: A meta-analytical review. *Journal of Business Venturing*, *26*(3), 341–358.

Unioncamere-Centro Studi delle Camere di Commercio Guglielmo Tagliacarne (2021). *Screenshot dell'economia: 25 istantanee sull'anno della crisi pandemica e sulle prospettive di ripresa*.

Vodák, J. (2011). The Importance of Intangible Assets for Making the Company's Value. *Human Resources Management & Ergonomics*, *5*(2), 104-119.

Webster, E. (2000). The growth of enterprise intangible investment in Australia. *Information Economics and Policy*, *12*(1), 1-25.

Wheelen, T.L., & Hunger, J.D. (2011). *Concepts in Strategic Management and Business Policy*, Pearson Education India.

Yoo, W., Mayberry, R., Bae, S., Singh, K., He, Q. P., & Lillard Jr, J. W. (2014). A study of effects of multicollinearity in the multivariable analysis. *International journal of applied science and technology*, *4*(5), 9.

Yuan, X., Hou, F., & Cai, X. (2021). How do patent assets affect firm performance? From the perspective of industrial difference. *Technology Analysis &*

Strategic Management, *33*(8), 943-956.

Zhang, N. (2017). Relationship between intangible assets and financial performance of listed telecommunication firms in China, based on empirical analysis. *African Journal of Business Management*, *11*(24), 751-757.

Zhang, W., Daim, T., & Zhang, Q. (2018). Understanding the disruptive business model innovation of E-business microcredit: a comparative case study in China. *Technology Analysis & Strategic Management*, *30*(7), 765-777.

Appendix

Table A1. Variables description

Variables	Type	Description *(source in parentheses)*
Dependent variables		
Profitability	Continuous	Gross Operating Margin, average value 2017-2019 *(Innolva - Innexta)*
Productivity	Continuous	Value added per employee, average value 2017-19 *(Innolva - Innexta)*
Resilience	Dummy	1 if the firm expects to go back to pre-Covid crisis level by 2021 *(Centro Studi Guglielmo Tagliacarne - Unioncamere survey)*
Independent variables		
intangibile assets variables		
R&D and Intellectual property	Dummy	1 if the firm has intellectual property rights (patents, trademarks or designs registered at the EPO in the period 2009-2019) *(DINTEC)*
Human capital	Dummy	1 if the firm invests in training activities including digital skills and recruitment of high-skill jobs; 0 otherwise *(Centro Studi Guglielmo Tagliacarne-Unioncamere survey)*
Organizational capital	Dummy	1 if the firm has a certification (quality, energy and environmental management, etc.); 0 otherwise *(Centro Studi Guglielmo Tagliacarne-Unioncamere survey)*
Open innovation	Dummy	1 if the firm carries out co-innovation with employees, customers, University and the supply chain firms; 0 otherwise *(Centro Studi Guglielmo Tagliacarne-Unioncamere survey)*
control variables		
Age	Continuous	Number of years since the establishment of the firm *(Business Register)*
Size	Continuous	Number of employees *(Business Register)*
Family	Dummy	1 if the firms if the family has the control of the ownership and manages the firm; 0 otherwise *(Centro Studi Guglielmo Tagliacarne-Unioncamere survey)*
Foreign	Dummy	1 if the firm is a foreign-invested enterprises; 0 otherwise *(Centro Studi Guglielmo Tagliacarne-Unioncamere survey)*
Food_m	Dummy	1 if the firm operates in Food manufacturing sector *(Business Register)*
P&H_m	Dummy	1 if the firm operates in Personal and Households goods manufacturing sector *(Business Register)*
Mechanichal_m	Dummy	1 if the firm operates in Mechanical manufacturing sector *(Business Register)*
Other_m	Dummy	1 if the firm operates in Other manufacturing activities *(Business Register)*
Trade_s	Dummy	1 if the firm operates in Trade sector *(Business Register)*
A&F_s	Dummy	1 if the firm operates in Accomodation and Food service activities sector *(Business Register)*
Other_s	Dummy	1 if the firm operates in Other service activities *(Business Register)*
North-West	Dummy	1 if the firm is located in the North; 0 otherwise *(Business Register)*
Center	Dummy	1 if the firm is located in the Center; 0 otherwise *(Business Register)*
South	Dummy	1 if the firm is located in the South; 0 otherwise *(Business Register)*

Table A2. Summary statistics

	Mean	Std.Dev
Profitability	2,056,905	4,425,668
Productivity	74,669	40,424
Resilience	0.356	0.479
R&D and Intellectual property	0.216	0.412
Human capital	0.460	0.498
Organizational capital	0.417	0.493
Open innovation	0.294	0.456
Age	37	13.620
Size	68	84.045
Family	0.597	0.491
Foreign	0.036	0.186
Food_m	0.110	0.313
P&H_m	0.169	0.375
Mechanichal_m	0.319	0.466
Other_m	0.205	0.404
Trade_s	0.068	0.252
A&F_s	0.040	0.196
Other_s	0.088	0.284
North	0.639	0.480
Center	0.195	0.396
South	0.166	0.372

Table A3. Variance Inflation Factor (VIF)

	VIF
R&D and Intellectual property	1.22
Human capital	1.37
Organizational capital	1.27
Open innovation	1.37
Age	1.02
Size	1.35
Family	1.06
Foreign	1.04
P&H_m	2.17
Mechanichal_m	2.85
Other_m	2.42
Trade_s	1.56
A&F_s	1.37
Other_s	1.85
Center	1.10
South	1.11

The VIF is calculated after OLS regression.