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**Article**

## Implications of Digitalisation on Skill Needs in a Sustainable Economy

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## IMPLICATIONS OF DIGITALISATION ON SKILL NEEDS IN A SUSTAINABLE ECONOMY

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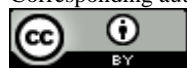
### Abstract

Digitalisation and mainly artificial intelligence led to significant disruptions at all levels of society, changing how we live, communicate, build communities, work, and learn. In addition, digital technologies offer solutions to achieve sustainable development goals. Therefore, to benefit from this potential, it is vital to understand the skill needs associated with sustainable digitalisation. The impact of digitisation on the labour market is largely documented, but there are still important debates on what future jobs will look like. On the one hand, some scenarios announce massive shifts and destruction of jobs with rhythms that cannot be managed well by societies, while others point instead to transformations of skills needs. Therefore, our article aims to investigate the links between digitalisation and skills needs among digitalised enterprises, focussing on those implementing artificial intelligence solutions. In this respect, we use various multivariate techniques to analyse the data made public for the Flash Eurobarometer 486 (2020). Our findings suggest that digitalisation leads to skills shortages and skill gaps among companies adopting different digital solutions. In other words, digitalisation requires more workers with better digital skills.

**Keywords:** Digital transformation, skills needs, skills shortage, sustainable digital economy.

**JEL classification:** C30, D22

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## Introduction

Recent technological change, which is part of the fourth industrial revolution, expands the incidence of job automation (Schwab, 2016). At the global level, digital technologies are changing the way businesses build and deliver their products and services, how they exchange information and connect, and how they relate to their clients. As a result of the digitalisation of the economy, the organisation of work is changing fundamentally. Moreover, digital technologies, in general, and artificial intelligence in particular, are considered to have great potential to optimise energy production, help climate research, and control agroecosystem activity (Mondejar et al., 2021). Therefore, digitalisation provides solutions to achieve sustainable development goals (Ionascu et al., 2022).

ICT technologies have shown, especially during pandemics and economic crises, their contribution to the resilience of individuals, businesses, and societies becoming more important, and it is just the beginning of their way in changing the traditional economy (Xianbin and Qiong, 2021). But the integration of digital technologies into all layers of society must meet at the same time competitive, economic, sustainable, and social goals.

Hence, a sustainable digital economy must pursue the adoption of ICT technologies but also to harness the changes following them in order to improve well-being and minimise negative consequences for individuals and society as a whole. Artificial intelligence and automation of industrial processes, essential for innovation and increased competitiveness in a global market, are extremely important, but they also must be ethical and avoid negative impacts on workers and communities.

In the past, the debate on the future of work anticipated a negative impact of digital technologies through massive job losses due to automation. More recently, a new theory emerged that digital technologies are more likely to lead to partial automation of specific job tasks and less likely to lead to full automation of occupations. Therefore, the main effect of digital technologies is expected to involve essential changes in the skills needed in the workplace. Evidence-based findings on the implications of digitisation are now essential for elaborating appropriate economic development policies capable of supporting the green and digital transition (Cedefop, 2022). In this context, the present research aims to understand the patterns of adoption of digital technology in companies and their implications for skills requirements. Thus, this document aims to investigate the factors that influence the implementation of digital technologies in companies and the extent to which they generate changes in the skills needed in the workplace, fuelling skills shortages. The results provide new evidence supporting the thesis that digitisation is producing significant changes in the skills needed in the workplace. These findings have important implications for the policies required for optimal economic development conditions that support green and digital transitions.

The paper is further structured in 4 sections. The main scientific results on the impact of digitisation are described in the first section. The second section presents the research methodology, describing the data set and the principles of PLS-SEM modelling. The estimation results and discussions are included in the third section, and the last section is dedicated to conclusions.

## 1. The scientific literature on the impact of digitalisation

We witness a profound transformation in the way work is performed and in the skills needed in the workplace. Similar to other industrial revolutions, digitalisation takes the form of a disruption that presents important challenges to companies and employees (Chinoracký and Orejová, 2019). Moreover, digital work is conducive to more blurred employment relationships, bringing specific changes and implications for workers and businesses (International Labour Organisation, 2022).

A major concern regarding the impact of digitalisation on employment is related to the idea that digital technologies will determine the closure of jobs. Early debates on the way digital technologies influence the labour market focused on consequences related to job polarisation and routine-biased technological change (Autor, Levy, and Murnane, 2003; Acemoglu and Autor, 2011; Goos, 2018). On the other hand, existing evidence suggests that digitalisation is associated with an increase in flexible employment, including part-time, temporary, and self-employment. Thus, digital technologies enable remote work and flexible work arrangements, allowing companies to access a more global talent pool.

A seminal study of the US labour market revealed that robot usage determines job losses and wage decline, especially for middle-skilled workers in routine and manual occupations (Acemoglu and Restrepo, 2020). However, other studies showed that digitalisation is more likely to automate part of the working tasks rather than entire jobs (Pouliakas, 2012; Nedelkoska and Quintini, 2018), including in European labour markets (Dauth et al., 2017; Klenert, Fernandez-Macias and Anton, 2023). While labour displacement is manifest in some technology-intensive business environments, the net negative impact is diminished by job growth at the intra-sectoral level and redesign or changes in job tasks allocation (Cedefop, 2022). Moreover, digitalisation creates new roles and industries. In this respect, artificial intelligence, cybersecurity, data science, and e-commerce have grown significantly. Digitalisation creates new job opportunities that require digital skills. Workers must adapt to the changing nature of work by acquiring new skills and updating their knowledge. Digitalisation increases the demand for digital skills such as programming, data analysis, and digital literacy. The growing digitalisation of jobs is reflected in the higher weight of digital skills in the recruitment process (Cedefop, 2023).

Additionally, digital technologies can improve productivity and efficiency in various industries. Automation of repetitive tasks allows workers to focus on higher-value activities. This can lead to economic growth and the creation of new job roles that require complex problem-solving and creativity.

Thus, more recent research takes into consideration the complex underlying factors and inter-relationships that shape the links between digitalisation and employment. In this respect, the adoption of digital technologies is more prevalent in growing companies that have succeeded to better negotiate various crises and shocks (Cedefop, 2022). Previous studies showed that better performing companies have a higher propensity for robot adoption, determining a net job creation rate of around 10% (Koch, Manuylov and Smolka, 2021).

Recognising the importance of sustainable development, economic growth policies have shifted the focus to sustainability, supporting fair and competitive transformation of economic sectors. This transformation depends on the extent to which companies introduce new products and services, restructuring how work is done in response to climate change.

An essential part of this transformation concerns the adoption of digital technologies that support the green transition. Thus, the implementation of these technologies represents a primary channel to propagate the green and digital transition. This process can produce important changes in the skills required for jobs through the reconfiguration of jobs, the emergence of new required skills, or new occupations (Cedefop, 2023).

Implications of digitalisation on the labour market are complex and multifaceted (Pelau, Dabija and Ene, 2021), and they can vary across industries, regions, or in relation to other characteristics of companies. This article aims to investigate the links between digitalisation and skills needs among enterprises that embrace new digital technologies, focussing on those who implement artificial intelligence solutions.

## 2. Research methodology

### 2.1. Data used

We used the data set from the Flash Eurobarometer 486: SMEs, start-ups, scale-ups, and entrepreneurship (European Commission, 2020a) to investigate the implications of digitalisation on skills needs in European companies. The survey was conducted in the period February- May 2020.

Eurobarometer 486 is a statistically representative survey. It is considered a valuable tool for the foundation of the European strategy "An SME Strategy for a Sustainable and Digital Europe" (European Commission, 2020b). Consequently, the database ensuing from this survey enabled the empirical validation of theories such as: the adoption of digital technologies (Omrani, 2022; Holl and Rama, 2023), the correlation between digitisation and sustainability (Del Baldo et al., 2022), performance in sustainable innovation (Labella-Fernández, Serrano-Arcos and Payán-Sánchez, 2021; Ardito, 2023) and the development of the circular economy (Findik et al., 2023). The results showed that the implementation of digital technologies is positively correlated with access to financing sources and company turnover (Del Baldo et al., 2022). Digitalisation has also been shown to be influenced by the quality and performance of the local business environment (Holl and Rama, 2023). In turn, the degree of digitalisation facilitates sustainable innovation (Labella-Fernández et al., 2021; Ardito, 2023).

To understand which digital technologies are adopted by companies in the EU, we used an UpSet representation. This type of plot is used to visualise the intersections between the adopted technologies. Figure 1 summarises the information provided by the companies' answers to the question about the implemented digital technologies. The list of possible answers is as follows: Artificial Intelligence (Ai), Cloud Computing (Cloud), Robotics (Robot), Smart Devices (ID), Big Data Analytics (BD), High Speed Infrastructure (Hsi), Blockchain (Bck). The question has multiple possible answers. Therefore, we sought a representation that simultaneously highlights the number of companies that implement a specific technology and the intersection of all possible combinations of adopted technologies. Thus, the horizontal bars associated with each technology show the number of companies that implemented that methodology, and the vertical bars show the number of companies that exclusively adopted the technologies marked by dots at the bottom of the graph. More than 6,000 companies have adopted cloud storage and file processing technologies. However, of these, 1850 have declared this technology as the only one

implemented, while 1090 have additionally adopted High Speed Infrastructure (Hsi). Cloud computing is often associated with high-speed infrastructure technology (Hsi) or with smart devices (ID). AI technology is usually associated with other technologies like smart devices (ID), high speed infrastructure (Hsi), and Cloud computing (cloud). The size of this set that comprises companies that adopted only these four technologies, is 92 (see Figure 1). To focus on companies that implement artificial intelligence solutions and to understand which are their main characteristics, we performed a correspondence analysis. The following findings are gathered from its output.

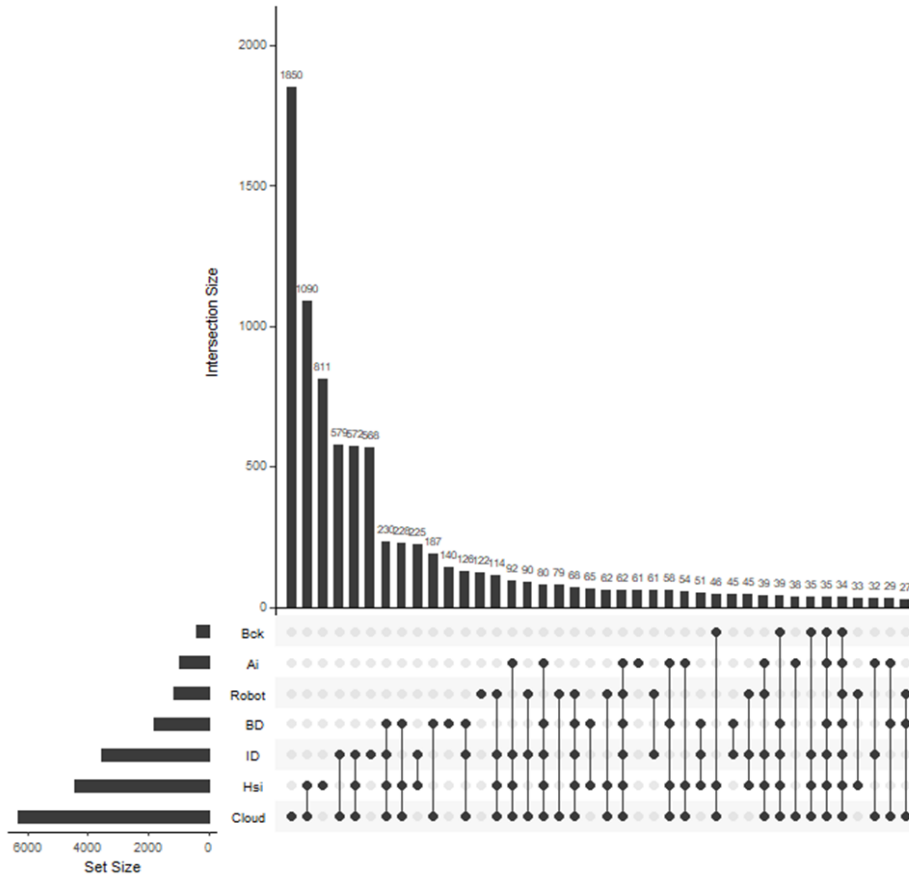


Figure no. 1. UpSet representation of digital technologies adopted by companies

Compared to companies adopting other digital technologies, companies that implement AI solutions are characterised by a higher share of growth expectations that exceed 20% per year (both in terms of employment and turnover) (see Figure 2). Therefore, they perform financially better (Del Baldo et al., 2022) and also aim to perform above the average in the near future, taking as many advantages as possible from the opportunities generated through digitalisation.

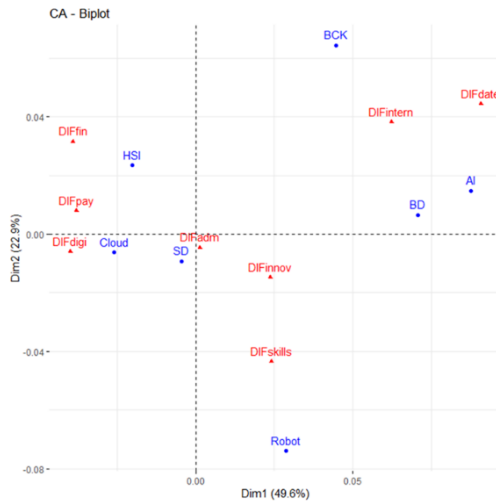


Figure no. 2. Correspondence between digital technology and growth expectations

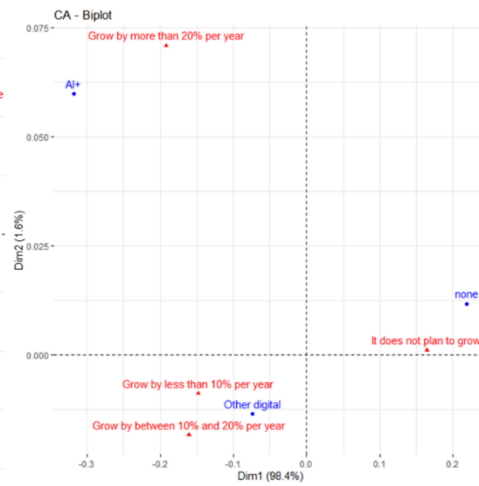


Figure no. 3. Correspondence between digital technology and key areas which pose the biggest problems

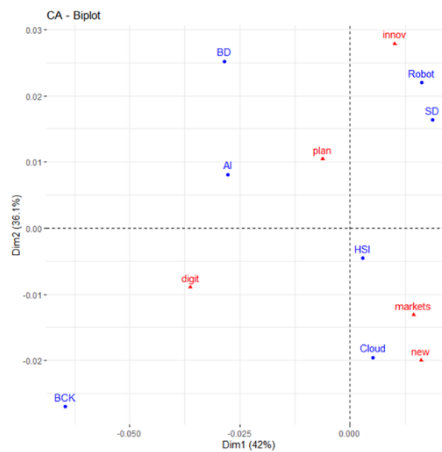


Figure no. 4. Correspondence between digital technology and strategies to grow

In terms of growth, either in employment or in turnover, depending on the adopted technologies, companies' strategies are different. For example, introducing some innovation-based solutions is more often associated with companies dealing with robotics or smart devices, meanwhile, while companies adopting AI solutions are more strategic and driven by a growth plan. Companies that implement cloud computing technology plan to grow as a result of operating in growing markets or entering new markets (see Figure 4).

Among the problems associated with digitalisation, companies adopting AI technology identify access to data and internationalisation as the most frequent challenges. Companies

dealing with robotics are more likely to report problems with skills shortages; those implementing Cloud computing report difficulties with digitalisation in general, while those adopting High-speed infrastructure are more likely to report problems associated with access to finance and payment delays. Regulation and administration procedures are declared as problems by companies implementing cloud computing and smart devices (see Figure 3).

## 2.2. Methods

To investigate the impact of digitalisation on skills needs in the business sector, we used a methodology based on partial least squares structural equation modelling (PLS-SEM). This is a variance-based partial least squares technique. This means that the explained variance of the endogenous constructs is maximised. This approach is suitable for analysing multiple blocks or constructs of variables. Each block is seen as a latent factor, and a set of linear relations are connecting these constructs. The main arguments that justify the use of this approach are the following: (i) it allows the use of the categorical variables available in the database; (ii) it eliminates the shortcomings related to the adequacy of the distributions since it does not require assumptions regarding the variables or error distributions; (iii) it combines the principles of factor analysis and regression, facilitating the construction of latent variables and simultaneously testing their relationships; (iv) it is suitable for the exploratory research that we are developing to investigate the decision to adopt digital technologies in companies and their impact on skill needs.

PLS-Sem is based on an iterative approach involving the specification and evaluation of two elements: an Inner model and an Outer model. The inner model is the structural model, and it specifies the relationships between the constructs. The outer model is the measurement model because it establishes the relationships between the indicator variables within the constructs. Each construct or latent variable is a linear combination of manifest variables. The coefficients used in this linear combination maximise the explained variance of the dependent variables (latent and observed) (Hair et al., 2014).

In terms of PLS-SEM modelling, in our investigation, there are four exogenous latent variables labelled as: Size, Growth, BusinessEnvironment, and Digitalisation explaining the variance of the endogenous block labelled SkillsNeed. The Digitalisation construct also acts as an endogenous factor being explained by the other three exogenous blocks. It is described below the path diagram of the inner model built with five blocks of variables (Sanchez et al., 2021).

The causalities illustrated in the model are founded on econometric estimations results demonstrating that: (i) the adoption of digital technologies is associated with the company size and growth capacity, (ii) the characteristics of the business environment represent significant drivers of digitalisation (Labella-Fernández et al., 2021; Omrani et al., 2022; Holl and Rama, 2023). Furthermore, the growing importance of digital skills in the recruitment process of workers due to job digitisation supports the dependency between the Digitalisation and SkillsNeed blocks (Cedefop, 2023). However, empirical evidence supports that skills shortages are also caused by insufficient or inadequate resources in the business environment (Van Dijk and Hacker, 2003).



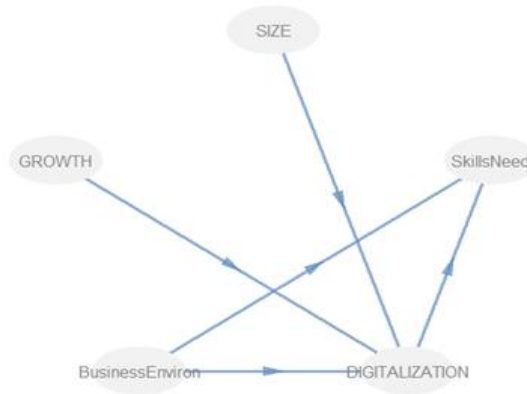


Figure no. 5. Path diagram of the inner model

The outer models of the exogenous/endogenous constructs are described in Table 1 showing the items used to build each of these blocks. For each latent construct, the outer model is designed in a reflective manner (mode A), meaning that the indicators or the manifest variables are caused by the construct. Reflective indicators are linked to their specific construct through loadings. Therefore, the evaluation of the outer model is based on reliability measures such as the Dillon-Goldstein rho and validity measures based on loadings.

Table no. 1. Latent and manifest variables - outer model specification

Latent variables	Manifest variables	Variable name	Variable type
Size	Number of employees	SizeE	Categorical, 4 categories. Levels: micro, small, medium and large.
	Annual Turnover in 2019	SizeT	Categorical, 8 categories. Levels: ranging from 1= 100000 euros or less to 8= more than 50 million euros.
Growth	Growth since 2016 - Turnover	GrT	Categorical, 4 categories. Levels: decreased, stable, increased by less than 30%, and increased by at least 30%.

Latent variables	Manifest variables	Variable name	Variable type
	Expected Growth 3 years - Employees	EGE	Categorical, 4 categories. Levels: no growth, less than 10%, 10-20%, more than 20%.
	Expected Growth 3 years - Turnover	EGT	Categorical, 4 categories. Levels: no growth, less than 10%, 10-20%, more than 20%.
BusinessEnviron	Business Environment - Overall strength	BE1	Categorical, 4 categories. Levels: Very good (1) to Very poor (4).
	Access to finance	BE2	
	Quality of support services	BE3	
	Access/ collaboration	BE4	
Digitalisation	Plan to grow as a result of increased digitalisation in your enterprise	Strategy	Binary. Levels: 0 (No), 1 (Yes)
	There is a need to introduce advanced digital technologies and your enterprise is currently considering which of them to adopt <i>or</i>  There is a need to introduce advanced digital technologies and your enterprise has already started to adopt them	Approach	Binary. Levels: 0 (No), 1 (Yes)
	Number of Digital technologies adopted	DigitNo4	Categorical, 4 categories. Levels: 0, 1, 2, more than 2 technologies.
SkillNeed	Availability of personnel with the right skills, including managerial skills	SkillsAv	Categorical, 4 categories. Levels: Very good (1) to Very poor (4).

Latent variables	Manifest variables	Variable name	Variable type
	Key areas which pose the biggest problems: Skills, including managerial skills	SkillsProbl	Binary. Levels: 0 (No), 1 (Yes)
	Barriers to digitalisation: Lack of skills, including managerial skills	BarrierSkills	Binary. Levels: 0 (No), 1 (Yes)
	Barriers to innovation: Lack of skills, including managerial skills	SkillsBarrierInno	Binary. Levels: 0 (No), 1 (Yes)

The evaluation of the inner model was based on the estimated path coefficients. The values of these coefficients are estimated by ordinary least squares regressions and lie in the interval (-1, 1). A bootstrap-based standard error is computed to test their significance. To test the significance of these estimations, the standard error is obtained based on the bootstrap resampling technique. The estimation was performed with the plspm library in R (Sanchez, 2013).

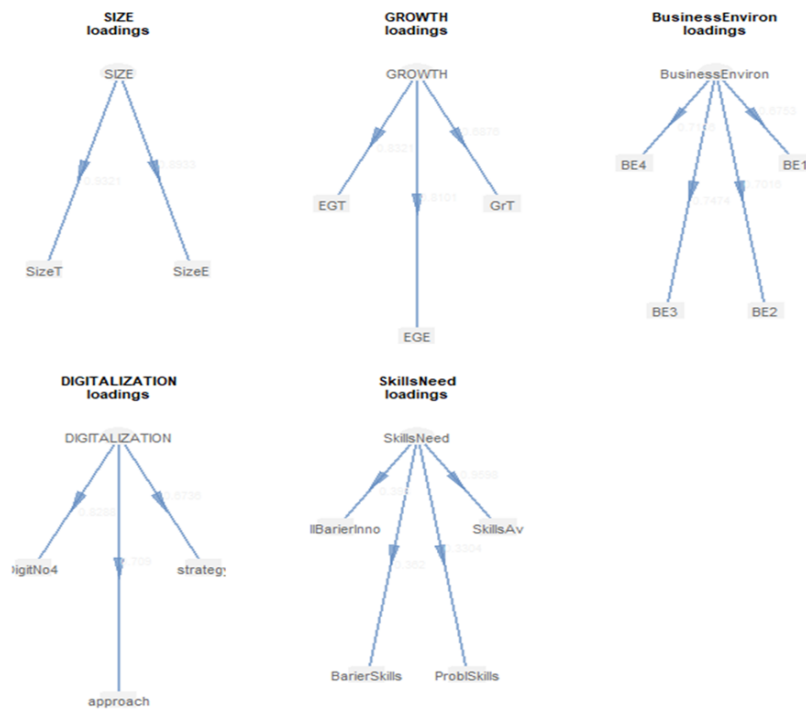


Figure no. 6. The measurement model

### 3. Results of the SEM modelling and Discussions

Assessing outer model reliability is traditionally done through measures such as Cronbach's alpha. However, in the context of PLS-SEM models, up-to-date references demonstrate the relevance of other internal consistency assessment methods (Hair et al., 2014). The evaluation based on Cronbach's alpha indicator is sensitive to the number of items included and the scale, leading to the underestimation of the internal consistency. In this research, the extent to which the indicators defining a specific block reflect the associated latent variable is evidenced by Dillon-Goldstein's rho index and the size of the first eigenvalue of the correlation matrix. Dillon-Goldstein's rho index is considered superior to Cronbach's alpha index because it quantifies how much the latent variable explains the manifest variables. The rule of thumb stipulates that a block is considered one-dimensional when Dillon-Goldstein's rho exceeds 0.7. Regarding the evaluation based on the highest eigenvalue of the estimated correlation matrix for each set of indicators, one-dimensionality is ensured by a first eigenvalue above one and lower values of the second eigenvalue (Sanchez, 2013). Based on these considerations, the blocks that the constructed model defines are valid.

**Table no. 2. Unidimensionality of indicators**

	MVs	DG.rho	eig.1st	eig.2nd
<b>SIZE</b>	2	0.913	1.680	0.319858
<b>GROWTH</b>	3	0.834	1.889	0.759543
<b>BusinessEnviron</b>	4	0.817	2.109	0.707139
<b>DIGITALISATION</b>	3	0.786	1.651	0.721065
<b>SkillsNeed</b>	4	0.779	1.895	0.898639

MV= number of manifest variables, DG rho= Dillon-Goldstein's rho, eig.1<sup>st</sup>= first eigenvalue, eig.2<sup>nd</sup>=second eigenvalue

**Table no. 3. Cross Loadings**

name	block	SIZE	GROWTH	Business Environ	DIGITALISATION	Skills Need
SizeE	SIZE	<b>0.89</b>	0.14	-0.13	0.29	0.02
SizeT	SIZE	<b>0.93</b>	0.16	-0.15	0.36	0.04
GrT	GROWTH	0.18	<b>0.69</b>	-0.14	0.17	-0.01
EGE	GROWTH	0.13	<b>0.81</b>	-0.09	0.18	0.01
EGT	GROWTH	0.08	<b>0.83</b>	-0.11	0.19	-0.01
BE1	BusinessEnviron	-0.12	-0.16	<b>0.68</b>	-0.10	0.24
BE2	BusinessEnviron	-0.18	-0.08	<b>0.70</b>	-0.13	0.22
BE3	BusinessEnviron	-0.07	-0.08	<b>0.75</b>	-0.08	0.29
BE4	BusinessEnviron	-0.08	-0.09	<b>0.71</b>	-0.09	0.26
strategy	DIGITALIZATION	0.21	0.13	-0.09	<b>0.67</b>	0.04

name	block	SIZE	GROWTH	Business Environ	DIGITALISATION	Skills Need
approach	DIGITALISATION	0.23	0.17	-0.07	<b>0.71</b>	0.03
DigitNo4	DIGITALISATION	0.33	0.20	-0.14	<b>0.83</b>	0.02
SkillsAv	SkillsNeed	0.00	-0.03	0.38	-0.02	<b>0.96</b>
ProblSkills	SkillsNeed	0.12	0.08	-0.01	0.13	<b>0.33</b>
BarrierSkills	SkillsNeed	0.11	0.03	0.03	0.14	<b>0.36</b>
SkillBarrier Inno	SkillsNeed	0.09	0.06	0.03	0.15	<b>0.40</b>

By analysing the cross-loads, we observe that each manifest variable properly reflects the latent factor to which it was assigned. The loadings are shown to emphasise that the manifest variables were selected correctly, taking the most significant coefficients for the latent factors they define.

**Table no. 4. Results of the inner model – path coefficients**

	SIZE	GROWTH	BusinessEnviron	DIGITALISATION	SkillsNeed
<b>SIZE</b>	0	0	0	0	0
<b>GROWTH</b>	0	0	0	0	0
<b>BusinessEnviron</b>	0	0	0	0	0
<b>DIGITALISATION</b>	0.317	0.168	-0.067	0	0
<b>SkillsNeed</b>	0	0	0.368	0.087	0

The estimated coefficients show that a weak business environment translated by poor overall strength, access to finance, quality of support services, or collaboration with business partners, educational institutions, or research organisations has a negative impact on companies' capacity to adopt advanced digital technologies and intensifies the lack of skills. A positive impact on digitalisation is attributed to the size and growth capacity of the company. The latent factor Digitalisation augments the problems associated with the lack of availability of staff with the matched skills. According to the metrics calculated to assess the prediction ability of the model, only 4.4% of the latent variability of the SkillsNeed construct is explained by digitalisation and the strength of the business environment.

**Table no. 5. Validation results with bootstrap**

	Estimate	Std.Error	perc.025	perc.975
SIZE → DIGITALISATION	0.317	0.01	0.297	0.337
GROWTH → DIGITALISATION	0.168	0.012	0.146	0.191
BusinessEnviron → DIGITALISATION	-0.067	0.011	-0.089	-0.044
BusinessEnviron → SkillsNeed	0.368	0.017	0.34	0.401
DIGITALISATION → SkillsNeed	0.087	0.021	0.045	0.128

The validation results obtained with bootstrap show that the 95% confidence intervals of our path coefficients do not contain zero. Thus, we can confirm that these coefficients are significant. The results confirm previous findings regarding the influence of company characteristics on their adoption behaviour of digital technologies, particularly regarding the firms' size and growth capacity (Koch, Manuylov and Smolka, 2021; Cedefop, 2022). These findings have implications for firms' decision to invest in skills development, including employees' digital skills, which is essential as they simultaneously strengthen their technological and innovation capabilities (Song, Tao and Shen, 2022). In addition, the obtained results complement the existing literature regarding the role of the business environment that can support the dual green and digital transition in companies through increased access to finance, quality support services, and supporting collaborative relationships.

Furthermore, the results of the SEM model support the thesis that the adoption of digital technologies generates changes in the content of tasks, inducing significant transformations in the skills required in the workplace (Cedefop, 2022). Hence, companies that adopt digital technologies to a greater extent are affected more by skills deficits and gaps, which are also fuelled by deficiencies in the business environment.

### **Conclusions**

The research presented within this paper assumes that the adoption of technologies is a key driver for the green and digital transition. The estimated model provides evidence supporting the thesis that digital technologies generate transformations in the content of job-specific tasks, reflected in skills shortages at the company level. These results are relevant for developing policies and programmes to support companies engaged in the green and digital transition. Therefore, increased access to financing, quality support services, and collaborative networks will support companies to accelerate digital technology adoption. In addition, recognising the critical role of updating and developing workforce skills to generate and adapt to change, public policies must take into account that the green and digital transition also involves a skills transition. Based on these findings, upskilling and continuous learning provided to employees become essential for companies embracing new digital technologies.

Our study is valuable in complementing the existing literature by bringing findings from microeconomic analysis (firm level). The results bring empirical contributions regarding the factors that influence companies' decisions to adopt digital technologies. According to our findings, a weak business environment is conducive to skills shortages and does not support digitalisation solutions. And when digitalisation occurs, it intensifies the problems related to skills shortages. Therefore, for companies to implement more digital solutions, their size and growth capacity are determinant, and digitalisation increases skills shortages and skills gaps. Increasing in skills obsolescence and skills needs among companies also put pressure on increasing training provided, which is time-consuming and costly, with high shares of the workforce remaining under-skilled and less capable of adapting to the new challenges of a rapidly evolving labour market.

Furthermore, the changes induced by digitalisation in the labour market have been accelerated during the COVID-19 pandemic and future evolutions are characterised by uncertainty. From this point of view, further research is needed for a better understanding

of the complex inter-relations between the adoption of digital technologies and changes of the skills needs. The central importance of this topic is accentuated by the contributions of new digital technologies to sustainable growth. Workforce planning, continuing training, skills development, and promoting a culture of lifelong learning are essential for a sustainable digital economy, but development also has to find the balance between technical shifts and skills management both at micro- but also at macro levels.

The potential of the PLS-SEM-based methodology in causality testing is demonstrated again in this study, developed on a database that reflects the situation of companies in Europe. Advanced methodological tools specific to this approach, such as moderation and mediation, should also be tested in future studies. At the same time, updating and developing the analysis using recent data sets that reflect the determinants of digitisation and its impact after the pandemic is required to understand the dynamics of the phenomenon.

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