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ORIGINAL ARTICLE

SMEs "Growing Smart": The Complementarity of Intangible and Digital Investment in Small Firms and Their Contribution to Firm Performance

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Abstract

Like large companies, small and medium-sized companies (SMEs) are turning to new digital technologies and knowledge-based capital to bolster their productivity and growth. However, data show that smaller companies lag significantly in implementing new Industry 4.0 technologies and in the intensity of their use. Lack of skills and human capital is often cited as one of the biggest barriers. This paper examines the benefits of digital technologies, intangible capital, and in particular the role of complementary investments in new technologies and intangible capital to maximize the impact on productivity growth. The analysis draws on extensive firm-level datasets combining business and employee registry data and the harmonized EU ICT usage survey for the period 2007–2020 in Slovenia. While SMEs lag behind large companies in the use of ICT on average, the use of ICT and other new technologies significantly increases the productivity of companies in the SME sector, especially when combined with the intangible investments that enhance the contribution of new technologies. Several conclusions emerge from the results, in particular the need to grow and invest intelligently, that is, to invest in intangible assets and new technologies simultaneously, even in SMEs.

Keywords: Digitalization, SMEs, Complementary intangible investments, Productivity

JEL classification: E22, O34

Introduction

Small and medium-sized companies (SMEs), like large companies, benefit significantly from new digital technologies that offer new opportunities for growth and increase business productivity and competitiveness (Remes et al., 2018; Wagner, 2007). SMEs have improved their performance through digitalization. In addition, companies are building their internal capabilities to cope with the external difficulties posed by the digitalization process (Teruel et al., 2022). However, SMEs lag behind in digital transformation compared to large companies. For example, in 2020, 27.23% of SMEs used a single digital technology and 21.57% used multiple digital technologies, compared to 28.16% and 46.28% of large companies, respectively (European Investment Bank, 2019). Apart from the delay in implementation, the potential of digital technologies for innovation and growth is often underutilized by SMEs due to the lack of other required complementary resources, mostly human or intangible resources as well as financial resources (Vitezić & Peric, 2015). As a result, the majority of SMEs do not fully benefit from the productivity and competitiveness that result from the adoption of digital technologies because they cannot clearly identify their needs or effectively use digital technologies (Organisation for Economic Cooperation and Development, 2022). Those companies that have the necessary (digital)

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capabilities are able to integrate the IT and business planning process more effectively, conceive of and develop reliable and cost-effective applications that support the business needs of the firm faster than competition, communicate and work with business units more efficiently and anticipate future business needs of the firm and innovate valuable new product features before competitors (Bharadwaj, 2000).

This complementarity between digital and intangible business resources has led firms to focus on investments in intangibles such as intellectual property, innovative capital, competencies and skills, business model development, brand strengthening, and others, as these investments provide competitive advantages to firms. However, SMEs also lag behind in investing in intangible capital, as a large proportion of SMEs do not invest in intangibles at all (Kostevc & Redek, 2021).

The paper examines the following research questions: (1) What are the characteristics of investment in new technologies and intangible investment as a function of firm size? (2) How important are simultaneous investments in intangible and new technologies for productivity growth? Methodologically, the analysis relies on a combination of official register microdata sets: (1) annual financial statement data available for the entire population of Slovenian firms provided by the Agency of the Republic of Slovenia for Public Legal Records and Related Services (AJPES), (2) microdata from the official harmonized survey on the "Use of ICT in Companies," and (3) the register of employees in Slovenia used to assess intangible investments in line with the H2020 Globalinto approach. The paper examines companies in Slovenia in the period between 2007 and 2020.

The results show that both investments in new technologies and intangible investments have a positive impact on SME productivity. However, the strongest impact is found for companies that invest in both at the same time or that "grow smartly." To our knowledge, this is the first study of its kind to examine the impact of complementary investments in new technologies and intangible capital in SMEs from a productivity growth perspective. It applies an innovative approach to estimating firm intangible capital based on the Globalinto method, overcoming the lack of data on intangible investment in firms.

The paper first provides a theoretical background to develop the hypotheses, followed by a discussion of the methodology and results. It then discusses the results and implications and concludes by summarizing the main findings.

1 Theoretical background

1.1 The impact of technology and digitalization on firm performance

The literature stresses the positive impact of digitalization, which has led to a number of innovative advances improving businesses' productivity and efficiency (Björkdahl, 2020; Bui & Le, 2023). New technologies help increase firms' short-run efficiency and long-run growth and competitiveness (Coad & Srhoj, 2020; Gao et al., 2012; Müller et al., 2018). Digital transformation generates additional revenue streams (Chawla & Goyal, 2022) through sales growth (Bahadir et al., 2009), allows better customer care and more efficient operations (Al Awadhi et al., 2021; Rekettye & Rekettye, 2019). Digital resources can reduce transaction costs and production expenses, improving operational efficiency (Mithas & Rust, 2016) and increasing internal efficiency, for instance, through better working and organizational practices (Schildt, 2017; Trittin-Ulbrich et al., 2021). Research also acknowledges the relationships between digitalization and businesses' innovative capacities, which can have a favourable impact on performance in terms of growth and innovation (Ferreira et al., 2019; Tsou & Chen, 2021). Studies have also shown linkages between soft-skill development and digital resources, that is, IT and big data, as a way to connect human and technological components for better performance (Caputo et al., 2019; Kristoffersen et al., 2021). Additional value added is generated also through innovative combinations of technologies involved in the process of digital transformation (Bharadwaj et al., 2013). Digital technologies also reduce costs, rapidly and cost-efficiently improve old or customize new products and processes (Chawla & Goyal, 2022). New technologies such as 3D printing, blockchain, and others, also have a positive effect on product innovation and a firm's performance (Menguc & Ozanne, 2005).

Digitalization, which is faster in large companies (Organisation for Economic Cooperation and Development, n.d.), is important for all firms, including SMEs. It allows firms to compete more efficiently by integrating operational and management information systems (Abdullah & Chatwin, 1994), become more flexible (Bharadwaj, 2000), and use ICT more efficiently (Ivanova & Castellano, 2012; Santoro et al., 2019). A 2019 economic survey of Singapore's first-quarter results showed that SMEs adopting digital tools increased their value by 25% and their productivity by 16% on average (Abanmai, 2020). Productivity gains are bigger for high-productivity firms (Berlingieri, 2018), although gains from technology depend also on the type of technology (e.g., cloud computing is more beneficial for small firms as a means to avoid investing in a large IT infrastructure; Bloom & Pierri, 2018). Consequently, we expect (H1) that *investments in digital technologies are positively associated with value added in SMEs*.

1.2 Intangible capital, firm performance, and technology implementation

Intangible capital consists of (1) computerized information, (2) innovative capital, and (3) economic competencies (Corrado et al., 2009). Higher levels of competition and a more digitalized economy results in businesses focusing on investments in intangibles such as intellectual property since these investments bring companies certain competitive advantages (Khan et al., 2019). Human capital, which represents a major part of intangible capital (economic competencies), is defined as the collective capability of a firm's employees comprising the skills, knowledge, experiences, and proficiency (Edvinsson, 1997). It represents an essential form of the competitive advantage of a firm (Liu & Jiang, 2020) and can leverage strategic capabilities such as digital capability through its sub-dimensions including human capital and their distinct roles (Altman et al., 2022; Chu et al., 2006). Similarly, the innovative property, R&D, design, and so forth enhance firm performance (Corrado et al., 2017; Maggi, 2019; Piekkola & Rahko, 2020; Roth, 2020); in particular, the companies that are more digitalized also benefit from more innovativeness, from product innovation to business model innovation (Menguc & Ozanne, 2005). Digital technology that is used for digital transformation does not necessarily have to be new, because its value added comes from the innovative combinations of information generation, extraction, computation, and communication technologies involved in the process of digital transformation (Bharadwaj et al., 2013), which again requires the use of intangible capital and a suitable company strategy with forms of digital transformation (Kane et al., 2015) to maximize the impact of technology.

We additionally argue that intangible investment and investments in new technologies are complementary and that firms that simultaneously invest in both intangible capital and new technologies will perform better. First, the lack of human capital, knowledge, and skills is a highly cited obstacle in new technology implementation (Čater et al., 2021) and investment at large (Andrews et al., 2018; European Investment Bank, 2019). Skills are important in the development of innovative business models needed for new technologies implementation (Baima et al., 2020), while new technologies can further increase the efficiency in completing organizational tasks, the speed and responsiveness of firms, and decision making (Pinzone et al., 2017). The number of qualified employees impacts the adoption of new technologies (Petroni et al., 2012). Educated people are also good innovators (De Albuquerque et al., 2012) and are better informed about the latest technologies available (more advanced technologies require a higher level of skills; Gruber, 2017; Walk et al., 2015).

Therefore, we expect that (H2) *simultaneous presence of investment in both new technologies and intangible assets is positively associated with value added*.

1.3 The characteristics and role of intangible investment in SMEs

SMEs' characteristics differ from those of large firms, due to their limitations regarding financial and human resources (Müller et al., 2018). SMEs largely lag behind in the use of both more complex digital technologies as well as in terms of the employment of ICT specialists (Čater et al., 2019; Maravić et al., 2021) and the use of intangible capital (Kostevc & Redek, 2021). Evidence also shows that SMEs have larger skills deficiencies than large companies and invest less (on a per-employee basis) in trainings compared to large companies. SMEs have difficulties in attracting a highly qualified workforce (Organisation for Economic Cooperation and Development, 2017). In addition, SMEs' challenges include not only the lack of resources (human and financial), but also a low degree of processes standardization and less automated production processes (Müller et al., 2018).

It has been shown that the level of technology usage differs among firms' sizes and industries (Berlingieri, 2018; Denicolai et al., 2021; Lu & Ramamurthy, 2011). The first reason for the differences lies in industry specifics, as not all technologies are appropriate for all industries (Banerjee et al., 2003; Utterback, 1974). The firm size also affects the level of technology usage as well as the optimal technology intensity level. First, the implementation of new technologies is often very costly, so only firms with substantial resources can afford it (and usually larger companies have relatively more resources available to invest; Berlingieri, 2018). The second reason lies in economies of scale, which will lead to a different optimal number of technologies used; third, the implementation of new technologies requires complementary investments in other intangible assets such as human capital in order for a firm to take full advantage of new technologies (Corrado et al., 2017).

Nonetheless, the literature shows that intangible investments have a positive impact on firm performance, which includes SMEs (Mansion & Bausch, 2020; Seo & Kim, 2020; Yadiati et al., 2019), although there were significant differences in the intensity and contribution of intangibles to firm performance (Kostevc & Redek, 2021). For example, the distribution of intangible investment is very skewed; many firms invest very little or nothing at all (Kaus et al., 2020), among them mainly small firms. For example, in Slovenia in 2020 there were around 75% of microfirms with no intangible capital compared to only around 5% of large companies. On average in Slovenia, 70% of SMEs had no intangible capital, though the estimations showed that it was in fact the smallest firms (up to 9 employees) that recorded the strongest impact of intangible capital on firm performance (Kostevc & Redek, 2021). Based on this, we hypothesize that (H3) *smaller companies on average report lower intangible investment intensity and digital intensity than larger firms* and, as already stated, that (H4) *intangible capital has a positive impact on firm performance in SMEs*.

1.4 *Exporting status and productivity*

Since the mid-1990s the availability of firm-level data has supported extensive research on the association between firm engagement in exporting and its performance. The correlation between productivity and export status has been proven to be robust over numerous datasets (Greenaway et al., 2005, and Wagner, 2007, provide extensive literature reviews). Theoretical models such as Bernard et al. (2003) and Melitz and Ottaviano (2008) emphasize the self-selection of firms into export markets based on an underlying productivity distribution, creating a strong correlation between productivity and export status. Given the small domestic market, a large proportion of Slovenian firms export (around 50% of companies in 2021, excluding sole proprietors and two thirds of companies in the estimation sample), leading to a relative scarcity of non-exporting control observations, in particular in the cohort of large firms in industries reliant on scale economies. Based on this, we control for exporting status in the productivity specification by including an indicator for firms that exported at least 50% of their total sales in addition to the standard exporting status indicator.

2 Methodology and data

The paper studies the link between productivity (value added) and its determinants, with the focus on evaluating the contribution of new technologies, intangible capital, and complementary investments in both. Methodologically, the estimation strategy is based on an evaluation of the production function, which relies on a modified approach utilized in H2020 Globalinto procedure for estimating the contribution of knowledge-based capital (i.e., intangible capital). We extend the specification by adding the perspective of ICT usage as well as the impact of openness (exports). The analysis relies on a combination of individual (employee) and firm-level datasets—accounting registry data for the population of companies and official national/Eurostat harmonized survey data.

2.1 *Empirical approach*

We employed a production-function-based investigation into the contributions of standard production factors: capital, non-intangible employees, intangible employees of three types (organizational, ICT, and R&D), and the intensity of use of new technologies. We followed the approach suggested by Piekkola et al. (2021a), where the elasticity of value added is derived based on an extended production function: $Y_{it} = AK_{it}^{\beta_K} L_{it}^{\beta_L} L_{ORGit}^{\beta_{Lorg}} L_{ICTit}^{\beta_{Lict}} L_{RDit}^{\beta_{Lrd}}$. K_{it} is capital per firm in a given year; L_{ORGit}, L_{ICTit}, L_{RDit} are the organizational, ICT, and R&D workers, respectively. β denotes the relevant elasticities in each case. The estimation was also extended with dummy variables, capturing the combined intensity of investment in technology and intangibles (D) for each of the groups j (as explained below). The relevant estimation equation is (1):

$$lnY_{it} = b_0 + b_L lnL_{it} + b_K lnK_{it} + b_{ORG} lnL_{ORGit} + b_{R\&D} lnL_{R\&Dit} + b_{ICT} lnL_{ICTit} + \Sigma_j b_j D_{jt} + e_{it} \quad (1)$$

Fixed-effects estimation was used controlling for industry (NACE, level 2) and year, as well as firm size to differentiate between different sub-classes of SMEs (Clark & Linzer, 2015). Additionally, in some specifications, the technological type of the industry as defined by the Organisation for Economic Cooperation and Development (OECD) (see Piekkola et al., 2021b) was used to control for differences across sectors by technological intensity rather than NACE sector.

2.2 *Construction of key variables*

2.2.1 *Intangible capital measurement*

To measure intangible capital, the methodological approach proposed by Piekkola et al. (2021b) within the H2020 Globalinto "Capturing the value of intangible assets in microdata to promote EU's growth and competitiveness" project was used. The methodology utilizes the microdata from the population-based statistical registry of employed workers, matched with firm-level data to overcome the lack of data on intangible capital. It proxies intangible capital by deriving a measure based on intangible work—for example, innovative capital depends on R&D or innovative work. To compose a measure of "intangible capital" work, the International Standard Classification of Occupations (ISCO) is used. The amount of intangible capital in a company was assessed by the number of people (and shares) in certain "intangible capital work" occupations according to the ISCO classification (for more details see Table A1 of the Appendix). Each employee was categorized into one of four groups: either non-intangible capital work or one of three intangible categories of workers (organizational, ICT, and R&D). The data were collapsed and merged with firm accounting data. Respective numbers and shares of each category of work were constructed for each company.

2.2.2 *Use of new technologies*

The variables for the use of new technologies in companies were created using the standardized EU survey "The use of ICT in companies" (see, e.g., Statistični urad Republike Slovenije, 2019). As the ICT questionnaire has evolved considerably since 2007 and the number of different technologies used has increased, both the number per year and the proportion of all available/investigated technologies each year were used to examine the intensity of use.

In addition, we had to consider sectoral and size differences. Consequently, several different variables were used. First, each company position was calculated relative to the maximum number of technologies used in each respective year, by dividing the number of technologies used by the firm in comparison to the maximum in that specific year (absolute maximum regardless of firm size and industry). Company size also affects the rationale of investment into new technologies, as not all technologies are relevant for microcompanies, depending on what their specialization is. On the other hand, among *medium companies*, the size and economies of scale allow companies to implement and use a *wider range* of technologies. Size also impacts the structure of employment and the share of intangible workers. The second indicator compared the number of technologies used to the best performing company, where the maximum was identified for each firm size group in every year and the actual number of technologies in a company was compared to the best performer in the size group (not controlling for industry). The literature highlights the differences among sectors in the use of technology using two measures, which we also considered. The third indicator considered the relative intensity of the firm (i.e., the number of technologies used in a firm) to the best performer in a specific NACE1 sector and size class.

2.2.3 *Other variables*

The empirical approach relies on production-function estimation. To evaluate the impact of relevant variables on firm performance, value added was required first. It was calculated using a standard approach, subtracting material costs from revenue. The number of non-intangible capital employees was constructed next, followed by the three types of intangible capital work (as described above). For each firm, average education of employees in years was calculated by averaging across educational attainments of all individuals that worked in a specific firm. The share of exports was calculated by dividing the sales in foreign markets by total sales. Since roughly two thirds of firms in the sample were exporters, a dummy variable was created, indicating whether the firm had at least a 50% export share, signifying export intensity.

2.3 *Data*

The analysis draws on four different registry databases. The proprietary data of AJPES provide the basic demographic characteristics about Slovenian businesses within the "Slovenian Business Register data" and the "AJPES" data about the entire population of Slovenian businesses (130 thousand). The "Statistical registry of employees" in Slovenia (about 800 thousand employees annually), which provides information on the structure of employees, their education, and occupation, was used to create the variables on intangible investments in companies. The datasets were merged with the microdata from the official, EU-wide harmonized survey on the "Use of ICT in companies," which is conducted by the Slovenian Statistical Office among about 1100–1500 companies per year. A total of 15,338 micro-, small and medium companies were analysed in the period between 2007 and 2020, ranging from 774 observations (2020) to 1471 observations (2013) yearly.[1]

The sample included 16.4% or 2512 microcompanies, 61.9% or 9503 small companies, and 21.7% or 3323 medium companies. The size was determined by employment (0–9, 10–49, 50–249 employees, respectively). More than one third of companies were from the manufacturing sector (33.4%, NACE C),

[1] The panel is unbalanced, depending on the sampling by the Statistical office of the Republic of Slovenia, for each survey round. On average, a company was included in the survey four times; around 12% of companies were included at least 10 times. The sampling is done in accordance with the methodology of the Statistical office of the Republic of Slovenia and Eurostat.

followed by the retail sector (21.8%, NACE G); around 9% were from the accommodation and food services sector (NACE I), and 9.6% from professional, scientific, and technical activities (NACE M), followed by transportation and storage (7.9%) and ICT (5.8%, NACE J). The companies were also divided according to the technology intensity of their respective NACE 2-digit sector according to the OECD classification (see also Bloch et al., 2021). Around 31% of companies belonged to the medium-low- and low-technology-intensive manufacturing sectors, and 7.5% to the high-technology-intensive manufacturing sector, while 43.6% of companies surveyed belonged to the low-knowledge-intensity services sector; the rest were knowledge-intensive services (18%).

3 Results

3.1 The differences in the intensity of use of new technologies and intangible investment in SMEs

Overall, 25.7% of the studied companies did not employ intangible workers, and 3.5% did not use technologies during the whole period of the study (2007–2020) (Table 1). The percentage was higher among microcompanies; no fewer than 50.0% of microcompanies did not employ intangible workers. Among small companies, 26.1% did not employ any intangible workers, and 5.9% of medium companies employed no intangible workers. Among large companies, only 0.4% (11 in total) did not employ any intangible workers. The share of companies which used no technology declined between 2007 and 2020. If in 2007 around 1.3% of companies used no technology (not even a computer), this share declined to only 0.3% by 2020. By size, the share of companies not using any technology was the largest among microcompanies, where in the entire sample 7.2% of observed companies did not use technologies, while there were only a handful of such companies among the 3300 medium companies observed in the sample. Also, the share of companies without intangible capital work declined in the observed period. Since 2007, the percentage of microcompanies that did not employ intangible labour varied but has on average decreased and was around 45% in 2020. In small companies, the volatility was lower, and the percentage of companies without intangible capital work also declined, from around 34% to 24%. The gap is the most pronounced between micro- and small companies on the one hand and medium companies on the other, where the share of companies without intangible capital work is around 5 to 6%.

A closer look at the technologies used in 2020 shows that while almost all companies, regardless of their size, used computers and the Internet (over 99%), there were significant differences in the use of the mobile Internet, which was utilized only by 79% and 87% of micro- and small companies, respectively, and 96% of medium companies. While 96% of medium companies had a website, only 68% of microcompanies did. The cloud was used in 23% of microcompanies, 43% of small companies, and 52% of medium companies. The use of more advanced technologies was lower in all size categories, but larger companies used them more frequently. Electronic invoices were used in 64%

*Table 1. Share of companies by size class with no intangible workers or no technologies used.**

	Without intangible capital				Without technologies				Total
Year	Micro	Small	Medium	Total	Micro	Small	Medium	Total	Number of observations
2007	.49	.34	.07	.37	SP	SP	.000	.013	977
2008	.51	.27	.07	.35	.267	.134	.051	.181	1027
2009	.56	.30	.05	.38	.022	.011	.000	.014	1185
2010	.61	.29	.07	.26	SP	SP	SP	.006	1058
2011	.53	.28	.06	.25	SP	SP	SP	.004	1156
2012	.53	.27	.04	.23	SP	SP	.000	.008	1180
2013	.46	.25	.06	.28	.029	.007	.000	.012	1471
2014	.53	.25	.06	.22	.074	.009	.000	.011	1101
2015	.38	.24	.06	.20	SP	SP	.000	.006	1112
2016	.32	.27	.06	.22	SP	SP	.000	.004	1146
2017	.47	.23	.05	.20	SP	SP	SP	SP	1150
2018	.46	.26	.06	.22	SP	SP	SP	.005	1150
2019	.46	.22	.06	.20	SP	.000	.000	SP	851
2020	.45	.24	.06	.21	.000	SP	.000	SP	774
Total	.50	.26	.06	.26	.072	.011	.004	.019	15,338
Total number of observations by company size									
Number	2512	9503	3323	15,338	2512	9503	3323	15,338	

*SP: "statistical protection," very small number of observations, actual number protected by the statistical data protection framework and are confidential. Data: Statistical Office of the Republic of Slovenia, own calculations.

*Table 2. Share of companies using a specific technology by company size and average number of selected technologies used in a company in 2020.**

	Micro	Small	Medium	Total
IT intensity (average number of technologies used)**	3.49	4.28	5.02	4.41
Computer	SP	SP	SP	.994783
Internet	1.00	SP	1.00	SP
Mobile Internet	.79	.87	.96	.89
Web page	.68	.85	.96	.87
Cloud	.23	.43	.52	.44
3D printing	.00	.05	.12	.06
Robots	SP	.07	SP	.10
Big data	.10	.09	.19	.12
E-invoices	.53	.59	.64	.60
E-sales	.11	.23	.18	.21
Computer exchange of data (RIP)	.00	.04	.15	.06
Internet of Things	SP	.16	SP	.18

*Use of computers and big data for 2018. **For 2020, 10 technologies in total were captured.
SP: "statistical protection," very small number of observations, actual number protected by the individual data protection code of the Statistical Office of RS. Data: Statistical Office of the Republic of Slovenia, own calculations.

of medium companies and 53% of microcompanies; e-sales were used in 11% of microcompanies and 18% of medium companies, and computerized data exchange was used in 15% of medium companies and only 4% of small companies (Table 2).

On average (over the entire period, not just in 2020 as in Table 2), microcompanies used 2.65 technologies (8 was the maximum among them), small companies used 3.65 different technologies (9 was the maximum among them), and medium companies used 4.15 different technologies (9 was the maximum among them). The *t*-test for pairwise comparison of means shows that the differences between all combinations of groups are statistically significant at $p = .000$, which confirms H3 that smaller companies on average report lower intangible investment intensity and digital intensity than larger firms.

As for investment in intangible capital, as measured by the share of intangible employees, its share was low (Table 3). On average, *82% of employees were non-intangible workers*. The share of *R&D* workers was the highest in medium companies at 8.3%, while it was between 5.9% and 7.3% in micro- and medium companies. The share of organizational workers ranged from 4.8 to 6.9%, while the shares of ICT workers, which ranged from 3.4% to 4.1%, were the lowest (and comparatively the highest in small companies). Interestingly, the median microcompany had no intangible workers of any kind. Over the period studied, the mean and median proportions were relatively stable on average, in particular with regard to organizational capital workers, which remained around 6.5% on average, while the shares of ICT and R&D workers increased by around 1.5 and 1 percentage point, respectively, over the investigated period. Interestingly, the share of organizational, ICT, and R&D workers declined in microcompanies, which could be a result of different factors, such as company growth as well as less attractive jobs in microcompanies compared to larger companies. In small and medium companies, the shares of all intangible capital workers increased over the observed period, which is consistent with the rising importance of the knowledge economy, primarily in knowledge-intensive services (Piekkola et al., 2021a).

Table 3. Share of intangible workers as % of all employees by company size over the observed period.

	Organizational capital work	ICT capital work	R&D capital work
Total			
Mean	.065	.038	.073
Median	.033	.000	.000
Micro			
Mean	.069	.035	.059
Median	.000	.000	.000
Small			
Mean	.070	.041	.073
Median	.043	.000	.000
Medium			
Mean	.048	.034	.083
Median	.031	.000	.046

Data: Statistical Office of the Republic of Slovenia, own calculations.

To examine the impact of the use of new technologies and intangible investments, as well as complementary investments in intangibles and new technologies, companies were divided into four groups (according to combined technology and intangible capital investment intensity): (1) firms with no intangibles and low technology intensity (below the median technology intensity measured as a share of total available technologies), (2) firms with intangible investment (measured as intangible employees) and low technology intensity, (3) firms with no intangible investment and high technology intensity, (4) firms with both intangible investment and high technology intensity (Table 4).

Table 4. Division of companies by size and ICT–IT intensity: shares of companies by group.*

	No intangibles, low tech. intensity	With intangibles and low tech. intensity	No intangibles and high tech. intensity	Both intangible investments and high tech. intensity	Total	No. of firms
Micro	28.8	20.3	21.3	29.7	100.0	2512
Small	13.5	26.3	12.6	47.6	100.0	9503
Medium	2.6	23.8	3.2	70.3	100.0	3323
Total	13.7	24.8	12.0	49.6	100.0	15,338

*Below median technology intensity, measured as share of total available technologies.
Data: Statistical Office of the Republic of Slovenia, own calculations.

As the data in Table 4 show, 28.8% of microcompanies belonged to the first group, while almost 30% of all microcompanies were both technologically above average and had invested in intangible capital work. Among small companies, 47.6% had invested in both intangible capital and technologically advanced products. Among medium companies, 70.3% had intangible capital and were also technologically advanced.

3.2 Relationship between ICT, intangible investment, and productivity

On average (Table 5, details in Appendix, Table A3), companies that were more *technologically advanced* and used *intangible capital* also had higher value added per employee. Of all the companies, those that invested in both had an average value added of €42.8 thousand per employee in the observed period (2007–2020), while those that did not use intangible assets and had low technological intensity only had €26.5 thousand value added per employee in the period studied, which speaks in favour of hypothesis H1 that investments in digital technologies are positively associated with value added in SMEs. Data also show that, on average, productivity changes with firm size, with primarily microfirms lagging behind.

This pattern is also evident among micro-, small and medium firms if each group is divided further by intensity of investment in intangibles and new technologies. Firms that excel in productivity are those that invest in both intangibles and are also above average in technological intensity. Also, those firms that either invest only in technology and are technologically advanced, or those that employ intangible labour (while technologically underperforming) are *better than those that lag in both*. In all three groups, value added is the highest in companies that both invest in intangibles and have above-average technological intensity. Companies which only use technology but have no intangible capital work have lower value added than companies that have only intangible capital work but invest little in new technologies. The differences between the group with no

Table 5. Descriptive statistics by company type (size and knowledge & tech intensity), 2007–2020.*

	Micro	Small	Medium	No intangibles, low tech. intensity	With intangibles, low tech. intensity	No intangibles, high tech. intensity	Both intangibles and high tech. intensity	Total
Value added per employee	33,222	39,335	38,339	26,462	38,983	29,844	42,840	38,046
Export share	.13	.21	.31	.15	.27	.13	.24	.22
Number of employees	7.98	21.15	107.63	16.34	37.47	17.84	48.57	37.73
Share of max number of technologies	.55	.61	.67	.39	.44	.71	.73	.61
Average years of education of employees	7.36	10.81	10.49	7.82	9.12	9.75	11.13	10.10
No. of employees	8.56	21.77	110.61	16.62	38.56	18.31	50.09	38.85
ORG workers share	.07	.07	.05	.00	.09	.00	.09	.07
ICT workers share	.03	.04	.03	.00	.04	.00	.06	.04
R&D workers share	.06	.07	.08	.00	.09	.00	.10	.07
Average number of technologies used	2.63	3.64	4.11	2.48	3.27	3.61	4.02	3.57
Share of companies with at least 50% exports	.11	.19	.32	.15	.26	.11	.22	.20

*Real value added in euros, 2015 prices.
Data: Statistical Office of the Republic of Slovenia, own calculations.

intangible capital work and low technology intensity and the group with both types is highest among medium companies, where the latter is 73% more productive (in the other two size groups, the group with both intangibles and high technological intensity is 62% and 68% more productive).

3.3 Relationship between simultaneous investment in intangibles and new technologies on the one hand and firm productivity on the other

Regression results are in Table 6. Fixed-effects panel estimation was used, with specifications including

*Table 6. Regression results on the impact on value added (coefficients and standard errors).**

Value added	1 b/se	2 b/se	3 b/se	4 b/se	5 b/se	6 b/se	7 b/se
Average years of education	.023*** .006	.022*** .006	.023*** .006	.023*** .006	.023*** .006	.018** .006	.019** .005
Non-intangible capital work	.627*** .013	.644*** .014	.647*** .014	.645*** .014	.643*** .014	.605*** .018	.605*** .014
ICT work	.044* .019	.038* .019	.043* .02	.039* .019	.040* .019	.075* .03	
Organizational work	.066** .012	.042** .013	.038** .014	.042** .014	.044*** .013	.037 .02	
R&D work	.130*** .013	.136*** .013	.135*** .015	.136*** .013	.135*** .013	.147*** .017	
Intangible capital work							.090*** .008
Capital	.051*** .021	.051*** .004	.051*** .004	.051*** .004	.051*** .004	.049*** .005	.046*** .021
Export (50% share) dummy	.065** .021	.065** .021	.063** .021	.063** .021	.064** .021	.021 .026	.046* .021
Share of max ICT in relevant size group and NACE2	.036 .027	.009 .028					
Share of max ICT##share of intangible organizational work			.579*** .147				
Share of max ICT##share of intangible R&D work			.025 .129				
Share of max ICT##share of intangible ICT work			.203 .143				
Share of max ICT in relevant size group##share of intangible ICT work				.251*** .065			
Share of max ICT in relevant size group and NACE2##share of intangible ICT work		.158*** .038			.205*** .055	.220*** .063	
Share of max ICT ##share of intangible ICT work							.078* .033
Industry dummy (NACE2)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Size dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Technological intensity category (OECD)						Yes	Yes
Ownership dummy						Yes	Yes
_cons	10.938*** .400	10.892 .399	10.874*** .4	10.881*** .4	10.891*** .4	10.606*** .11	10.501*** .148
N	15,876	15,838	15,876	15,876	15,876	12,015	12,015
r^2_w	.409	.412	.41	.41	.41	.356	.356
r^2_b	.681	.688	.687	.687	.687	.551	.545
r^2_o	.708	.714	.713	.714	.713	.544	.538
σ_e	.313	.312	.313	.313	.313	.311	.311
σ_u	.636	.629	.63	.63	.63	.614	.617
ρ	.805	.803	.802	.802	.802	.796	.797

Note: Log-log form was used.
Significance levels: * <.05, ** >.01, *** <.001.
Data: Statistical Office of the Republic of Slovenia, own calculations.

indicator variables for year, industry (NACE level 2), and size class (micro, small, medium). Double logarithmic form was used for the estimation equation. The last two regressions additionally control for ownership type (private, public, mixed, other) and technological intensity according to the OECD.

The results show that, on average, the elasticity of value added with respect to employment of non-intangible capital was the highest. However, the stock of human capital is important, as can be seen from the elasticity of value added with respect to the average years of education of employees in the company. With respect to the three types of intangible labour, which is included either separately (columns 1–6) or as whole (sum of all three categories, column 7), the results show a systematic positive and significant elasticity, as expected, which also confirms hypothesis H4 that intangible capital has a positive impact on firm performance in SMEs.

While technological intensity itself does not have a significant impact[2] (column 1), the combined impact of technology and intangible capital work is positive and significant regardless of specification. The first specification studied the combined effect of the intangible work type (for each of the three categories) and relative share of the number of technologies the firm used, relative to the highest number used in a specific year (not controlling for firm size or sector, see Table A2 for variable description). The second controlled also for size (Share of max ICT in relevant size group), and the third for size and sector (Share of max ICT in relevant size group and NACE2). The last captured the combined effect of intangible capital and relative share of the number of technologies the firm used, relative to the highest number used in a specific year. The relationship between simultaneous investments in new technologies and intangible capital on the one hand and productivity on the other is, in all cases, positive and significant, which confirms the hypothesis (H2) that simultaneous investment in both new technologies and intangible assets is positively associated with value added, that is, productivity. After controlling for industry, year, as well as ownership and technological intensity of industries according to the OECD (see Bloch et al., 2021), the results remain positive and significant. This confirms the combined importance of technology investment/use when also accompanied by intangible capital investment.

4 Discussion

4.1 Main findings and implications

The Fourth Industrial Revolution with a wide range of new technologies, including robotization, smart factories, artificial intelligence, and others, has a significant impact on productivity growth both in SMEs and in the economy at large (Aernoudt, 2019; Morrar et al., 2019; Szabo et al., 2020; Tsou & Chen, 2021). New technologies are expected to boost productivity also due to their impact on innovation and business model transformation (Bui & Le, 2023; Caputo et al., 2019), while intangible capital has been reported to contribute as much as 30% of total productivity growth (Nonnis et al., 2023; Piekkola et al., 2021b; Tsakanikas et al., 2020). The literature has also suggested that there is a link between knowledge (intangible capital) and digitalization, which enhances the impact on innovativeness, creativity, and performance (Bui & Le, 2023; Caputo et al., 2019), especially when supported by a solid strategy, which could be deemed intangible (organizational) capital as well. The literature also points out that the lack of human capital and skills, which is a large part of intangible capital, that is, the part of economic competencies, is a major obstacle in identifying, implementing, and using appropriate technologies (Čater et al., 2021). In the literature, knowledge and digitalization are increasingly important also for small firms (Aernoudt, 2019; Foroudi et al., 2017).

This paper has focused on identifying whether there is a positive relationship between SME performance and simultaneous investment in both new technologies and intangible capital (proxied by intangible work). In particular, three elements have been investigated: first, whether *investments in digital technologies are positively associated with value added in SMEs* (H1). Second, we have been interested in whether *simultaneous presence of investment in both new technologies and intangible assets is positively associated with value added* (H2). Third, we have explored *the intensity of intangible investment in smaller firms relative to those in larger ones* (H3) and *the impact of intangible capital on firm performance in SMEs* (H4).

Results show that, on average, the firms that were more technologically advanced and used intangible capital also had higher value added per employee; specifically, those that invested in both had an average value added of €42.8 thousand per employee during the 2007–2020 observation period, compared to only

[2] Several different measures of technological intensity were used, from the number of technologies (absolute number) to relative measures. Here, only one such example is provided; however, the result is consistently insignificant, regardless of the measure.

half of the value added per employee produced by those that did not use intangible assets and had low technology intensity during the observation period.

The results, obtained through a production-function estimation of the contributions of different factors, from intangible work to technology and combined effects of technology and intangible work, highlight that this positive relationship indeed exists and is highly significant even after controlling for a number of other factors. The results also show that there is a significant productivity gap between firms that lag in technology and intangible investments in comparison to firms that rely on both factors, with the difference reaching even over 70% higher productivity (if measured by value added per employee).

This finding has important implications for managers, particularly with respect to the existing literature on productivity as well as barriers to implementation and use of new technologies. SMEs represent the majority of the business population in all countries; their share in Slovenia is over 99%, with microcompanies representing around 95% of all companies (Statistični urad Republike Slovenije, n.d.). Improving their productivity by focusing on improving technological intensity, knowledge intensity, or, ideally, both would have a significant impact on overall economic performance.

The results highlight that to maximize the impact of new technologies, a firm's decision to invest in new technologies to maximize the outcome should always be accompanied by strengthening (intangible) human capital and improving skills (education and training). In SMEs, the ability to invest in such resources may be limited, for financial and non-financial reasons (Aiello et al., 2020; Ferrando & Preuss, 2018; Oliveira Neto et al., 2017; Zubair et al., 2020). Consequently, their ability to grow is hampered twice—both due to the lack of investment as well as inability to unlock the potential of combined investment.

Therefore, governments or stakeholders (such as chambers of commerce) could support the "smart growth" of SMEs by preparing training or providing support for technology adoption and use to maximize the efficiency of using new technologies. Given the possible financial obstacles to investments, such "educational" campaigns should also be supported by investment programs (Organisation for Economic Cooperation and Development, 2019, 2022).

4.2 Contributions

To the best of our knowledge, this paper is the first to examine the complementarity of investments in new technologies and intangible capital in SMEs from the perspective of firm productivity in this manner. It is also, to our knowledge, the first analysis of the complementarity of investments in technology and intangible capital, particularly from the perspective of emerging markets. The analysis applies an innovative approach to the estimation of firms' intangible capital, based on the methodology of Innodrive and Globalinto, to help overcome the problem of lack of data on intangibles as defined by Corrado et al. (2009). The paper confirms that complementary investments are indeed the most beneficial on average, which also supports the literature highlighting the role of human capital (which is part of intangible capital) in technology implementation. Indeed, it is reported that the lack of skills, the resistance of employees to change, and the lack of appropriate (technical) profiles is one of the main barriers to technology adoption (Čater et al., 2021). The analysis also draws on rich registry-based microdata collected through official statistics, which is the most reliable source of data available.

4.3 Limitations and challenges for future research

Several limitations provide opportunities for future research. In the future, analyses should focus on each segment of SMEs separately and examine the causes of differences in their behaviour, also separating fast-growing firms from those that grow slowly. The possible presence of "overinvestment" or diminishing returns and the suitability of different technologies for SMEs could be explored. Previous research has pointed to the importance of strategy in business development (Björkdahl, 2020), with ownership also playing a major role in determining behaviour and goals in small businesses. It has been reported that family businesses focus more on stability as they are often a source of social security for the owner and family, which means they are less risk-taking and less ambitious (Redek & Oblak, 2016).

One of the challenges for future research is also to test for the link between firm size and firm growth. This is known as Gibrat's law (Bojnec & Fertő, 2020). Although we have not studied firm growth, but rather their productivity level, this could also be linked to firm size, as suggested by Gibrat's law. To take this possibility into account, size dummies have been included, following the H2020 Globalinto methodology. However, we acknowledge that we have not been able to appropriately test for the issue of Gibrat's law (Fiala & Hedija, 2019; Srhoj et al., 2018), since the dataset used combines administrative data and survey data (with varying structure of companies per survey wave). The estimation sample is a non-balanced panel, often comprising only one data point (ID, year) per firm. Therefore, we have not been able to test appropriately for the challenge of Gibrat's law, as was for example suggested and done by Bojnec and Fertő (2020) for Slovenian agricultural companies, who relied on a number of different tests, from simple CD to multiple other unit root tests, such as Pesaran, HS, HMW and other.

Depending on the availability of data, similar investigations could be relevant also at sectoral level, potentially using combined dataset from Eurostat (on digital technology) and EU Klems (for intangible investments).

5 Conclusion

Digital transformation is expected to significantly boost productivity growth, just as other industrial revolutions have done. Large companies will take the lead in technological transformation, while smaller ones will lag behind significantly. In addition, smaller companies lag behind in complementary investments in intangible capital that enable firms to use digital technologies more efficiently. SMEs also lag behind in intangible investments, especially when considering the median firm. However, the results show that complementary investments in both technology and intangible capital boost productivity growth the most, which is a very important finding in a restructured economy like Slovenia's or other emerging economies. Results of the regression confirm that more technologically advanced firms using intangible capital have higher value added per employee compared to firms with low technology intensity and no intangible assets in the observed period. This is an outcome that is not only important for small businesses. However, given the discrepancy, SMEs will lag behind comparatively more and will not be able to reap all the productivity benefits unless they invest in both technology and intangible capital and focus especially on human capital development. Relating to our results this means that SMEs should improve their productivity by focusing on technological intensity and knowledge intensity; primarily investing in both would have a significant impact on overall economic performance.

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Appendix

Table A1. Classification of occupations into three intangible capital work categories.

Minor ISCO code	Minor ISCO label
Organizational capital occupations	
121	Business Services and Administration Managers
122	Sales, Marketing and Development Managers
131	Production Managers in Agriculture, Forestry and Fisheries
132	Manufacturing, Mining, Construction and Distribution Managers
134	Professional Services Managers
241	Finance Professionals
242	Administration Professionals
R&D capital occupations	
211	Physical and Earth Science Professionals
212	Mathematicians, Actuaries and Statisticians
213	Life Science Professionals
214	Engineering Professionals (excluding Electrotechnology)
215	Electrotechnology Engineers (excluding Telecommunications Engineers)
216	Architects, Planners, Surveyors and Designers
221	Medical Doctors
222	Nursing and Midwifery Professionals
223	Traditional and Complementary Medicine Professionals
311	Physical and Engineering Science Technicians
314	Life Science Technicians and Related Associate Professionals
321	Medical and Pharmaceutical Technicians
ICT capital occupations	
133	Information and Communications Technology Services Managers
251	Software and Applications Developers and Analysts
252	Database and Network Professionals
351	Software and Applications Developers and Analysts
352	Database and Network Professionals

Source: Adapted from Bloch et al. (2021).

Table A2. List of variables and source of variables in order of appearance in the regression table.

Variable	Description	Data source
Value added	Revenue minus intermediate costs	AJPES
Average years of education	Calculated as average years of education for all employees in the firm. Data on completed education provided in the registry. Number of years of education for each individual was calculated using a formula: primary education is 8 years, secondary 4 years, university 4 years, masters 2 years.	Statistical registry of employees
Non-intangible capital work	Number of workers that do not fall into one of the intangible work categories (see Table A1 for intangible capital work categories)	AJPES
ICT work	Number of workers in the ICT intangible work category (Table A1)	Statistical registry of employees
Organizational work	Number of workers in the organizational intangible work category (Table A1)	
R&D work	Number of workers in the R&D intangible work category (Table A1)	
Intangible capital work	Total number of intangible workers (ICT, organizational, and R&D)	
Capital	Reported in the financial statements	AJPES
Export (50% share) dummy	Calculated as share of sales abroad in total sales. Dummy was given value of 1 if the share was at least 50%.	
Share of max ICT	Number of technologies used by a firm in a relevant year, divided by the maximum number of technologies used in any given firm in that year	Use of ICT in companies
Share of max ICT in relevant size group and NACE2	Number of technologies used by a firm in a relevant year, divided by the maximum number of technologies used in any given firm in that year	
Share of max ICT in relevant size group	Number of technologies used by a firm in a relevant year and size group (micro-, small, medium), divided by the maximum number of technologies used in any given firm in that year and size group (micro-, small, medium)	
Share of max ICT in relevant size group and NACE2	Number of technologies used by a firm in a relevant year, NACE Level 2 group and size group (micro-, small, medium), divided by the maximum number of technologies used in any given firm in that year, NACE Level 2 group and size group (micro, small, medium)	
Industry (NACE2)	NACE Level 2 industry dummy	Slovenian Business Register data
Size	Micro, small, medium-sized dummy	
Year	Year	AJPES
Technological intensity category (OECD)	8 groups (high-tech, medium-high-tech, medium-low-tech, and low-tech manufacturing, R&D, ICT, management services, and other services	OECD classification adjusted by Bloch et al. (2021)
Ownership	Private, public/state, mixed, other	Slovenian Business Register data

Prepared using linked employer–employee datasets provided by the Statistical Office of the Republic of Slovenia. This analysis would not be possible without their expert support, in particular the User Relations Section of the Data Publication and Communication Division.

Table A3. Descriptive statistics by company size and type.

		Value added per employee	Export share	Number of employees	Share of max number of technologies	Average education of employees in years	Employment number by SRDAP	OC workers share	ICT workers share	R&D workers share	Average number of technologies used	Share of companies with at least 50% exports
Micro	mean	33,222	.13	7.98	.55	7.36	8.56	.07	.03	.06	2.63	.11
	p50	26,096	.00	7.39	.60	10.67	8.00	.00	.00	.00	3.00	.00
	sd	84,818	.26	3.45	.23	5.93	4.53	.12	.14	.15	1.20	.32
	N	2413	2512	2512	2512	2329	2512	2512	2512	2512	2512	2512
Small	mean	39,335	.21	21.15	.61	10.81	21.77	.07	.04	.07	3.64	.19
	p50	30,062	.03	17.18	.60	11.61	18.00	.04	.00	.00	4.00	.00
	sd	49,181	.31	11.84	.17	4.08	13.21	.10	.14	.15	1.17	.39
	N	8365	9503	9503	9503	7583	9503	9503	9503	9503	9503	9503
Medium	mean	38,339	.31	107.63	.67	10.49	110.61	.05	.03	.08	4.11	.32
	p50	30,071	.10	90.00	.67	11.43	93.00	.03	.00	.05	4.00	.00
	sd	39,878	.37	56.27	.16	3.96	61.81	.07	.12	.12	1.23	.46
	N	2935	3323	3323	3323	2617	3323	3323	3323	3323	3323	3323
No intangibles, low tech. intensity	mean	26,462	.15	16.34	.39	7.82	16.62	.00	.00	.00	2.48	.15
	p50	22,519	.00	11.58	.43	10.67	12.00	.00	.00	.00	2.00	.00
	sd	16,897	.30	17.17	.16	5.07	17.56	.00	.00	.00	1.34	.36
	N	1888	2098	2098	2098	1657	2098	2098	2098	2098	2098	2098
With intangibles and low tech. intensity	mean	38,983	.27	37.47	.44	9.12	38.56	.09	.04	.09	3.27	.26
	p50	30,799	.05	19.66	.50	11.27	20.00	.06	.00	.04	3.00	.00
	sd	39,320	.35	43.46	.13	5.26	45.41	.11	.14	.16	1.43	.44
	N	3231	3797	3797	3797	2495	3797	3797	3797	3797	3797	3797
No intangibles, high tech. intensity	mean	29,844	.13	17.84	.71	9.75	18.31	.00	.00	.00	3.61	.11
	p50	25,153	.00	12.00	.75	11.20	12.00	.00	.00	.00	3.00	.00
	sd	21,938	.26	18.71	.09	4.17	19.82	.00	.00	.00	0.81	.31
	N	1720	1838	1838	1838	1703	1838	1838	1838	1838	1838	1838
Intangible investments, high tech. intensity	mean	42,840	.24	48.57	.73	11.13	50.09	.09	.06	.10	4.02	.22
	p50	32,350	.05	25.92	.75	11.88	27.00	.06	.00	.05	4.00	.00
	sd	71,797	.32	53.71	.09	4.09	56.91	.11	.16	.16	1.00	.41
	N	6874	7605	7605	7605	6674	7605	7605	7605	7605	7605	7605
Total	mean	38,046	.22	37.73	.61	10.10	38.85	.07	.04	.07	3.57	.20
	p50	29,333	.02	18.31	.60	11.46	19.00	.03	.00	.00	4.00	.00
	sd	55,554	.32	46.35	.19	4.65	48.85	.10	.14	.14	1.27	.40
	N	13,713	15,338	15,338	15,338	12,529	15,338	15,338	15,338	15,338	15,338	15,338

Data: Statistical Office of the Republic of Slovenia, own calculations.