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DIGITAL TRANSFORMATION AS A DOUBLE-EDGED SWORD: BOOSTING SALES WHILE INCREASING PRESSURE ON SKILLS

Jan HUNADY, Veronika CHYLAKOVA

Faculty of Economics, Matej Bel University in Banska Bystrica, Banska Bystrica, Slovakia

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Abstract. While the adoption of digital technology in companies has many benefits, it may also bring several challenges. Potential pressure on new skills is one of them, and it can be especially evident for SMEs. The main aim of the paper is to examine the potential consequences of digital transformation on SMEs' sales and the availability of skills. The analysis is based on the firms' microdata from the Flash Eurobarometer 537 (2023) questionnaire survey. The survey was conducted on more than 15000 respondent firms from 27 EU and 8 non-EU countries. The research uses a synergistic approach combining logistic regression and propensity score matching to identify the potential effects of digital technology adoption on future skill shortages and turnover. The results show that digital technology cannot close the skills gap in SMEs. Moreover, it can even further amplify the problem because it requires hiring employees with new skill sets complementary to digital technology. However, adopting digital technology can drive significant sales growth. The study presents new findings that allow us to propose recommendations for addressing skill shortages in SMEs in a rapidly changing business environment.

Keywords: digital technology, digital transformation, skills shortage, sales increase, SMEs.

JEL Classification: O33, L25, J24.

Corresponding author. E-mail: *jan.hunady@umb.sk*

1. Introduction

Digital transformation (DT), a fundamental technological change of recent decades, presents both challenges and opportunities for companies. The DT of most businesses is currently not considered an optional improvement but more as an essential step toward business sustainability and firms' survival in the digital environment. Small and medium-sized enterprises (SMEs) are mostly lagging behind larger firms in the intensity of digitalisation (Eller et al., 2020). Moreover, most SME managers are not fully aware of the potential benefits of digitalisation (Pfister & Lehmann, 2023). Emerging technologies (e.g., artificial intelligence, cloud computing, and big data) act synergistically, intensifying their effects and making adaptation for companies even more complex. On the one hand, digital transformation can improve efficiency, productivity, and scalability, thereby positively affecting the company's long-term financial performance. This positive effect can be reflected in increased sales and revenues. On the other hand, it often puts pressure on the company in the short- and medium-term. In addition to the costs of acquiring the technology, a business often faces skills shortages. The adoption of new technology is driving changes in skill demands (Wang et al., 2021), and innovative firms are more likely to experience skills shortages (Horbach & Rammer, 2022). This problem is even more pronounced for small and medium-sized businesses (SMEs) due to their limited skill availability (Castro-Silva & Lima, 2023). Limited financial and human resources are hindering SMEs' adoption of digital technologies (Lehner & Sundby, 2018).

Currently, there is a significant gap in the empirical literature on the potential consequences of digital transformation for SMEs. Such micro-level studies on larger samples are rather rare. Most previous studies have examined the determinants of digital technology adoption. Our aim is to bridge this gap by analysing a large microdata sample of SMEs, with a focus on the potential effects of digital transformation.

The main research goal of this paper is to examine the potential consequences of digital transformation for SMEs' sales and the availability of skills, while accounting for other factors, such as reskilling. Our approach considers four diverse measures to address skill shortages in SMEs. The first one represents the adoption of new digital technology, and the other three capture various ways to

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strengthen human capital in a company. Measures related to human capital include staff reskilling, improved recruitment, and improved working conditions. In accordance with the main goal, we also created three main research questions as follows:

- RQ1: Does the adoption of digital technology in SMEs lead to an increase in turnover?
- RQ2: Does the staff reskilling in SMEs lead to an increase in turnover?
- RQ3: Is the adoption of digital technology positively associated with skills shortages?

The combination of logistic regression and propensity score matching enables us to provide empirical evidence for all three research questions. The next section systematically reviews previous studies' findings to lay the essential foundations for our research. The methodology and data are described in the third section. The main results are shown and discussed in the fourth section of the paper, followed by the conclusions.

2. Literature review

Previous studies examining the adoption of digital technology in companies typically focus on specific company characteristics and types of digital technologies (e.g., Kinkel et al., 2022; Corò & Volpe, 2020). Most of these studies use smaller samples and techniques which often do not allow causal claims. However, based on previous results, we can still identify several factors related to digital transformation. These findings are important, especially for selecting covariates that will be used as covariates i.e. predictors of "treatment" in propensity score matching.

2.1. Determinants of digital adoption and firm economic performance

The decision to use digital technology in a firm is usually shaped by technological, environmental, and organisational factors (Bin & Hui, 2021; Baker, 2012). Organisational factors include company size, company age, and the availability of digital skills (Kinkel et al., 2022). Small and medium-sized enterprises face the most significant challenges in adopting and utilising digital technology (Lehner & Sundby, 2018). However, their membership in an industry cluster or similar organisation can mitigate these challenges (Götz, 2021). Company size is positively correlated with economic performance, as measured by total turnover and employment (Yazdanfar & Öhman, 2014). However, the association between firm size and employment growth is not significant once controlling for the firm age (Haltiwanger et al., 2013). Moreover, a firm's longevity in the market appears to be also crucial for adopting certain digital technologies (Haller & Siedschlag, 2011). A similar relationship is expected for financial indicators, which tend to improve systematically as companies age (Coad et al., 2013).

Industry classification is frequently identified as a significant determinant of digital technology adoption (Ohlert et al., 2022). While some industries tend to use digital technology more often, others have certain challenges that are difficult to overcome. More specifically, the company's digital capability is closely associated with the adoption of digital technology (Rupeika-Apoga et al., 2022). In addition to organisational characteristics, external factors also seem to play an important role. Results from many previous studies strongly suggest that spatial and country-specific factors are particularly relevant for digital technology adoption (Han & Park, 2017; Holl & Rama, 2023; Hunady et al., 2022). Determinants of digital adoption are further systematised in Table 1.

Table 1. Systematization of empirical findings on digital technology adoption (source: author's)

Outcome	Key findings	Author(s)
Firm performance	Firm size improves performance but is not significant for employment growth when controlling for firm age	Yazdanfar and Öhman (2014); Haltiwanger et al. (2013)
Firm age	Firm age supports digital adoption and improves financial outcomes.	Haller and Siedschlag (2011); Coad et al. (2013)
Adoption barriers	SMEs face stronger barriers to digital technology adoption.	Lehner and Sundby (2018)
Capability driven adoption	Digital skills and firm capabilities increase the likelihood of digital technology adoption.	Kinkel et al. (2022); Rupeika-Apoga et al. (2022)
Structural and environmental effects	Industry, spatial factors, and cluster participation significantly influence adoption patterns.	Han and Park (2017); Holl and Rama (2023); Hunady et al. (2022); Ohlert et al. (2022); Götz (2021)

As shown, previous studies reveal the complex nature of firms' decision-making regarding the adoption of digital technology and its determinants. Accounting for these factors is necessary for evaluating the role of digital technology. Hence, all the mentioned factors have been used as control variables in regressions and as covariates of digital technology adoption as a first step in propensity score matching.

2.2. Economic consequences of digital adoption: evidence on financial performance and skill demand in SMEs

Our research aims to go beyond identifying factors associated with the adoption of digital technologies in SMEs. While many studies focus on drivers of digital technology adoption, our research focuses mainly on the economic consequences of that decision. We aim to investigate the subsequent consequences of changes in turnover and skills-related issues. This problem is still significantly underexamined. However, a significant body of literature con-

firms the important function of digital adoption in shaping the firm-level economic performance. To understand the relationship between internal actions and turnover growth, we rely on the Resource-Based View (RBV) developed by Barney and Arikan (2005). RBV suggests that a firm's financial performance is affected by the effective utilisation of its internal resources. Based on the RBV, digital technology represents a form of capital that enables SMEs to improve internal efficiency and scalability. The use of digital technologies is fundamentally changing business strategies, business processes, and firm capabilities (Bharadwaj et al., 2013). Furthermore, digital transformation can improve internal business processes (Schwertner, 2017) and lead to better strategic decisions and stronger internal controls in companies (Xu et al., 2024). Digital technologies, as such, create space for the adoption of new business models and are often crucial for improving business performance (Lungu et al., 2024). This technology can open opportunities in data science, which has the potential to improve firms' productivity (Chatterjee et al., 2024; Nucci et al., 2023). Our first research question (RQ1) addresses the potential effects of digital technology adoption on turnover growth. The second research question (RQ2) considers the role of reskilling as an alternative investment that has the potential to increase turnover growth. Human capital appears to be a similarly important factor, based on the RBV and Human Capital Theory (HCT), which suggests that investing in improving staff skills can increase productivity and drive turnover growth (Onkelinx et al., 2016).

Most innovative activities are positively associated with turnover growth (Morone & Testa, 2008) and value-added (Hunady et al., 2020). Moreover, digitalisation is also often associated with better overall financial performance for SMEs (Eller et al., 2020), particularly through improved visibility and customer engagement (Verma, 2024). There are at least five main benefits of digital technology for SMEs, including increased revenue, improved consumer and employee satisfaction, and increased productivity and efficiency (Pfister & Lehmann, 2023). Empirical evidence further indicates that digitalisation contributes to broader economic performance in SMEs, particularly when supported by higher levels of internet literacy (Muffarriddin et al., 2024). The mentioned benefits may further increase total turnover and change skill needs.

Since digital technology reinforces automation, companies are likely to substitute low-skilled labour for less costly capital (Xie et al., 2021). New technologies shift certain tasks from labour to capital, reducing the cost of human labour. This creates a stable long-run equilibrium with new roles for human labour that balance the advantages of technology (Acemoglu & Restrepo, 2018). In line with that finding, the adoption of digital technologies such as artificial intelligence (AI) can shift a company's workforce composition (Babina et al., 2024). The availability of certain hard and soft skills is important for the adoption of digital technologies (Kinkel et al., 2022). Especially advanced digital technologies often require a high level of competence to realise their full potential (Hernandez-de-Mendez et al., 2020). Hence, results from previous studies indicate that the adoption of digital technology has consequences for skill shortages in SMEs, and we examined this problem in more detail. This issue is formulated by the third research question (RQ3).

In summary, although no other studies have directly examined these specific problems using a similar methodology, the systematised empirical evidence presented in Table 2 indicates that digital technology may increase turnover while simultaneously exacerbating skill shortages in European SMEs. This highlights the importance of our research questions and the relevance of our approach.

Table 2. Key empirical outcomes of digitalization (source: author's)

Outcome	Key findings	Author(s)
Firm performance effects	Digitalization improves firm performance, productivity, and turnover growth, particularly via better processes, customer engagement and data use.	Bharadwaj et al. (2013); Schwertner (2017); Xu et al. (2024); Chatterjee et al. (2024); Morone and Testa (2008); Eller et al. (2020); Verma (2024); Pfister and Lehmann (2023)
Mechanisms and capabilities	Digital technologies act as strategic resources improving efficiency, scalability and business model innovation.	Barney and Arikan (2005); Lungu et al. (2024)
Human capital and skills effects	Digitalisation increases demand for digital skills, requires reskilling, and is associated with skills shortages in SMEs.	Onkelinx et al. (2016); Kinkel et al. (2022); Hernandez-de-Mendez et al. (2020)
Labour market adjustments	Digitalisation drives automation, labour substitution, and workforce restructuring leading to new labour- technology equilibrium.	Xie et al. (2021); Babina et al. (2024); Acemoglu and Restrepo (2018)
Contextual moderation	Effects of digitalization are stronger when supported by internet literacy and complementary capabilities.	Muffarriddin et al. (2024); Nucci et al. (2023)

Although most empirical evidence suggests that digital technology has a potential to improve the economic and financial performance of SMEs, it may also introduce significant challenges in several areas. This study examines this dichotomy in greater detail using empirical data from EU countries.

3. Methodology and data

The analysis examines the potential consequences of digital technology adoption and staff reskilling in SMEs. SMEs are using both types of measures (digital technology and reskilling) to deal with skill shortages. We are focused on identifying the relationship between these measures and

total turnover and skill shortages after their adoption in firms. Moreover, the research considers selected firms' characteristics as control variables and as covariates (in PSM). It is based on secondary data from Flash Eurobarometer Survey No. 537 (European Commission, 2023). This questionnaire survey was carried out in 27 EU countries between September 11 and October 13, 2023. Firms from 27 EU countries plus 8 non-EU countries (Iceland, Norway, Switzerland, the United Kingdom, North Macedonia, Turkey, the United States, Canada, and Japan) were respondents. More than 19,000 respondents' companies were interviewed, but invalid or unavailable responses reduced the sample to approximately 15,600. To examine the formulated research question and fulfil the paper's main aim, we used a set of quantitative techniques. Our approach synergically combines logistic regression with quasi-experimental methods (Propensity Score Matching). Comparing the results allows us to make certain causal claims about two specific independent variables. This approach also has the potential to improve the accuracy and robustness of our results. Data from answers to the question "Over the past 2 years, has your company's annual turnover increased?" have been used as the dependent variable in the first regression model. The reported increase in turnover was coded as 1; it was coded as 0. The question "Does your company experience skill shortages after implementing any measures?" was used in the second regression. Answers indicating no skill shortages were coded as 1; otherwise, as 0.

Since we want to examine the potential effect of digital technology adoption, we used adoption as the main independent variable. SMEs were asked whether they had begun using digital technology more intensively to address skill shortages. Since the questionnaire survey considers only digital technology in general, we are not able to distinguish between different types of digital technology. Such an aggregate category encompasses a broad spectrum of tools including cloud computing, artificial intelligence, cloud computing, big data, and automated production systems. It is important to acknowledge that more advanced technologies, such as AI, may require significantly higher levels of specialized competencies compared to basic digital tools, potentially leading to varied impacts on turnover and skill demand.

Moreover, to make our results more robust, we need to compare the effects of digital technology adoption with adoption of another measure. Staff reskilling has been chosen as the best proxy for skill improvement in the company. Both key independent variables are described in Table 3. Firms may make a crucial decision about whether to address the problem of skill shortage through the adoption of digital technology or by reskilling current staff. We examined the expected outcomes of both types of decision on turnover and the persistence of skills shortages following the introduction of each measure. Potential relationships and their significance have been examined using logistic regression, including control variables. A set of control variables has been selected based on theoretical assumptions and the results of previous studies, which have been systematically analysed in the literature review. Control variables have also been used as covariates for probit regression to determine matching, providing input into the propensity score matching.

Table 3. Description of two key independent variables (source: author's)

Name	Coding	Question
DIGITAL TECH ADOPTION	More intense use of digital technologies to replace human resources = 1 Otherwise = 0	In the past two years, what measures, if any, has your company taken to address skills shortages? Please choose the three most important ones.
STAFF RESKILLING	Training/reskilling of the current staff = 1 Otherwise = 0	

Independent variables that were used as control variables and predictors are described in Table 4.

Table 4. Description of control independent variables (source: author's)

Question	Variable	Coding
What is the size of your company in terms of the number of employees?	Employees	1 to 4 employees = 1; 5 to 9 = 2; 10 to 49 = 3; 50 to 249 = 4; 250 to 499 = 5; 500 or more = 6
In what year was your company established? (2023 – the year when the company was established)	Company age	Years (min = 1; max = 274)
What is the average age of your employees?	Employees' age	Under 20 years = 1; 20–29 = 2; 30–39 = 3; 40–49 = 4; 50 or above = 5
Are you a member of an industry cluster or another SME business support organization?	Industry cluster	Yes = 1; No = 0
Which of the following best describes the area where your company is located?	Community size	A rural area = 1; less than 20,000 inhabitants = 2; 20,000–100,000 inhabitants = 3; 100,000-500,000 inhabitants = 4; over 500,000 = 5
Industry: 11 dummy variables created based on NACE categories (reference category = ICT)		
Country (location): 35 dummy variables created (reference category = USA)		

Due to potential endogeneity and selection bias, the results of logistic regression analyses generally do not allow us to make strong causal claims. Hence, most results should be interpreted as associations rather than as causation. To deal with this problem regarding the effects of our main independent variable, capturing the adoption of digital technology, we decided to also apply propensity

score matching (PSM). This technique allows us to use a quasi-experimental design to examine the potential causal effect of digital technology adoption on firms' turnover and skills-related problems. Similarly to our approach, PSM on survey-based data has recently been used to examine the impact of financial constraints on the financial performance of Finnish SMEs (Kotamäki, 2025). In our case, a probit regression with digital technology adoption as the dependent variable was used as the first step in PSM, based on covariates. This was followed by matching similar respondent firms using propensity score matching (PSM). PSM was applied to compare and obtain more robust results. Hence, digital technology adoption was seen as a potential "treatment", and we identify its consequences on firms' turnover and absence of skill shortages. Based on the results, we can identify potential effects of adoption of digital technology on turnover and skills-related problems.

4. Results

First, we examined graphical representations of key variables, including digital technology adoption, reskilling, turnover, and the absence of skill shortages. Figures 1 and 2 can help us begin identifying possible relationships and

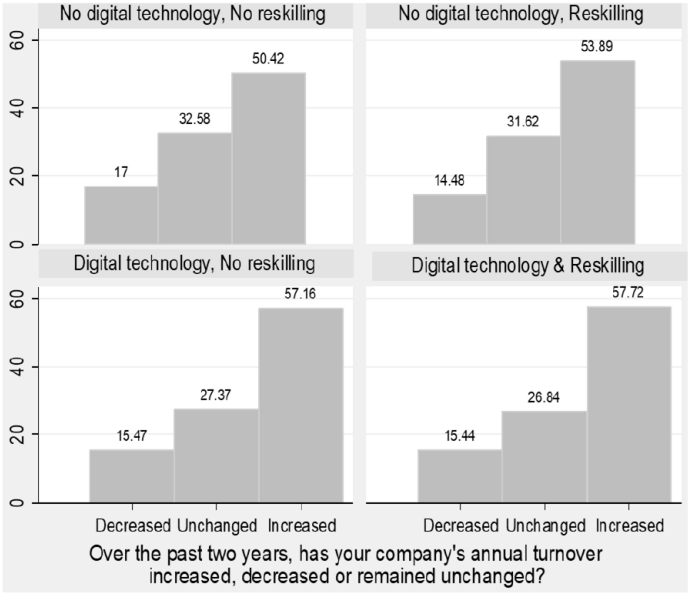


Figure 1. Distribution of SMEs based on annual turnover change by adoption of digital technology and reskilling (source: author's calculations)

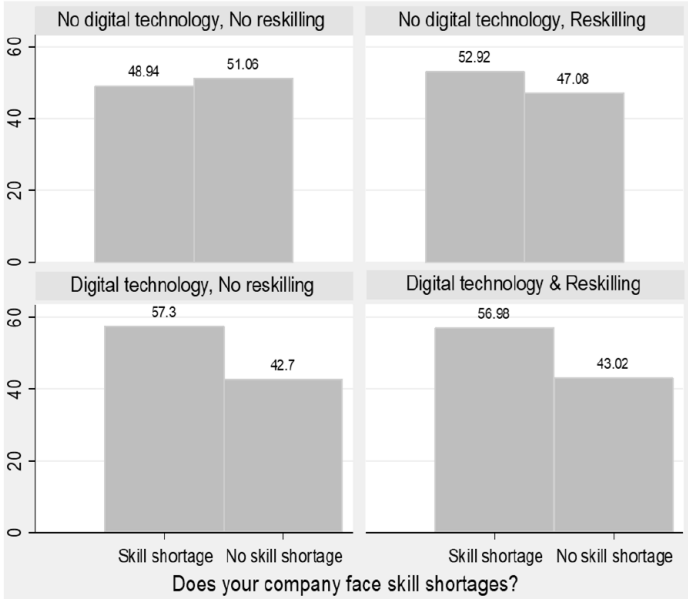


Figure 2. Distribution of SMEs based on reported skill shortages by adoption of digital technology and reskilling (source: author's calculations)

dependencies. Figure 1 shows the annual turnover change of four categories of SMEs based on their digital technology adoption and reskilling activities. The data reveals a positive correlation between digital adoption and turnover growth. Additionally, the figure indicates that firms that engage in both digital adoption and reskilling do not significantly outperform those that adopt only digital technology. This fact suggests that digital technology represents the main driver of turnover growth.

Conversely, the potential relationship between turnover changes and reskilling is unclear. Firms without digital technology adoption and without actions towards staff reskilling report the lowest growth and the highest rate of turnover decrease. This result suggests that a lack of activities in both areas is associated with financial vulnerability and market stagnation.

Figure 2 illustrates potential associations regarding skills shortages in SMEs. Interestingly, firms using digital technology reported the highest skill shortages, but this result does not appear to be related to reskilling activities. Firms without digital technology and reskilling reported the lowest skills shortage. Overall, the use of digital technology appears to be associated with increased difficulties in acquiring and maintaining the right set of skills within the company.

Possible relationships among the observed variables will be examined in more detail based on the results of logistic regression models in Table 5.

The results allow us to identify potential determinants of company growth, proxied by the turnover indicator, as well as challenges posed by skill shortages. While our focus is mainly on the adoption of digital technology and staff reskilling, we also find several interesting results regarding other control variables. Digital technology adoption appears to be significantly and positively related to increased turnover. These results suggest that SMEs that use digital technology are more likely to experience turnover growth. On the contrary, we fail to find a similar significant association regarding reskilling. Our results also indicate that turnover growth is strongly associated with larger company size, measured by the number of employees and membership in an industry cluster. However, the average age of employees and the overall age of the company are negatively correlated with the probability of achieving increased turnover. The industry type seems to play only a marginal role, but the financial sector shows a significantly higher likelihood of reporting turnover growth. The differences between rural and urban environments do not appear to be a significant factor in determining the probability of increased turnover in SMEs. Country influence is captured using dummy variables for all examined countries except the reference category.

The dependent variable used in the second regression measures the likelihood of having no problems with skill shortages. We found that larger companies tend to report significantly more difficulty in finding the right skills. On the contrary, firms with a higher average employee age and those operating in the financial or water sectors are less likely to experience this sort of problem.

Table 5. Results of logistic regression (source: author's calculations)

Variables	Increased turnover	No problems with skill shortages
DIGITAL TECH ADOPTION	0.214*** (0.0506)	–0.296*** (0.0775)
STAFF RESKILLING	0.0601 (0.0479)	–0.0933** (0.0457)
Industry cluster	0.242*** (0.0620)	–0.201*** (0.0489)
Employees	0.211*** (0.0229)	–0.196*** (0.0258)
Employees age	–0.231*** (0.0329)	0.0499** (0.0205)
City over 100k	0.0610 (0.0483)	0.00230 (0.0385)
Rural	–0.00550 (0.0471)	–0.0259 (0.0463)
Company age	–0.0041*** (0.0009)	–0.00032 (0.00075)
Mining	–0.0241 (0.286)	0.0467 (0.217)
Manufacturing	–0.0771 (0.0878)	–0.122* (0.0702)
Energy	0.113 (0.199)	–0.0108 (0.171)
Water	–0.101 (0.125)	0.292** (0.127)
Construction	–0.0397 (0.0934)	–0.223*** (0.0725)
Sale	0.00462 (0.0929)	0.0475 (0.0773)
Transportation	–0.0332 (0.124)	0.0800 (0.0951)
Accommodation	–0.0467 (0.102)	–0.0556 (0.105)
Financial	0.275** (0.134)	0.300** (0.122)
Real estate	–0.179 (0.165)	0.0428 (0.138)
Professional	–0.00741 (0.103)	0.0180 (0.0857)
Constant	–0.163 (0.165)	0.255 (0.234)
Observations	15,635	15,635

Note: Robust standard errors in parentheses. 35 country dummy variables have been included in both regressions, (not shown in the table), *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Based on our results, both digital technology adoption and reskilling are negatively correlated with this outcome. This suggests that firms that actively adopt digital technology and train their employees are more likely to have skill gaps. However, this correlation may reflect reverse causality, where firms experiencing skill gaps are more likely to adopt these measures. Therefore, while reskilling and

technology adoption in SMEs often occur in response to skill shortages, neither action appears to resolve skill shortages directly. It is crucial to examine these relationships in more detail using techniques such as propensity score matching (PSM). To test the robustness of our findings, we applied PSM not only to adoption of digital technology but also to variable capturing staff reskilling. Staff reskilling was considered as an alternative way or complement to digital technology adoption when addressing skill gaps.

The first set of PSM results is summarised in Table 6, which shows the difference between the treated group (those SMEs which adopted digital technology) and the control group (those that did not). Treated and control companies are paired based on their similarity in propensity scores. The t-statistics indicate whether the differences between the two groups of SMEs are statistically significant. Regarding the adoption of digital technology, the differences are statistically significant at the 1% level for increased turnover and at the 5% level for the absence of problems with skill shortages. The difference is positive in the first case and negative in the second.

Table 6. Results of PSM for "Adoption of digital technology" (Average Treatment Effect on the Treated) (source: author's calculations)

Action	Treated (Treatment: adoption of digital tech.)	Controls	Diff.	S.E.	T-stat
Increased turnover	0.552	0.492	0.059	0.02	2.93***
No problems with skills shortages	0.4203	0.4613	-0.041	0.02	–2.01**

Note: Probit regressions have been used to calculate propensity score, which represents the probability of each firm being assigned to a treatment group.

Hence, our results strongly suggest that the adoption of digital technology is strongly linked to turnover growth and to an increase in skill shortages. Thus, we found stronger empirical support for previous findings from the results of logistic regression. The results are similar, but this time we identify likely causal relationships. Our findings suggest that, although digitalisation stimulates turnover growth, it simultaneously increases human capital requirements in SMEs.

Moreover, PSM results related to digital technology adoption have been further compared with those related to reskilling to test the robustness of the results and investigate the consequences of two different actions aiming at the same outcomes (addressing these skill shortages). The most essential results are shown in Table 7.

In this case, the revealed differences between the treated (skilled firms) and the control groups are statistically insignificant for both turnover and skill shortages. Consequently, this suggests that reskilling, in isolation, does not act as a causal factor of turnover growth. As a result, we fail to find any short-run empirical effect of reskilling. Furthermore, neither turnover nor skill shortages appear to be significantly related to staff training in SMEs. This finding likely indicates that the dependence between reskilling and skill shortages identified by logistic regression cannot be interpreted as a causal effect but rather a correlation. Finally, the potential effect's intensity is further expressed in terms of average treatment effects (ATE) shown in Table 8.

Table 7. Results of PSM for "Reskilling" (Average Treatment Effect on the Treated) (source: author's calculations)

Action	Treated (Treatment: Reskilling)	Controls	Diff.	S.E.	T-stat
Increased turnover	0.517	0.501	0.017	0.012	1.38
No problems with skills shortages	0.463	0.475	–0.012	0.012	–1.01

Note: Probit regressions have been used to calculate propensity score, which represents the probability of each firm being assigned to a treatment group.

Table 8. Average treatment effects (ATE) on turnover based on PSM (source: author's calculations)

	Coef.	Robust std. errors	z-stat
ATE digital technology (1 vs. 0)	0.0498	0.016	3.04***
ATE Reskilling	0.0172	0.011	1.60

The results represent the expected change in the outcome attributable to each action (adopting digital technology and reskilling). ATE of digital technology adoption has a coefficient of 0.0498, and the effect is statistically significant at the 1% level. This result indicates that the adoption of digital technology in SMEs increases the probability of reporting turnover growth by approximately 5 percentage points after controlling for all main firm characteristics. In contrast, the ATE for reskilling (0.0172) is not statistically significant.

Conversely, the ATE for reskilling actions indicates a much smaller coefficient, and it is not statistically significant at any standard threshold. While the data shows a positive trend, it does not provide enough evidence to confirm that reskilling can really cause reliable turnover growth based on our sample of SMEs.

5. Discussion

Our key results provide several novel or complementary findings. We have identified relationships that were previously unreported. These findings are based on similarly large samples of SMEs in EU countries. Our results suggest that adoption of digital technology in SMEs can often lead

to a "productivity-skill paradox". The adoption and usage of digital technology in SMEs can have many benefits. In our case, we found that it leads to a significant increase in sales. However, these benefits can be offset by the growing skills shortage. The potential of digital technology to support market expansion comes at the cost of securing a sufficiently high-quality and well-skilled workforce. This result complements the findings of several previous studies. Most studies found that digital transformation is commonly associated with improvements in financial performance and increased productivity in companies (Lungu et al., 2024; Pfister & Lehmann, 2023; Eller et al., 2020; Chatterjee et al., 2024). Pfister and Lehmann (2023) argue that adoption of digital technology is associated with a significant increase in revenue, productivity, efficiency and consumer satisfaction. This fact may also be attributed to digital technology-driven advancement in business processes (Schwertner, 2017) and strategic decision-making (Xu et al., 2024). Regarding our first research hypothesis (RQ1), we conclude that the adoption of digital technology in SMEs increases turnover. Our results provide new empirical evidence on this issue and expand knowledge regarding European SMEs.

On the other hand, we are unable to find evidence of the potential effect of reskilling on increased turnover. Hence, with respect to the second research question (RQ2), reskilling is unlikely to lead to substantial turnover growth during the examined period. This contrasts with the findings of Onkelinx et al. (2016), but the lack of statistical significance may be attributed to the relatively short look-back period of the survey, and potential long-run effects cannot be ruled out. Investing in human capital can take a longer period to affect financial performance. Our data cannot capture the long-term consequences for turnover or human capital. Moreover, our data also do not capture the intensity and specific type of training. This could play a crucial role in mitigating skill shortages and reducing turnover. However, based on our results, reskilling likely does not lead to substantial turnover growth during the examined period.

Although digital technologies seem the clear strategic choice over reskilling, the decision is not simple. Our results also suggest that adopting digital technology does not solve the problem of limited skills within the company. Companies often try to introduce digital technology to replace missing human resources, but they are unlikely to succeed. In fact, adopting new technology may even amplify the problem. This finding is closely related to two main facts. Firstly, even the introduction of digital technology requires specific hard and soft skills. Such skills are often unavailable (Kinkel et al., 2022; Hernandez-de-Mendez et al., 2020). This is especially relevant for SMEs, which have typically limited skill availability (Castro-Silva & Lima, 2023).

Secondly, digital technology has strong potential to fundamentally change companies' skill demands (Wang et al., 2021). It can induce a shift in firm capabilities and workforce composition (Bharadwaj et al., 2013; Babina et al., 2024). Even if we assume these crucial changes lead to a stable equilibrium in the long run, companies must adapt their priorities. They must focus on specific employee competencies needed (Acemoglu & Restrepo, 2018). These results help us answer the third and final research question (RQ3). Likely, the adoption of digital technology is positively associated with skills shortages in SMEs.

Despite our best efforts to obtain the most reliable results from the large dataset, it is still important to acknowledge the limitations of our study. One of the main issues concerns the independent variables capturing the adoption of digital technology and reskilling. These variables are based entirely on respondents' self-reported information. This can lead to different perception problems and biases, such as social desirability bias. This problem cannot be fully eliminated and needs to be considered. Moreover, the questionnaire data do not allow us to differentiate the effects of different types of digital technology. We are only able to capture an aggregate category which includes a broad spectrum of digital technologies. Hence, it is important to acknowledge that the consequences on skills and trover can be slightly different. It is likely that more advanced technologies may require even higher levels of specialised competencies compared to basic digital tools. Using data from the questionnaire survey can also lead to selection bias and endogeneity. To address this problem for the two key dependent variables, we used a combination of logistic regression and propensity score matching. This approach should eliminate the mentioned problems to a minimum. However, most logistic regression results should be still interpreted with caution due to potential endogeneity issues. Since the questionnaire data is cross-sectional, we are still not able to fully account for time-invariant unobserved heterogeneity. Even though PSM reduces selection bias, the results should be viewed as strong evidence rather than definitive proof of long-term causality. Potential problems of omitted variables have been addressed by including a set of control variables for industries and countries in the sample. It allows us to consider country- and industry-specific factors. However, here we see an opportunity for further research focused on similar problems. Next studies can consider external factors which could influence the adoption of digital technology. Data do not allow us to distinguish between different types of digital technology, which could be useful for more detailed policy implications. This is another room for future research that can be based on our results. Similar differentiation can also be useful for reskilling. Specific forms of reskilling may be associated with significant changes in turnover and skill shortages.

6. Conclusions and policy implications

This study provides new empirical evidence on the effects of digital transformation in SMEs on company growth and the challenges related to a lack of adequate skills. By syn-

ergistically combining logistic regression and propensity score matching with a sample of more than 15,000 firms, we have identified a so-called "productivity-skill paradox". Our results strongly suggest that digital technology adoption in SMEs acts as a "double-edged sword", boosting sales while putting additional pressure on the availability of skills within the company. SMEs that want to adopt digital technology as a tool to help them deal with the skills shortage need to be aware of the mentioned consequences.

In comparison with reskilling activities, the adoption of digital technology appears particularly impactful. Adoption of digital technology increases the probability of turnover growth in the next few years by approximately 5 percentage points. On the contrary, staff training and reskilling programs focused on eliminating skills shortages do not show any immediate effects on both companies' turnover and the subsequent problems with skills. Managerial decision-making in SMEs, which usually have limited financial and personnel capacities, is therefore relatively challenging. From a managerial perspective, the results suggest that digital transformation should be implemented alongside broader strategic human resource planning. The final decision to adopt new digital technology will initially put pressure on certain types of skills (e.g., digital skills), as also reported in previous studies, followed by a change in the business model and a fundamental shift in skill demand. For SMEs that can effectively address the above problems, digital technologies will boost their sales and help them grow their businesses.

Our findings also carry several implications for public policy. To mitigate the negative effects of digital technology on the skills gap, policymakers should move beyond direct or indirect financial subsidies. While technology acquisition is only the beginning of successful digital transformation, public support also needs to focus on subsequent steps. More complex grants supporting the integration of digital technology with the acquisition of human capital should get priority. This is especially crucial for SMEs, which are typically short on additional human and financial capital. The strategic priority should be the step-by-step implementation of digital technology, followed by competency audits and the subsequent hiring of required skills.

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References

Acemoglu, D., & Restrepo, P. (2018). The race between man and machine: Implications of technology for growth, factor shares, and employment. *American Economic Review*, *108*(6), 1488–1542. https://doi.org/10.1257/aer.20160696

Babina, T., Fedyk, A., He, A., & Hodson, J. (2024). Artificial intelligence, firm growth, and product innovation. *Journal of Financial Economics*, *151*, Article 103745. https://doi.org/10.1016/j.jfineco.2023.103745

Baker, J. (2012). The technology–organization–environment framework. In Y. Dwivedi, M. Wade, & S. Schneberger (Eds), *Information systems theory*: *Explaining and predicting our digital society* (Vol. 1, pp. 231–245). Springer. https://doi.org/10.1007/978-1-4419-6108-2_12

Barney, J. B., & Arikan, A. M. (2005). The resource-based view: Origins and implications. In M. A. Hitt, R. E. Freeman, & J. S. Harrison, *The Blackwell handbook of strategic management* (pp. 123–182). Wiley. https://doi.org/10.1111/b.9780631218616.2006.00006.x

Bharadwaj, A., El Sawy, O. A., Pavlou, P. A., & Venkatraman, N. V. (2013). Digital business strategy: Toward a next generation of insights. *MIS Quarterly*, *37*(2), 471–482. https://doi.org/10.25300/MISQ/2013/37:2.3

Bin, M., & Hui, G. (2021). A systematic review of factors influencing digital transformation of SMEs. *Turkish Journal of Computer and Mathematics Education*, *12*(11), 1673–1686. https://doi.org/10.17762/turcomat.v12i11.6102

Castro-Silva, H., & Lima, F. (2023). The struggle of small firms to retain high-skill workers: Job duration and the importance of knowledge intensity. *Small Business Economics*, *60*(2), 537–572. https://doi.org/10.1007/s11187-022-00602-z

Chatterjee, S., Chaudhuri, R., Vrontis, D., & Papadopoulos, T. (2024). Examining the impact of deep learning technology capability on manufacturing firms: Moderating roles of technology turbulence and top management support. *Annals of Operations Research*, *339*(1), 163–183. https://doi.org/10.1007/s10479-021-04505-2

Corò, G., & Volpe, M. (2020). Driving factors in the adoption of Industry 4.0 technologies: An investigation of SMEs. In *Industry 4.0 and regional transformations* (pp. 112–132). Taylor & Francis Group. https://doi.org/10.4324/9780429057984-7

Coad, A., Segarra, A., & Teruel, M. (2013). Like milk or wine: Does firm performance improve with age? *Structural Change and Economic Dynamics*, *24*, 173–189. https://doi.org/10.1016/j.strueco.2012.07.002

Eller, R., Alford, P., Kallmünzer, A., & Peters, M. (2020). Antecedents, consequences, and challenges of small and medium-sized enterprise digitalization. *Journal of Business Research*, *112*, 119–127. https://doi.org/10.1016/j.jbusres.2020.03.004

European Commission. (2023). *Flash Eurobarometer FL537*: *SMEs and skills shortages'* (version v1.00, 2023). http://data.europa.eu/88u/dataset/s2961_fl537_eng

Götz, M. (2021). Cluster role in industry 4.0 – a pilot study from Germany. *Competitiveness Review*: *An International Business Journal*, *31*(1), 54–82. https://doi.org/10.1108/CR-10-2019-0091

Haller, S. A., & Siedschlag, I. (2011). Determinants of ICT adoption: Evidence from firm-level data. *Applied Economics*, *43*(26), 3775–3788. https://doi.org/10.1080/00036841003724411

Haltiwanger, J., Jarmin, R. S., & Miranda, J. (2013). Who creates jobs? Small versus large versus young. *The Review of Economics and Statistics*, *95*(2), 347–361. https://doi.org/10.1162/REST_a_00288

Han, J., & Park, C. M. (2017). Case study on adoption of new technology for innovation: Perspective of institutional and corporate entrepreneurship. *Asia Pacific Journal of Innovation and Entrepreneurship*, *11*(2), 144–158. https://doi.org/10.1108/APJIE-08-2017-031

Hernandez-de-Mendez, M., Morales-Menendez, R., Escobar, C. A., & McGovern, M. (2020). Competencies for Industry 4.0. *International Journal on Interactive Design and Manufacturing*, *14*, 1511–1524. https://doi.org/10.1007/s12008-020-00716-2

Holl, A., & Rama, R. (2023). Spatial patterns and drivers of SME digitalisation. *Journal of the Knowledge Economy*, *15*, 5625–5649. https://doi.org/10.1007/s13132-023-01257-1

Horbach, J., & Rammer, C. (2022). Skills shortage and innovation. *Industry and Innovation*, *29*(6), 734–759. https://doi.org/10.1080/13662716.2021.1990021

Hunady, J., Pisár, P., Vugec, D. S., & Bach, M. P. (2022). Digital transformation in European Union: North is leading, and South is lagging behind. *International Journal of Information Systems and Project Management*, *10*(4), 39–56. https://doi.org/10.12821/ijispm100403

Hunady, J., Pisar, P., & Durcekova, I. (2020). R&D investments in the European ICT sector: Implications for business performance. *Business Systems Research*: *International Journal of the Society for Advancing Innovation and Research in Economy*, *11*(3), 30–44. https://doi.org/10.2478/bsrj-2020-0025

Kinkel, S., Baumgartner, M., & Cherubini, E. (2022). Prerequisites for the adoption of AI technologies in manufacturing – Evidence from a worldwide sample of manufacturing companies. *Technovation*, *110*, Article 102375. https://doi.org/10.1016/j.technovation.2021.102375

Kotamäki, M. (2025). *Financial constraints and firm performance*: *Evidence from SMEs using survey data and propensity score matching* (Discussion paper No. 172). Aboa Centre for Economics. https://ace-economics.fi/kuvat/dp172.pdf

Lehner, F., & Sundby, M. W. (2018). ICT skills and competencies for SMEs: Results from a structured literature analysis on the individual level. In C. Harteis (Eds), *The impact of digitalization in the workplace*: *An educational view* (pp. 55–69). Springer. https://doi.org/10.1007/978-3-319-63257-5_5

Lungu, A. E., Georgescu, M. R., & Juravle, D. (2024). A bibliometric analysis of digital entrepreneurship. *Journal of the Knowledge Economy*, *15*(4), 18617–18645. https://doi.org/10.1007/s13132-024-01885-1

Morone, P., & Testa, G. (2008). Firms growth, size and innovation an investigation into the Italian manufacturing sector. *Economics of Innovation and New Technology*, *17*(4), 311–329. https://doi.org/10.1080/10438590701231160

Muffarriddin, I. A., Ramadani, L. A., & Aminy, M. M. (2024). Digital economy and MSMEs' revenue: Moderating role of internet literacy. *Jurnal Ilmiah Al-Tsarwah*, *7*(1), 1–8. https://doi.org/10.30863/al-tsarwah.v7i1.6955

Nucci, F., Puccioni, C., & Ricchi, O. (2023). *Digital technologies and productivity*: *A firm-level investigation for Italy* (Working paper No. 3). SSRN. https://doi.org/10.2139/ssrn.4546688

Ohlert, C., Giering, O., & Kirchner, S. (2022). Who is leading the digital transformation? Understanding the adoption of digital technologies in Germany. *New Technology*, *Work and Employment*, *37*(3), 445–468. https://doi.org/10.1111/ntwe.12244

Onkelinx, J., Manolova, T. S., & Edelman, L. F. (2016). The human factor: Investments in employee human capital, productivity, and SME internationalization. *Journal of International Management*, *22*(4), 351–364. https://doi.org/10.1016/j.intman.2016.05.002

Pfister, P., & Lehmann, C. (2023). Measuring the success of digital transformation in German SMEs. *Journal of Small Business Strategy*, *33*(1), 1–19. https://doi.org/10.53703/001c.39679

Rupeika-Apoga, R., Petrovska, K., & Bule, L. (2022). The effect of digital orientation and digital capability on digital transformation of SMEs during the COVID-19 pandemic. *Journal of Theoretical and Applied Electronic Commerce Research*, *17*(2), 669–685. https://doi.org/10.3390/jtaer17020035

Schwertner, K. (2017). Digital transformation of business. *Trakia Journal of Sciences*, *15*(1), 388–393. https://doi.org/10.15547/tjs.2017.s.01.065

Verma, A. (2024). The impact of digital marketing adoption on firm performance: A case study of small and medium enterprises in India. *International Journal of Strategic Marketing Practice*, *6*(1), 1–11. https://doi.org/10.47604/ijsmp.2453

Wang, J., Hu, Y., & Zhang, Z. (2021). Skill-biased technological change and labor market polarization in China. *Economic Modelling*, *100*, Article 105507. https://doi.org/10.1016/j.econmod.2021.105507

Xie, M., Ding, L., Xia, Y., Guo, J., Pan, J., & Wang, H. (2021). Does artificial intelligence affect the pattern of skill demand? Evidence from Chinese manufacturing firms. *Economic Modelling*, *96*, 295–309. https://doi.org/10.1016/j.econmod.2021.01.009

Xu, N., Lv, W., & Wang, J. (2024). The impact of digital transformation on firm performance: A perspective from enterprise risk management. *Eurasian Business Review*, *14*, 369–400. https://doi.org/10.1007/s40821-024-00264-9

Yazdanfar, D., & Öhman, P. (2014). Life cycle and performance among SMEs: Swedish empirical evidence. *The Journal of Risk Finance*, *15*(5), 555–571. https://doi.org/10.1108/JRF-04-2014-0043