

Does digitalization adoption stimulate the performance of the European SMEs?

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Abstract

Purpose – This research aimed to determine whether adopting digital technologies influences the performance of Small and medium-sized enterprises (SMEs) in the European Union.

Design/methodology/approach – Our study is based on the country-level dataset of the 27 European Union member states, covering the period from 2014 to 2023. The SME performance is measured by the two primary outcome variables – average value added of the SMEs in the country and average employment. The empirical approach relied on estimating the Least Squares Dummy Variables (LSDV) panel Vector Autoregressive models with Impulse Response functions, indicating the effects of digitalization over time.

Findings – The obtained results document a statistically significant and positive impact of the Digital Economy and Society Index (DESI) and basic digital skills enhancement on both performance variables, with up to two years of positive effects.

Practical implications – The article concludes that the digitalization efforts of the European Union member countries play a significant role in shaping SMEs' competitiveness. Therefore, they could be used as evidence to support policymakers' ongoing initiatives towards adopting digitalization and advancements in the digital economy.

Originality/value – The study relies on a robust econometric approach, and it visually displays the effects of digitalization adoption on SMEs' performance over time. Uniquely, it provides a whole European picture of SMEs' digital transformation and its impact on firms' performance.

Keywords Digitalization, SMEs, Value added, Employment, Europe

Paper type Research article

1. Introduction

The need to analyze the effects of integrating digital technologies in the business sector has intensified in recent years (Frank *et al.*, 2024; Cimino *et al.*, 2025; Wang and Zhang, 2025). This was also influenced by the COVID-19 pandemic, which presented unprecedented challenges to the business environment. When physical contact was limited, many enterprises had to transfer their activities to the online environment (Moshood *et al.*, 2024; Soltani *et al.*, 2025). Those enterprises that had already integrated a series of digital technologies into their processes, at least basic ones, managed to adapt more quickly to the challenges that arose. The

JEL Classification — O14, O11

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OECD (2021) reported that 70% of SMEs worldwide have intensified their use of digital technologies in response to the COVID-19 pandemic. However, the key question is whether these efforts were positively translated into enhanced economic contributions.

Therefore, this study, grounded in the European context, assumes that in contemporary economies, making effective use of digital technologies has become increasingly important as a significant factor in a firm's ability to compete (Gómez-Sánchez *et al.*, 2024; Zamani, 2022) and survive (Oyeleran-Oyeyinka and Lal, 2006). Furthermore, the European Commission (2023) prioritizes the digitalization of enterprises. Since 2014, the European Commission has been tracking the progress of European Union (EU) member states in the digital area through the Digital Economy and Society Index (DESI) reports (European Commission, 2024b). The DESI index assessed the advancements made by EU members and summarised measures of Europe's digital performance from 2014 to 2022. A key component of the EU's digital transition, respectively, the 2030 policy programme "The Road to the Digital Decade" was accepted by the EU Council at the end of 2022. According to the European Council (2022), this programme outlines the specific digital goals that the EU and its member states aim to achieve by the end of the decade in four main areas: enhancing digital education and skills; protecting and sustaining digital infrastructures; transforming businesses digitally; and digitalizing public services.

In 2023, 59% of Small and Medium-sized Enterprises (SMEs) in the European Union achieved a basic level of digitalization. The target for 2030 is set to 90%. Additionally, only 4% of SMEs demonstrated a very high level of digital intensity, while nearly 20% had a high level. Most SMEs reported low (34%) or very low (42%) levels of digital intensity (Eurostat, 2024a). The European Commission (2024a) proposed measuring the economic performance of SMEs through two indicators, namely, value-added generated by SMEs and employment in SMEs, indicators that are well established as indicators of firm competitiveness (Blažková and Dvouletý, 2019; Falciola *et al.*, 2020; Yadav *et al.*, 2022; Varga *et al.*, 2024). The value-added of SMEs experienced a continuous annual increase (except in 2020), but the high inflation rate significantly impacted their growth. In 2022, value-added actually decreased by 1.4%. Employment in SMEs registered in 2022 increased by 2.4%.

Although SMEs represent the overwhelming majority of enterprises in EU countries and are the backbone of the European economy (European Commission, 2023), studies on digital technologies in SMEs are fewer than those that analyze large enterprises, as noted by the scholars asking for more studies on the role of digitalization in shaping firm performance (Moshood *et al.*, 2024; Frank *et al.*, 2024). The existing research is driven mostly by cross-sectional surveys with limited sample sizes or focuses only on selected industries or countries. Only a few studies offer multi-country perspectives (Yunis *et al.*, 2018; Brodny and Tutak, 2022; Abakpa and Dvouletý, 2025a, b). For example, a study by Brodny and Tutak (2022) provided a very interesting overview of European digitalization progress. However, the authors did not employ rigorous methods to quantify the effects of digital transformation over time, besides providing results of basic statistical testing and correlations. Thus, there is a need to advance the current state of knowledge by delivering more robust empirical findings.

Therefore, our study addresses the issue of the effects of digitalization over a ten-year time span, making the provided findings more generalizable at the European level and offering a unique contribution to policymakers and the scholarly community. Specifically, building on the Resource-Based View (RBV) theoretical approach, the study analyses a sample of 27 European Union members using robust econometric methods to determine whether digitalization adoption stimulates the performance of SMEs. To determine the effects of digitalization over time, the empirical approach estimates the Least Squares Dummy Variables (LSDV) panel Vector Autoregressive models with Impulse Response functions. The main findings emphasize that the Digital Economy and Society Index (DESI) and basic digital skills positively and statistically significantly affect SMEs' performance. These findings can help both the business community and practitioners clarify how the level of digitalization influences business performance. This research also contributes to the literature on

digitalization, addressing the existing gap in understanding the effects of adopting digital technologies on the performance of SMEs.

The article is structured as follows. The following section presents the study's theoretical foundation by introducing the literature review on the linkages between SMEs' digitalization and performance and formulating the hypotheses. In the second section, we describe the data through descriptive statistics. Next, we present and discuss the results from the econometric analyses. The final section summarizes the findings and provides directions for future research.

2. Literature review

Digitalization is the process of using data, digital technologies, and connections to create new activities or modify existing ones (OECD, 2019). Moving to a digital business, or digitalization, is the application of digital technologies to change a business model (Gartner, 2018) and provide new avenues for generating income and increased value added. The European Investment Bank (EIB) reports that improved business performance is correlated with digitalization. Unlike non-digital businesses, digital businesses typically have higher productivity and efficient management, are more innovative, grow faster, and generate jobs with higher remuneration (European Investment Bank, 2020). Businesses that make digitalization investments may surpass their competitors regarding sales growth and operational effectiveness (Grijalba *et al.*, 2024).

According to Manresa *et al.* (2024), digitalization generates higher returns for enterprises in places with better substantial infrastructure and high-speed internet connection availability. Well-developed digital infrastructure enhanced productivity gains for the enterprises that invested in becoming more digital during the pandemic, based on the EIB (2023) report. Jaumotte *et al.* (2023) also emphasized the crucial role of digital infrastructure in supporting enterprises to accelerate their digital transformation.

Businesses must gradually integrate digital technologies into everyday operations (Moshood *et al.*, 2024). This methodical assimilation would enable firms to continuously evolve and adapt to digital technologies (Zammuto *et al.*, 2007). The integration and application of digital technologies in business operations help enterprises in the process of data collecting and analysis, in obtaining improved business performance (Björkdahl, 2020; Truant *et al.*, 2021), but also to create new business models oriented to build and capture value during different stages of the product life cycle (Visnjic *et al.*, 2018). Digitalization enhances the competitiveness of enterprises, introduces new approaches to meet client expectations (Davies, 2004), and often leads to increased innovation, the exploitation of new business opportunities, and improved efficiency (Papadopoulos *et al.*, 2022; Kohtamäki *et al.*, 2020). Therefore, the performance of enterprises is generally stimulated by the use of digital technologies, as noted by prior research studies (Zhou *et al.*, 2021; Kádárová *et al.*, 2023; Grijalba *et al.*, 2024).

Furthermore, enterprises can enhance performance and sustain their development by investing in digital technologies, equipping employees with digital skills, and implementing effective digital transformation strategies. Several studies (e.g. Wamba *et al.*, 2017; Kohtamäki *et al.*, 2020; Frank *et al.*, 2024) have found that organisations invest in digital tools but often fail to integrate them strategically. Therefore, enterprises must be agile and integrate digital transformation into their corporate strategy, business model, and organizational structures to capitalize on market opportunities. The takeaway from the earlier research is that the level of digital transformation in enterprises depends on several factors, including the size of the enterprise, as larger corporations, equipped with more resources, have a better starting position. Moreover, the literature has shown that obstacles to SMEs' digitalization arise from a lack of strategic planning, insufficient attention to procedures, poor performance monitoring (Kumar *et al.*, 2024), as well as insufficient funds to purchase digital technologies and infrastructure (Gupta *et al.*, 2022; Restrepo-Morales *et al.*, 2024).

We already argued that digitalization can improve the performance of SMEs and represent a source of competitive advantage (Mazzarol, 2015; Chan *et al.*, 2019; Octavia *et al.*, 2020; Bellakhal and Mouelhi, 2023; Pfister and Lehmann, 2024) since it can help them increase customer satisfaction (Pfister and Lehmann, 2023), boost productivity (Zhu *et al.*, 2021), service quality, promote internal collaboration and communication, and streamline operations and production (Kádárová *et al.*, 2023). SMEs can better compete in the market by utilizing digital technologies, which is crucial for their growth and competitiveness (Prohl-Schwenke and Kleinaltenkamp, 2021; Schlichter and Nielsen, 2022). Furthermore, SMEs and entrepreneurs can connect with suppliers and customers, obtain real-time information, and respond rapidly to changing supply chains and markets with the aid of high-speed networks (Kergroach, 2021; Ghobakhloo *et al.*, 2022).

Digital technologies are more responsive and adaptive and can potentially increase their value significantly (Koch and Windsperger, 2017). However, at the same time, SMEs have limited resources (in terms of the Resource-Based View of the firm, c.f. Chen *et al.*, 2024), and digitalization-driven investments require many of those, compared to large corporations that usually generate an adequate amount of revenue to implement advanced automation and digitalization (Bokša *et al.*, 2020). On the other hand, SMEs that are more inflexible may experience fewer returns from digitalization implementation (Etienne Fabian *et al.*, 2024), which requires experienced management and skilled, open-minded employees to a certain degree of flexibility (Freddi, 2018; Sousa and Rocha, 2019). These aspects are crucial, although they differ across industries to some extent, yet SME management needs to be prepared to mitigate employees' fear that the implementation of digitalization will result in losing their jobs (Levy and Murnane, 2004; Acemoglu and Restrepo, 2018; Barbieri *et al.*, 2020).

To summarize, the success of digitalization implementation in terms of increased company performance requires well-implemented and justified investments in digital technologies, training employees in digital skills, and implementing digital transformation strategies in line with the firm's objectives (Bouwman *et al.*, 2019; Teng *et al.*, 2022). Based on the conducted literature review, we consider digitalization and digital transformation as an essential part of the firm resources as of the Resource-Based View of the firm (Chen *et al.*, 2024), we assume that mobilization of these resources might result in higher firm performance of the SMEs (Audretsch and Belitski, 2024), and therefore, we present the following hypothesis to be tested:

- H1.* There is a positive association between digitalization and the SME's performance in the European Union member countries.

3. Data

Our dataset targets the SME sector in 27 European Union member states, covering the period from 2014 to 2023. We work with the two primary outcome variables to measure SMEs' economic performance. The first represents the average value added of the SMEs, i.e. value-added of SMEs (in mil. EUR) divided by the number of SMEs in the country. The second captures the average employment in SMEs, i.e. the number of persons employed in SMEs divided by the number of SMEs (Eurostat, 2024b). Furthermore, two digitalization-related explanatory variables were obtained from Eurostat (2024c) and the European Commission (2024a), reflecting the Digital Economy and Society Index (DESI) and basic digital skills (% of individuals in the labour force). Well-educated employees are frequently required for the adoption of new digital technologies (Sousa and Rocha, 2019); therefore, possessing basic digital skills is a crucial indicator that may influence the adoption of digital technologies and their implementation in SMEs.

In addition, we work with the two institutional and economic control variables, Gross Domestic Product (GDP) per capita in constant USD obtained from World Development

Indicators (World Bank, 2024) and Economic Freedom Index (Heritage Foundation, 2024). The summary statistics that provide information about the mean, standard deviation, minimum, and maximum are reported in Table 1.

The DESI index varies between 19.4 and 69.6, showing the existence of significant variability across the observations. The standard deviation is 11.21, indicating a relatively high-value dispersion around the mean. This implies that the countries in the sample have significantly different degrees of digitalization. Basic digital skills vary between 19% of individuals and 42%, pointing out that there is variability across the observations. The standard deviation is 4.98, smaller than that for DESI, emphasizing the existence of a dispersion of values around the mean. This shows that the differences between individuals with basic digital skills in the analyzed countries are not as large as in measuring the degree of digitalization. At the level of the variables considered to measure the performance of SMEs, the variations are no longer as high as the others.

4. Analysis and results

As explained before, this study aims to determine whether adopting digital technologies influences the performance of SMEs in the European Union, assuming that the digitalization adoption will increase the efficiency and productivity of the SMEs and, therefore, positively impact the performance of SMEs (Radicic and Petković, 2023; Hassan *et al.*, 2024). A complex cross-country analysis accounting for the effects over time and across countries is needed to apply robust econometric methodology and answer this empirical question, thereby testing the empirical validity of the stated hypothesis. We constructed a panel dataset of the 27 European Union membership countries and applied the Least Squares Dummy Variables (LSDV) panel Vector Autoregressive (VAR) models with Impulse Response (IR) functions to understand the effects of digitalization over time.

The panel VAR approach has the advantage of accounting for interrelationships among the closely correlated macroeconomic variables, estimating a complex system of variables, and reflecting their effects over time, including the time lags. The critical issue is optimal time lag selection, as Holtz-Eakin *et al.* (1988) emphasized. In our case, we attempted to account for the most lengthy lags, but at the same time, we had to consider a relatively short analysis period, which resulted in an optimal trade-off between the two-year lags included in the VAR system

Table 1. Descriptive statistics

Variable/ indicator	Measurement	Data source	Mean	Standard deviation	Minimum	Maximum
Value added per number of SMEs	Ratio, in mil. EUR divided by the number of SMEs	Eurostat	0.17	0.13	0.03	0.62
Persons employed per number of SMEs	Ratio, the number of persons divided by the number of SMEs	Eurostat	3.92	1.14	2.30	7.57
DESI index	Index	European Commission	44.30	11.21	19.40	69.60
Basic digital skills	% of individuals in the labour force	Eurostat	29.20	4.98	19.12	42.92
GDP per capita	Constant USD	World Bank	31483.27	20014.33	10904.35	99526.46
Economic freedom index	Index	Heritage Foundation	70.13	5.71	53.2	82.0

Note(s): $N = 216$

Source(s): Own calculations in STATA 14 software

estimations. Including more than two lags for each of the variables would endanger the econometric stability of the system and leave us with a limited number of statistical observations, as [Antonietti and Mondolo \(2023\)](#) and [Tuğan \(2021\)](#) noted. To address the issue of omitted variables, we include in our estimation sets of dummy variables that account for cross-country heterogeneity.

Given two main outcome variables measuring the economic performance of SMEs, we estimated two panel VAR systems. We report results for the average employment of the SMEs outcome variable in [Table 2](#) (impulse responses reported in [Figure 1](#)) and for the average value added of the SMEs in [Table 3](#) (impulse responses reported in [Figure 2](#)). Equations in both estimated VAR systems were found to be statistically significant, determined on the p -values of F-statistics, and we report detailed coefficients, standard errors, t-statistics, p -values and 95% confidence intervals for each of the estimated variables. [Figures 2 and 3](#) are more informative for answering our research question because they simulate how the outcome variables would react to shock increases of the explanatory variables, i.e. DESI, basic digital skills, GDP per capita and Economic Freedom Index, over time.

4.1 The effects of digitalization on employment of SMEs

According to the results reported in [Table 2](#) and [Figure 1](#), we can observe a statistically significant effect of both digitalization-related variables on the average employment of SMEs, which aligns with the recent study results of [Azigi and Baffour \(2024\)](#). In particular, impulse response functions document how employment would change if the country's DESI index improved. We can see an apparent positive effect reaching the peak within two years; since the shock, both confidence intervals have a positive outcome and then decrease. The impact of the digital skills of the economically active population enhancement does not have a short-term effect; we can see from the graph that the positive effect increases after one year, reaching a peak again at about two years, and then the impulse mitigates. [Figure 1](#) also shows the GDP per Capita and the Economic Freedom Index. While the sharp increase in Economic Freedom brings relatively straightforward positive effects on employment, the response to the GDP per Capita increase is negative and declining. This might be explained by the different technology-employment mix of resources that the SMEs apply in wealthier economies. Prior research ([Vivarelli, 2014](#); [Antonazzo et al., 2025](#)) explains that as countries become wealthier, some SMEs shift from labour-intensive to capital-intensive industries, which also requires restructuring of the workforce and job positions, possibly explaining this negative effect.

4.2 The effects of digitalisation on value added of SMEs

Similarly, we report the results concerning the value added of SMEs in [Table 3](#) and [Figure 2](#). The obtained results are conclusive on a statistically significant effect of both digitalization-related variables on the average value added of SMEs. Similar results were also obtained by the study of [Szabó et al. \(2024\)](#) and [Verdeş et al. \(2024\)](#).

Compared to the effects on employment, we see in [Figure 2](#) an immediate positive impact for both variables, reaching a DESI peak after about two years and after one year in the case of digital skills adoption. This may be related to the earlier observations of [Sousa and Rocha \(2019\)](#), who noted that digital skills are a key prerequisite for the adoption of digital technologies. Without them, more advanced technologies could not be adopted and disseminated across the population of SMEs. Therefore, the positive effects on value-added may occur more quickly than those resulting from the improved digital infrastructure.

The effects of macroeconomic control variables (GDP per Capita and Economic Freedom Index) are similar to those reported in the first estimated VAR system. This is an important observation because the analysis period and the set of countries remain unchanged, yet the effects of the outcome variables differ. In this matter, we observe again a decreasing response of the SMEs' value added to the GDP per capita increase and an increasing response to the rise of Economic Freedom, reflecting the institutional quality of the countries in the sample. One could

Table 2. Panel LSDV vector autoregression results

Equation	Parms	RMSE	R-squared	F-statistics	p-value F(10,125)
Persons employed per number of SMEs	37	0.073941	0.9967	18.65369	0.0000
DESI index	37	4.84642	0.8404	13.72331	0.0000
Basic digital skills	37	2.49343	0.7981	9.306465	0.0000
GDP per capita	37	31214.6	0.9988	24.5749	0.0000
Economic freedom index	37	1.39911	0.9522	8.897182	0.0000

Equation/Variable	Coefficient	Standard error	t-statistics	p-value	95% confidence interval	
<i>Persons employed per number of SMEs</i>						
<i>l1_Persons Employed Per Number of SMEs</i>	0.5235147	0.071649	7.31	0.000	0.3817124	0.665317
<i>l1_DESI Index</i>	0.0016784	0.000992	1.69	0.093	−0.000285	0.0036417
<i>l1_Basic Digital Skills</i>	0.0008776	0.0024317	0.36	0.719	−0.003935	0.0056902
<i>l1_GDP per Capita</i>	−8.15e−08	2.08e−07	−0.39	0.695	−4.92e−07	3.29e−07
<i>l1_Economic Freedom Index</i>	0.0033871	0.0053719	0.63	0.529	−0.0072445	0.0140188
<i>l2_Persons Employed Per Number of SMEs</i>	0.0590731	0.0641982	0.92	0.359	−0.067983	0.1861292
<i>l2_DESI Index</i>	0.0008768	0.0010459	0.84	0.403	−0.0011932	0.0029468
<i>l2_Basic Digital Skills</i>	0.0012611	0.0028855	0.44	0.663	−0.0044496	0.0069717
<i>l2_GDP per Capita</i>	−1.47e−07	2.10e−07	−0.70	0.486	−5.61e−07	2.68e−07
<i>l2_Economic Freedom Index</i>	−0.008199	0.0056504	−1.45	0.149	−0.0193818	0.0029838
<i>DESI index</i>						
<i>l1_Persons Employed Per Number of SMEs</i>	−5.946714	4.696185	−1.27	0.208	−15.24105	3.34762
<i>l1_DESI Index</i>	0.1546867	0.0650218	2.38	0.019	0.0260006	0.2833729
<i>l1_Basic Digital Skills</i>	0.3418544	0.1593843	2.14	0.034	0.026413	0.6572957
<i>l1_GDP per Capita</i>	6.87e−06	0.0000136	0.51	0.614	−0.00002	0.0000338
<i>l1_Economic Freedom Index</i>	1.230813	0.3520983	3.50	0.001	0.5339667	1.927659
<i>l2_Persons Employed Per Number of SMEs</i>	−3.1084	4.207824	−0.74	0.461	−11.43621	5.219405
<i>l2_DESI Index</i>	−0.1965439	0.0685537	−2.87	0.005	−0.3322202	−0.0608676
<i>l2_Basic Digital Skills</i>	−0.4343888	0.1891251	−2.30	0.023	−0.8086909	−0.0600867
<i>l2_GDP per Capita</i>	4.71e−06	0.0000137	0.34	0.732	−0.0000225	0.0000319
<i>l2_Economic Freedom Index</i>	1.143889	0.3703501	3.09	0.002	0.4109205	1.876858
<i>Basic digital skills</i>						
<i>l1_Persons Employed Per Number of SMEs</i>	−3.396552	2.416135	−1.41	0.162	−8.178383	1.385279
<i>l1_DESI Index</i>	0.0705567	0.033453	2.11	0.037	0.0043491	0.1367643
<i>l1_Basic Digital Skills</i>	0.3655878	0.0820015	4.46	0.000	0.2032967	0.5278788
<i>l1_GDP per Capita</i>	−3.32e−06	7.00e−06	−0.47	0.636	−0.0000172	0.0000105
<i>l1_Economic Freedom Index</i>	0.5862963	0.1811506	3.24	0.002	0.2277767	0.9448159
<i>l2_Persons Employed Per Number of SMEs</i>	0.4371794	2.164878	0.20	0.840	−3.847384	4.721742
<i>l2_DESI Index</i>	0.1138777	0.0352701	3.23	0.002	0.0440738	0.1836816
<i>l2_Basic Digital Skills</i>	−0.3570637	0.0973028	−3.67	0.000	−0.5496379	−0.1644894
<i>l2_GDP per Capita</i>	5.79e−06	7.07e−06	0.82	0.415	−8.21e−06	0.0000198
<i>(continued)</i>						

Table 2. Continued

Equation/Variable	Coefficient	Standard error	t-statistics	p-value	95% confidence interval	
<i>l2_Economic Freedom Index</i>	0.0908639	0.190541	0.48	0.634	−0.2862404	0.4679683
<i>GDP per capita</i>						
<i>l1_Persons Employed Per Number of SMEs</i>	−17225.85	30246.93	−0.57	0.570	−77088.28	42636.58
<i>l1_DESI Index</i>	114.3142	418.7887	0.27	0.785	−714.5206	943.1489
<i>l1_Basic Digital Skills</i>	38.06633	1026.554	0.04	0.970	−1993.611	2069.743
<i>l1_GDP per Capita</i>	0.5894525	0.087601	6.73	0.000	0.4160793	0.7628258
<i>l1_Economic Freedom Index</i>	4411.721	2267.775	1.95	0.054	−76.48736	8899.93
<i>l2_Persons Employed Per Number of SMEs</i>	−6988.946	27101.52	−0.26	0.797	−60626.21	46648.32
<i>l2_DESI Index</i>	416.5394	441.5368	0.94	0.347	−457.3168	1290.396
<i>l2_Basic Digital Skills</i>	473.874	1218.107	0.39	0.698	−1936.91	2884.658
<i>l2_GDP per Capita</i>	0.297443	0.0885053	3.36	0.001	0.12228	0.4726059
<i>l2_Economic Freedom Index</i>	−3026.469	2385.331	−1.27	0.207	−7747.334	1694.396
<i>Economic freedom index</i>						
<i>l1_Persons Employed Per Number of SMEs</i>	−1.130156	1.355738	−0.83	0.406	−3.813329	1.553018
<i>l1_DESI Index</i>	0.0213863	0.0187711	1.14	0.257	−0.015764	0.0585366
<i>l1_Basic Digital Skills</i>	0.0965498	0.0460125	2.10	0.038	0.0054853	0.1876143
<i>l1_GDP per Capita</i>	−1.03e−06	3.93e−06	−0.26	0.794	−8.80e−06	6.74e−06
<i>l1_Economic Freedom Index</i>	0.5538695	0.101647	5.45	0.000	0.3526975	0.7550414
<i>l2_Persons Employed Per Number of SMEs</i>	0.9661723	1.214753	0.80	0.428	−1.437975	3.37032
<i>l2_DESI Index</i>	−0.0070465	0.0197907	−0.36	0.722	−0.0462148	0.0321217
<i>l2_Basic Digital Skills</i>	−0.1422589	0.0545984	−2.61	0.010	−0.2503158	−0.0342019
<i>l2_GDP per Capita</i>	1.13e−06	3.97e−06	0.28	0.777	−6.72e−06	8.98e−06
<i>l2_Economic Freedom Index</i>	0.0153068	0.1069161	0.14	0.886	−0.1962933	0.226907
Note(s): 162 observations, 27 groups						
Source(s): Own estimations in STATA 14 software						

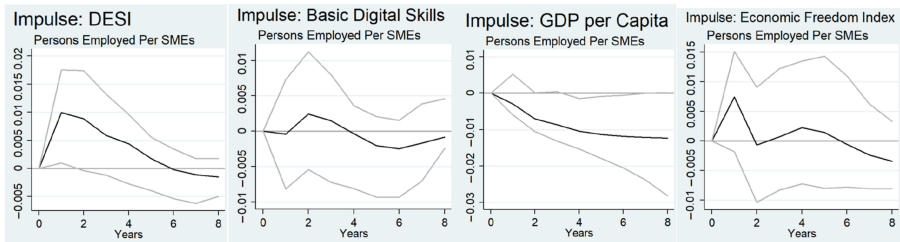


Figure 1. Responses of persons employed per number of SMEs to impulses in DESI index, basic digital skills, GDP per capita and economic freedom index. Note: 95% confidence intervals are displayed. Source: Own calculations in STATA 14 software

Table 3. Panel LSDV vector autoregression results

Equation	Parms	RMSE	R-squared	F-statistics	p-value F(10,152)
Value added per number of SMEs	37	0.010736	0.9946	20.75643	0.0000
DESI index	37	6.03997	0.7610	9.224856	0.0000
Basic digital skills	37	2.39758	0.8062	11.18557	0.0000
GDP per capita	37	29222.1	0.9988	54.43672	0.0000
Economic freedom index	37	1.34967	0.9548	16.23576	0.0000

Equation/Variable	Coefficient	Standard error	t-statistics	p-value	95% confidence interval	
<i>Persons employed per number of SMEs</i>						
<i>l1_Value Added Per Number of SMEs</i>	0.6605343	0.0788474	8.38	0.000	0.504756	0.8163125
<i>l1_DESI Index</i>	0.0002483	0.0001306	1.90	0.059	−9.75e−06	0.0005063
<i>l1_Basic Digital Skills</i>	0.0007584	0.0003295	2.30	0.023	0.0001075	0.0014094
<i>l1_GDP per Capita</i>	−5.78e−09	2.95e−08	−0.20	0.845	−6.41e−08	5.25e−08
<i>l1_Economic Freedom Index</i>	0.0009124	0.0007253	1.26	0.210	−0.0005207	0.0023454
<i>l2_Value Added Per Number of SMEs</i>	0.1920899	0.0869241	2.21	0.029	0.0203544	0.3638254
<i>l2_DESI Index</i>	−0.0000643	0.0001407	−0.46	0.648	−0.0003422	0.0002136
<i>l2_Basic Digital Skills</i>	−0.0011687	0.0003953	−2.96	0.004	−0.0019498	−0.0003876
<i>l2_GDP per Capita</i>	−2.29e−10	2.95e−08	−0.01	0.994	−5.86e−08	5.81e−08
<i>l2_Economic Freedom Index</i>	−0.000405	0.0007834	−0.52	0.606	−0.0019528	0.0011427
<i>DESI index</i>						
<i>l1_Value Added Per Number of SMEs</i>	68.49076	44.36071	1.54	0.125	−19.15242	156.1339
<i>l1_DESI Index</i>	0.4495196	0.0734821	6.12	0.000	0.3043415	0.5946977
<i>l1_Basic Digital Skills</i>	0.5607404	0.1853725	3.02	0.003	0.194501	0.9269798
<i>l1_GDP per Capita</i>	5.55e−06	0.0000166	0.33	0.739	−0.0000273	0.0000384
<i>l1_Economic Freedom Index</i>	0.7131857	0.4080794	1.75	0.083	−0.0930543	1.519426
<i>l2_Value Added Per Number of SMEs</i>	−72.98303	48.90481	−1.49	0.138	−169.604	23.6379
<i>l2_DESI Index</i>	−0.3518538	0.079133	−4.45	0.000	−0.5081965	−0.1955112
<i>l2_Basic Digital Skills</i>	−0.4055804	0.2224267	−1.82	0.070	−0.8450274	0.0338666
<i>l2_GDP per Capita</i>	−2.07e−06	0.0000166	−0.12	0.901	−0.0000349	0.0000307
<i>l2_Economic Freedom Index</i>	0.433065	0.440744	0.98	0.327	−0.4377103	1.30384
<i>Basic digital skills</i>						
<i>l1_Value Added Per Number of SMEs</i>	−37.94635	17.60907	−2.15	0.033	−72.73648	−3.156216
<i>l1_DESI Index</i>	0.0817706	0.0291689	2.80	0.006	0.0241419	0.1393994
<i>l1_Basic Digital Skills</i>	0.4504097	0.073584	6.12	0.000	0.3050302	0.5957891
<i>l1_GDP per Capita</i>	−3.48e−06	6.59e−06	−0.53	0.598	−0.0000165	9.54e−06
<i>l1_Economic Freedom Index</i>	0.4134763	0.1619879	2.55	0.012	0.0934377	0.7335148
<i>l2_Value Added Per Number of SMEs</i>	67.30704	19.41286	3.47	0.001	28.95317	105.6609
<i>l2_DESI Index</i>	0.090788	0.031412	2.89	0.004	0.0287275	0.1528485
<i>l2_Basic Digital Skills</i>	−0.3742185	0.0882927	−4.24	0.000	−0.5486579	−0.1997792
<i>l2_GDP per Capita</i>	4.00e−06	6.59e−06	0.61	0.545	−9.02e−06	0.000017
(continued)						

Table 3. Continued

Equation/Variable	Coefficient	Standard error	t-statistics	p-value	95% confidence interval	
<i>l2_Economic Freedom Index</i>	0.0742405	0.1749542	0.42	0.672	−0.2714154	0.4198965
<i>GDP per capita</i>						
<i>l1_Value Added Per Number of SMEs</i>	75561.83	214622.3	0.35	0.725	−348466.2	499589.8
<i>l1_DESI Index</i>	12.1304	355.515	0.03	0.973	−690.2584	714.5192
<i>l1_Basic Digital Skills</i>	−89.42641	896.8541	−0.10	0.921	−1861.336	1682.483
<i>l1_GDP per Capita</i>	0.6359103	0.0803291	7.92	0.000	0.4772045	0.7946161
<i>l1_Economic Freedom Index</i>	3614.522	1974.336	1.83	0.069	−286.1618	7515.205
<i>l2_Value Added Per Number of SMEs</i>	−103919.9	236607.2	−0.44	0.661	−571383.3	363543.5
<i>l2_DESI Index</i>	385.4047	382.8549	1.01	0.316	−370.9993	1141.809
<i>l2_Basic Digital Skills</i>	444.6735	1076.126	0.41	0.680	−1681.423	2570.77
<i>l2_GDP per Capita</i>	0.3584837	0.0803521	4.46	0.000	0.1997326	0.5172349
<i>l2_Economic Freedom Index</i>	−2661.921	2132.371	−1.25	0.214	−6874.834	1550.992
<i>Economic freedom index</i>						
<i>l1_Value Added Per Number of SMEs</i>	22.23977	9.912716	2.24	0.026	2.65528	41.82427
<i>l1_DESI Index</i>	0.0060458	0.0164201	0.37	0.713	−0.0263953	0.0384868
<i>l1_Basic Digital Skills</i>	0.0522673	0.0414228	1.26	0.209	−0.0295715	0.1341061
<i>l1_GDP per Capita</i>	−1.64e−06	3.71e−06	−0.44	0.658	−8.97e−06	5.69e−06
<i>l1_Economic Freedom Index</i>	0.6216794	0.0911882	6.82	0.000	0.4415193	0.8018394
<i>l2_Value Added Per Number of SMEs</i>	11.68221	10.92813	1.07	0.287	−9.908426	33.27285
<i>l2_DESI Index</i>	0.0103778	0.0176828	0.59	0.558	−0.0245581	0.0453137
<i>l2_Basic Digital Skills</i>	−0.1725951	0.0497028	−3.47	0.001	−0.2707927	−0.0743976
<i>l2_GDP per Capita</i>	1.49e−06	3.71e−06	0.40	0.689	−5.84e−06	8.82e−06
<i>l2_Economic Freedom Index</i>	−0.0237779	0.0984874	−0.24	0.810	−0.2183588	0.1708031
Note(s): 189 observations, 27 groups						
Source(s): Own estimations in STATA 14 software						

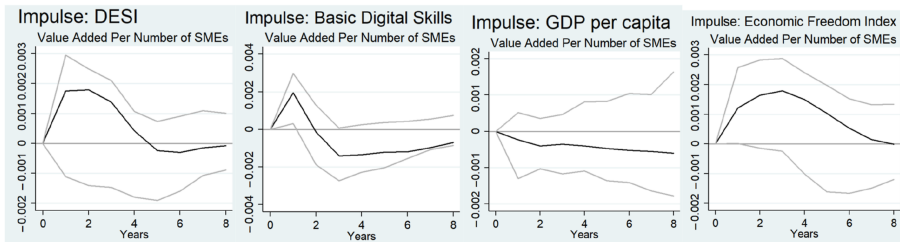


Figure 2. Responses of value added per number of SMEs to impulses in DESI index, basic digital skills, GDP per capita and economic freedom index. Note: 95% confidence intervals are displayed. Source: Own calculations in STATA 14 software

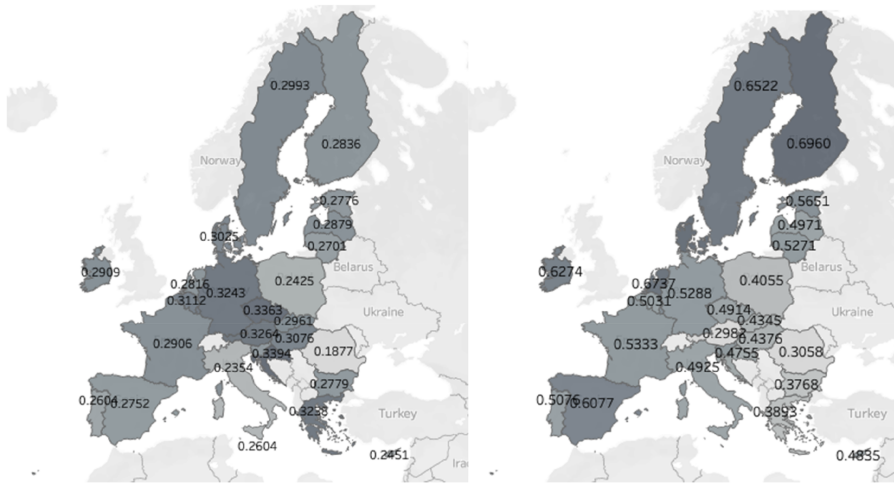


Figure 3. European countries by level of digitalization. Notes: Basic digital skills levels are displayed on the left map, and DESI scoring is displayed on the right map. The darker the colour, the higher the level of digitalization. Source: Own representations with Tableau Desktop

say that the effects on value added sound counterintuitive. We also need to link this finding with the fact that SMEs are a heterogeneous population of businesses with different productivity levels and economic performance. While some SMEs are highly productive, and others are significantly less productive, that brings us to the need to explore cross-industrial heterogeneity further, compare specific SMEs across sectors, their characteristics and account for those in the empirical analysis to obtain a holistic picture (Dvouletý and Blažková, 2021; Owalla *et al.*, 2022).

4.3 Heterogeneity of the countries in digitalization levels

The statistical analysis results empirically support the stated hypothesis that there is a positive association between digitalization and SME's performance in the European Union member countries. However, there is still a critical diversity even within the included sample of countries, which we attempt to illustrate visually in this section. Essentially, we utilized the most recent, i.e. 2023, values of digitalization (DESI index and Basic digital skills) for all 27 countries. Figure 3 illustrates that European countries exhibit heterogeneity in their levels of digitalization. For the DESI index, the highest values are obtained by the Nordic countries, while for basic digital skills, the countries in Central Europe are ranked best. From a country-level analysis perspective, this heterogeneity calls for more in-depth results at the regional level of countries. These observations align with those of other authors who reported this diversity, such as Brodny and Tutak (2022) and Castelo-Branco *et al.* (2019). These findings are remarkably similar to those of Brodny and Tutak (2022, p. 27), who reported that Denmark and Finland have achieved an expert level of digital maturity, whereas the lowest digital maturity was observed among SMEs in Bulgaria, Hungary, Romania, and Greece. In this way, a one-size-fits-all policy approach towards digitalization enhancement is not possible, and policymakers need to respect the diversity of the European SMEs and their entrepreneurial ecosystem contexts (Roshan *et al.*, 2025; Matricano *et al.*, 2025).

5. Conclusions, recommendations and avenues for future research

Our study contributes to a deeper understanding of the impact of digitalization on SMEs' performance from a European context perspective. The analysis focused on an extended

sample of 27 European countries, covering the period from 2014 to 2023. Through the present research, the study examined the relationship between the two measurements of digitalization (DESI index and basic digital skills) and SME performance quantified by employment and value-added of SMEs. The main findings from the estimated econometric models provide empirical support for the stated hypothesis that there is a positive association between digitalization and SME performance in European Union member countries.

This is an essential finding for European policymakers, as digitalization-driving policies are relevant and can further enhance SMEs' competitiveness. Such results are also in line with the Resource-Based View of the firm (see [Chen et al., 2024](#); for details), looking at digitalization as a part of the essential resources of each enterprise's competitiveness. Overall, our findings are in line with the results of previous research ([Mazzarol, 2015](#); [Wamba et al., 2017](#); [Eller et al., 2020](#); [Bellakhal and Mouelhi, 2023](#); [Pfister and Lehmann, 2024](#)), which show that the economic performance of SMEs is improved when the enterprise uses digital technologies in its activity. However, the digitalization-fostering policies need to be carefully tailored to the needs of the SMEs, progress milestones need to be monitored, and effects tracked and quantified in order to ensure the highest possible effectiveness of those policies ([Bouwman et al., 2019](#); [OECD, 2021, 2023](#)). In this way, we recall the recent experience of [Henderson \(2023\)](#), who documented the digital technology diffusion policy adopted in Wales (United Kingdom). The policy aimed to support approximately 6,600 companies through blended learning, technology adaptation, and tailored advisory services. According to [Henderson \(2023\)](#), a key factor in the policy's success was the ongoing cooperation between policy officials and the advisory panel, which consisted of local authorities, business representatives, and university experts, reflecting the specific needs of the Welsh context. Additionally, [Parsons et al. \(2023, pp. 103–104\)](#) provide a structured overview of digitalization policies in six countries, i.e. Greece, Germany, Iceland, New Zealand, Switzerland and the United Kingdom. However, the authors based their findings on the positioning of the policies, their aims and scope, and qualitative interviews rather than on the effects they deliver, which remains a challenge for future research.

We also need to remember that European countries are heterogeneous in terms of the level of digitalization and the performance of SMEs. Future research needs to provide a more complex understanding of how the SMEs' management and owners balance labour and capital inputs and optimize productivity. This calls for a more in-depth analysis of the regional and industry levels of digitalization adoption among SMEs, as well as micro-level impacts of the specific technologies and tools, including the implementation of Artificial Intelligence (AI) and blockchain into business processes, as well as public administration ([Martínez-Navarro and Bigné, 2022](#); [Sýkorová et al., 2024](#); [Abakpa and Dvoutletý, 2025a, b](#); [Al Omoush et al., 2025](#); [Zaman et al., 2025](#); [Alon et al., 2025](#); [Dvoutletý et al., 2025](#)).

For this purpose, the entrepreneurial ecosystem concept may be a suitable theoretical framework, serving as a complex framework that can help in the advanced monitoring of the SME population's digitalization advancement ([Hudik and Dvoutletý, 2025](#); [Roshan et al., 2025](#)). Specifically, we recommend that policymakers and experts establish indicators representing the proportions of digitally mature SMEs (placed as entrepreneurial outcomes in the ecosystem framework) and systematically monitor their value-added and employment contributions (placed as aggregate outcomes in the ecosystem framework) at the country or regional level.

At the same time, we must acknowledge that our analysis is limited to a sample of European Union member countries, which prevents us from including other countries worldwide. Thus, data availability is the main limitation of our study. In future studies on this topic, we propose incorporating more digitalization-specific elements into the analysis (such as advanced digital technologies and levels of digital literacy) and empirically examining the impact of adopting digital technologies on SMEs' performance using advanced microeconomic techniques, including counterfactual assessment or propensity score matching. Furthermore, we suggest future research expand on the current study more extensively by conducting a multilevel

analysis, accounting for all micro-, meso- and macro-drivers of digitalization, which would provide more holistic results, reflecting the nature of the entrepreneurial and innovation ecosystems (Cicchello *et al.*, 2024; Fischer *et al.*, 2024).

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