Drivers of Digital Transformation in SMEs

Nessrine Omrani, Nada Rejeb, Adnane Maalaoui, Marina Dabić, and Sascha Kraus

***Abstract*—This study aims to identify and analyze factors determining the adoption of digital technologies in SMEs. Drawing on the technology–organization–environment framework, the study highlights enabling factors from three different contexts and hypothesizes their relationship with digital technology adoption. The data used were collected from 15 346 European Union and non-European Union SMEs to test an ordered logit regression model that highlights the factors associated with an increased level of digital technologies adoption in SMEs. The empirical results show that the technology context (IT infrastructure and digital tools) along with the existing level of innovation are the main drivers that act as stepping stones in digital technology adoption. Corporate regulation, available skills, and financial resources (as organizational variables) also play a significant role in the adoption decision. Unexpectedly, the influence of the environmental context is marginal. The implications of this study are emphasized for theory and practice, laying a foundation for further empirical studies in this field.**

***Managerial relevance statement:* This article reviews the empirical research on digital technologies adoption and examines the drivers of such adoption in SMEs. The factors identified provide guidance for practitioners adopting digital technologies in SMEs, by suggesting they assess the readiness of their firms before investing in digital technology. This research helps advance the conversation on digitalization drivers especially by bringing the discussion into the organization boundaries, as our findings highlight the predominance of organizational drivers over the technological and environmental ones. SMEs have to overcome the challenges associated with constructing an IT infrastructure capable of implementing new technologies. Indeed, while striving to adopt new digital technologies (e.g., AI, big data, IoT), many SMEs are still unprepared. Therefore, rather than adopting mimetic behaviors based on external pressure, SMEs that aim for digitalization should first assess their existing technologies, and further develop a meticulous technological roadmap that includes skills upgrades and investments in upskilling employees' capabilities. Therefore, developing a fully integrated strategic approach is crucial before the adoption of digital technologies**

***Index Terms*—Digital technology adoption, digital transformation, SMEs, TOE model.**

I. Introduction

DIGITAL transformation has disrupted numerous markets putting immense pressure on incumbent SMEs to move toward innovation-driven organizations [70].

Digital transformation has been defined as "the use of new digital technologies, such as mobile, artificial intelligence, cloud, blockchain, and the Internet of Things (IoT) technologies, to enable major business improvements" [1, p.326]. The transition toward digital technologies offers possibilities but also challenges with its corresponding organizational changes [2] and increased systems complexity [3]. A current challenge is that digital transformation involves fundamental transformation in SMEs, which requires specific technological and organizational resources for successful adoption, e.g., knowledge management [4], information processing capability [5], and digital networking [6]. In some instances, companies need to radically change individual mindsets [7], the organizational design [8], and the corporate strategic vision while implementing modern technologies that support new business goals and customers' requirements [9].

Accordingly, academic research on the question of what drives digital technology adoption has increased in recent years. Kammerlander et al. [7] emphasized the importance of the fit between digital technologies and organization members' identity perception; for example, in terms of customer expectations. According to Li et al. [5], organizational mindfulness toward digital transformation is a prerequisite to digital technology transition. Verhoef et al. [6] argued that the strategic imperatives of digital transformation are digital resources (e.g., big data analytics capability), an organizational structure that adapts to digital change and the existence of a digital growth strategy within the company. Other studies emphasize the role of competition, as well as customers' and other stakeholders' pressure in prompting the firm's decision to adopt digital technologies [10], [11].

Despite the important advances in this research area, critical gaps remain in our understanding of digital technology adoption drivers, and it is challenging for managers to make decisions on the potential adoption of digital technologies. In particular, the academic literature on this topic is fragmented, with most studies focusing on a specific category of digital technology

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adoption drivers, i.e., organizational [5], technological [12], or environmental [13]. Other studies focus only on adoption drivers of a specific technology, e.g., artificial intelligence (AI) [14], social media [15], blockchain [12], or big data [16]. While previous research has contributed to advancing knowledge in this field, focusing on a specific category of drivers and/or a specific technology would limit the generalizability of results and prevent academicians from building a theory of digital technology adoption, which is considered a milestone of digital transformation [17].

To fill these gaps, we aim to address three categories of digital technology adoption drivers: organizational, technological, and environmental, as identified by the technology–organization–environment (TOE) framework. Examining various categories of determinants would enable a better understanding of the nature of digital technology adoption drivers and evaluate the weight of each category. The core approach of this framework relies on identifying the effects of internal factors (i.e., technological and organizational) and external environmental factors. The use of an integrative model that combines various drivers and a wide range of digital technologies would contribute to building a theoretical framework on why SMEs adopt digital technologies, and whether distinctive features influence digital technology adoption in SMEs at different levels.

Data collected were used in 2020 from 15 346 SMEs employing one or more persons from the EU27 and additional 12 non-EU countries. The data focus on the triggers and challenges that SMEs in Europe face when growing, transitioning to more digitalization and innovative business models. An ordered logit regression model was used to highlight the factors associated with an increased level of digital technology adoption. The findings emphasize the primacy of the technological and organizational factors. In particular, results underline the opportunities presented through digital tools exposure, firms' innovation level and the existence of corporate regulation enhancing digital technology adoption. Results also uncover the digital technology challenges induced by a shortage of both human skills and financial resources. Unexpectedly, the influence of the external environment is shown to be marginal.

This research contributes to the increasing digital transformation literature by offering an integrative view of which factors directly affect the adoption of digital technologies in SMEs. Specifically, this research provides complementary evidence on how the organizational context is combined and balanced with additional technological and (to a lesser extent) environmental contexts, to drive the digital transformation of SMEs.

As findings point to the role of internal factors (e.g., innovation rate, available skills, and internal regulation), this research points to the need to expand the theoretical basis of digital technology adoption by including theories from other fields (e.g., the resource-based view and the dynamic capabilities approach and organizational identity field), in addition to technology-based theories. In practice, most SMEs are still at an early stage of adopting advanced digital technologies as they often do not have the resources and capabilities to invest in recent technologies and need to be very efficient in allocating their financial resources [18], [19]. While the resource argument holds in the context of SMEs, other barriers should be considered by academicians and policymakers. This research has practical implications for managers in strengthening technological resources and IT infrastructure, employees' digital skills, innovation level, and corporate regulation in order to enhance firms' digital transformation.

The rest of this article is organized as follows. Section II presents the literature review and the hypotheses. Section III describes the research methodology, the data, and the model used. Section IV presents the results. Section V discusses the main findings. Finally, Section VI concludes this article.

II. Litterature Review

A. Theoretical Background

Technology adoption has been theorized at different levels of analysis (individual, organizational, and interorganizational). The technology acceptance model [20], the unified theory of acceptance and use of technology [21], and the theory of planned behavior [22] theorized the acceptance of information technology at the individual level. The diffusion of innovation theory focuses on both individual and organizational determinants of technology adoption. Organizational aspects include: characteristics of organizational structure, communication processes, and internal resources [23]. According to these theoretical frameworks, the technology adoption behavior is determined by the performance expectancy (perceived usefulness), effort expectancy (ease of use), and social influence. From a different perspective, the institutional theory emphasizes the role of the external environment in shaping technology adoption behavior [24]. According to the institutional theory, the adoption process is greatly affected by normative institutional pressures [13], i.e., political and social sources [25], [26], including interaction with customers, competitors, trading partners, and governments, which can potentially affect a firm's decision to adopt digital technologies.

The literature review reveals a number of studies that focused on a specific category of factors driving organization adoption behavior. Kammerlander et al. [7] examined the fit between digital technologies and organizational identity as perceived by firm members, as organizational identity might be challenged (or enhanced) by the adoption of disruptive innovation. Digital technology adoption might be contradicted, for example, by customers being conservative with regard to digitalization. According to the authors, innovation adoption is likely to occur when corresponding adaptations do not contradict their domain identity (the value delivered to customers) nor their role in the industry (leaders versus followers). Moreover, Li et al. [5] argued that organizational mindfulness (the ability of companies to capture and respond to emerging threats) raises the ability of companies to effectively deploy their organizational resources to better implement digital technologies. Verhoef et al. [6] examined the prerequisite for the digitalization of companies. They underline a number of factors: the existence of specific capabilities (digital agility and digital networking capability) and resources (digital assets), flexible and agile organizational structures that allow adaptation to change, and the use of digital platforms

as a digital growth strategy. The importance of adaptation has been emphasized in innovation literature (e.g., [27]). From the same perspective, recent studies examined the organizational readiness for technology adoption defined by the degree to which an organization is ready to digitally transform the current organization [28]. Nguyen et al. [28] conceptualize readiness for technology adoption at three levels: assets, capabilities, and commitment (organizations' support for innovation initiatives). Jöhnk et al. [29] identified five AI readiness factors (strategic alignment, resources, knowledge, culture, and data). From a different perspective, previous research also shows that digital technology adoption can be driven by customer needs (improved customer service, new product offerings, tailored services, and better management of customer relationships) [2]. Some firms also use digital technologies to communicate a positive image of the firm being digital and innovative [11]. Also, suppliers as (potential) partners might be a driver for digital technology adoption. In the supply chain literature, existing research shows that firms are incited to adopt digital technologies implemented by other supply chain partners in order to optimize their operations and improve their communication [30]. Moreover, digital technologies offer the potential to help firms significantly outperform competitors by reducing their costs (e.g., reduced paperwork and error rates), optimizing their business models, improving their marketing efforts, human resource management [10], and increasing their collaboration with geographically distributed manufacturing entities [31]. As an illustration of competition pressure, Hänninen et al. [32] showed that multisided platforms are affecting the retail sector in a way that makes traditional retailers struggle to compete against this new form of business and remain relevant amidst this new digital competition.

Although this body of research has considerably improved our understanding of digital technology adoption drivers, it does not provide a full picture of the phenomena. Most works focus on either organizational, technological, or environmental factors. To overcome the subsequent fragmentation of the literature in this field, the TOE framework could be useful. The TOE model proposed by Tornatzky et al. [33] has been recognized to have superior strength over other models of technology adoption [19], [34] as it offers an integrative view of digital technology adoption drivers and allows a comparison between different categories of drivers, i.e., whether these factors affect digital technology adoption at the same level.

The TOE framework has recently been used in the context of a specific digital technology. For example, Abed [15] examined the factors that affect the intention of SMEs to use social commerce (social media and e-commerce applications) and found that the environmental context (the effect of consumer pressure and the effect of trading partners' pressure) had the most significant influence on the intention to use social commerce by SMEs, compared with organizational and technological factors. Sun et al. [35] found that the technological context (technological resources and competence) is the most influencing factor in an organization's adoption of big data. From the same perspective, El-Haddadeh et al. [16] found that technological drivers (technology perceived benefits and technology complexity) directly enhance the adoption of big data for the realization of social goals, whereas organizational and environmental factors have an indirect effect by increasing top management support for technology adoption. Based on a conceptual framework, Yang et al. [11] stated that technological intelligence (the degree of intelligence of digital technology) and supply chain cooperation are two important factors of digital technologies for supply chain management. Chen et al. [14] underlined different aspects of AI adoption that are related to AI attributes (e.g., compatibility and complexity), organizational capabilities (e.g., managerial support), as well as external environment (e.g., competitive pressure and market uncertainty). According to Liang et al. [12], the intention to adopt blockchain technology is shaped by functional and symbolic benefits, which are influenced by an existing fit between technology and environment, on the one hand, and technology and task, on the other hand. Mittal et al. [36] reviewed smart manufacturing (SM) and Industry 4.0 maturity models and investigated the triggers of SM adoption in SMEs (including the use of digital threads and big data). Research shows that the adoption of SM/Industry 4.0 depends on organizational cultural mindset change reflecting the willingness of the firm to pursue the shift toward Industry 4.0.

While combing different categories of factors to explain digital technology adoption, these studies focus on a specific technology making the generalizability of results difficult. Our study aims to fill this research gap by examining different drivers and the adoption of a wide array of digital technologies by SMEs.

In the following section, the impact of the environmental, organizational and technological contexts on the adoption of digital technologies in SMEs was hypothesized.

B. Hypotheses Development

1) Business Environment and Digital Technology Adoption: The environmental context consisting of the arena where a firm conducts its business is expected to affect the organizational decision to adopt technology innovation. The role of the external environment has been highlighted in previous research in the innovation literature [37] arguing that environmental changes, coupled with environmental uncertainty, challenge traditional business models and are critical triggers of innovation [69]. The business environment refers to external pressures and/or support for adoption, such as industry characteristics, market structure, competition [11], government regulation [13], and business infrastructure [12]. This dimension refers to the paradigmatic changes triggered by disruptive digital competitors and technologies, and changing consumer behavior [1], [38].

Collaboration with business partners is an argument cited in the literature on technology adoption. Coping with technological advances and keeping close cooperation with external partners are the main external drivers for many firms adopting digital technologies [39]. When a core player decides to use a particular digital system, other partners usually face the pressure of adapting to that system [40]. Another external driver comes from competition [6], [10]. Adopting digital technologies is regarded as an approach to enhancing firms' competitiveness. Indeed, most firms tend to adopt digital technology if they see competitors adopting it, as they believe that it is the orientation of the whole

industry [10]. Many firms have been exploring how to use faster, more accurate digital management systems to facilitate lean and agile activities and stay competitive [11]. Relatedly, previous studies show that the regulatory environment at the national level can promote the development of digital technologies as entire industries, e.g., big data [35] and AI industries [14]. From this point of view, continued government support encourages firms to embrace new digital technologies.

The following is hypothesized.

Hypothesis 1: External resources available to SMEs within the business environment triggers their organizational decision to adopt digital technologies.

2) Organizational Factors and Digital Technology Adoption: The organizational context refers to the internal characteristics and resources of the firm. It is defined as formal and informal resources that reinforce the adoption of technologies, such as top management support [14], human skills and competencies [11], [41], and financial resources [29].

Digital technology adoption has strategic and operational drivers [42]. Many SMEs are actively developing digital strategies as part of their core business orientation. They believe that adopting digital technologies has the potential to trigger both incremental and disruptive innovation [11]. The adoption of digital technologies is also largely driven by internal operational problems. In particular, there is a greater need for firms to gain new business insights, unravel strategic information [2], communicate with internal and external stakeholders [43], and cut down operational costs [36].

Moreover, in order to achieve beneficial digital adoption, digital transformation requires specific organizational resources [1], [7]. Technological competencies, digital resources, support from top management, and organizational structure have been shown to influence an organization's decision to adopt digital technologies [6] and [35]. Van Zeebroeck et al. [44] observed a strong positive association between the scope of strategy change and the stage of digital technologies adoption, suggesting the existence of a link between technological structure and strategy. Besides, management support is a critical determinant of digital technology adoption. Supportive attitude and policies, allocation of financial resources [45], the existence of a strategic roadmap for digitalization processes are critical to the adoption decision. Relatedly, the adoption process usually involves changes in business tasks and processes, which might cause internal resistance. Indeed, Warner and Wäger [1] argued that rigid strategic plans, a high level of centralization and resistance to change are important internal barriers to digital transformation. Also, management support for digital security and privacy is shown to be an influential organizational factor for a firm's digital technology adoption [46].

Recently, capability building for digital transformation has received growing scholarly attention [1]. Dynamic capabilities are innovation-based and provide the capacity to create, extend, and modify a firm's resource base [47]. In particular, it has been reported that firms need to build strong dynamic capabilities to rapidly create, implement, and transform their business models to remain relevant in the emergent digital economy [48], [49]. In this perspective, digital technology adoption challenges may result from a shortage of employees and management skills [50].

In addition, regulation at the organizational level is recognized as a determinant of digital technology adoption. For example, corporate social responsibility is considered a form of corporate self-regulation that integrates into the firm's existing business models [46]. According to Ghobakhloo [46], corporate social responsibility policy ensures the firm's preservation of ethics and social norms, and clarifies the firm's relationships with its stakeholders (customers, business partners, local and global communities, etc.). Top management support plays a key role in facilitating value creation from digital technology adoption for the realization of sustainable development goals (SDGs) [16]. Some firms adopt digital technologies as part of their sustainability strategy. For example, firms utilize digital technologies (e.g., big data) to help them implement SDGs and monitor their progress [16].

Finally, an organizational context that supports innovation and fosters change is expected to enhance new technology adoption. Top and middle management can encourage innovations that further the firm's core mission and vision [51]. Their role in promoting innovation includes communication about the importance of innovation and its role within the firm's overall strategy as well as rewarding innovation behavior among subordinates.

Hypothesis 2: The availability of internal resources enhances the firm's decision to adopt digital technologies.

Hypothesis 3: The level of innovation introduced is positively associated with the adoption of digital technologies.

3) Technological Factors and Digital Technology Adoption: The technological context refers to current practices and equipment internal to the firm, as well as the set of available technologies external to the firm [24], [52]. The digital transformation offers additional relevant technologies, such as big data, blockchain, AI, machine learning, cloud computing, or social media applications.

The adoption of digital technologies depends on their perceived benefits/value. Firms adopt new information technology only if they perceive that the new technology can bring business opportunities or overcome existing deficiencies [35], [53]. According to Oliveira et al. [54], when the benefits of the technology exceed existing practices and processes, the adoption of the technology (cloud computing) is likely to occur. The perceived value of the new technology also depends on technology complexity, compatibility of the technology with the organizational previous practice [53], [55], and technology trialability, i.e., the ability to experiment with the performance of the new technology [12], [56]. At the adoption stage, perceived benefits relate to the experienced advantages and the value that have been delivered to the organization by already implemented digital technologies [57].

In addition to perceived potential advantages, the existence of an IT infrastructure and preexisting digital technology exposure are two important drivers of digital technology adoption and digital transformation [5], [16], [50]. In this perspective, cybersecurity maturity and digitalization maturity are recognized to influence the decision of SMEs to adopt digital technologies

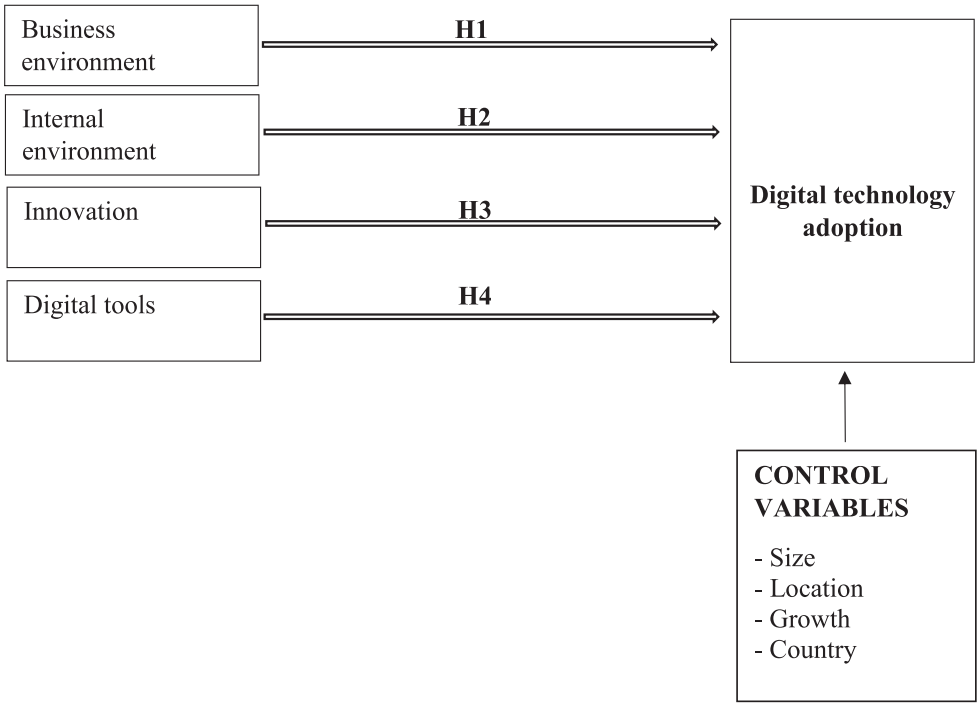

Fig. 1. Conceptual model.

[46]. Digital maturity refers to "a firm's capability to purposefully leverage digital technologies, channels, and skills in support of transforming its processes, talent engagement, and production models" [46], p. 2392). Digital maturity enables firms to effectively benefit from digital technologies in order to reshape their organization's business models. Similarly, an integrated cybersecurity system that ensures the security, safety, and reliability of communications is indispensable and helps increase the perceived value of digital technology adoption [58]. In a similar perspective, Neumeyer et al. [59] highlighted the relevant role of technology literacy to foster technology adoption for entrepreneurship and innovation.

Overall, to achieve their full potential, digital technologies need a high level of related technology resources. SMEs with more extensive technology resources can provide a facilitating platform that smooths the adoption of new technology innovation. Technology resources refer to the existing level of IT infrastructure available to firms, such as computer hardware, software, and linkages [60]. Technology resources also include human IT resources and IT-enabled intangibles [61], which shape the speed of adoption by allowing firms to quickly reconfigure or implement the new digital technology resources [5].

Thus, the following hypothesis is proposed.

Hypothesis 4: The level of existing digital tools is positively linked to digital technology adoption.

In Fig. 1, our conceptual developments are summarized as follows. The business environment represents external triggers, including business infrastructure, availability of external resources, and access to collaboration partners, which enhance the adoption of digital technologies. The model also specifies two core categories of enablers—organizational environment (including organization internal resources, skills, corporate regulation, and innovation level) and technological resources that refer to the level of digital tools and IT infrastructure available within the firm.

III. Methodology

A. Data Collection

To test our research hypotheses, a dataset collected in Europe, namely the Eurobarometer 486, was used. The survey was conducted in the EU27 and an additional 12 non-EU countries, and focuses on the barriers and challenges that SMEs in Europe face when growing, transitioning to more digitization. The survey collected responses from 15 346 telephone interviews with SMEs employing one or more persons between February 19 and May 5, 2020.

B. Variables

1) Dependent Variable: The level of digital adoption is the dependent variable. In the Eurobarometer 486, individuals were asked, using a four-point Likert scale, about their firm's approach to digital technologies. The variable equals 3 if the firm adopts advanced technologies, 2 if it adopts basic technologies, 1 if there are difficulties to adopt digital technologies, and 0 if no digital technologies are adopted. Table I tabulates the dependent variable.

2) Independent Variables: Independent variables in our model are related to internal challenges the firm can face (financial, regulatory, innovation, access to data, payment delays, skills, etc.), the level of innovation, the business environment, and the availability of digital tools.

TABLE I
DEPENDENT VARIABLE

Variable	Description
Dependent variable	
Digital Adoption	Equals 3 if the enterprise adopts advanced technologies, 2 if it adopts basic technologies, 1 if there is difficulty to adopt digital technologies, and 0 if no digital technologies are adopted.

Business environment: Respondents were asked to rate the business environment according to the overall strength and performance of the regional business environment, access to private and public finance, quality of support services provided by private and public actors, access to and collaboration with business partners (including other firms, public sector, educational institutions, and research organizations), availability of staff with the needed skills (including managerial skills), legal and administrative environment, and infrastructure for business, such as available office space and Internet connectivity.

Organizational environment: Respondents were asked about internal barriers to digitalization that the firms can face: the measurement items relate to innovation, regulatory obstacles or administrative burden, access to data, internationalization, access to finance, payment delays, skills including managerial skills, and difficulties with digitalization. The respondents were asked to indicate up to three key areas which represent the biggest problems for the firm.

Availability of digital tools. Respondents were asked to specify the digital technologies adopted to date: AI (e.g., machine learning or technologies identifying objects or persons), cloud computing (i.e., storing and processing files or data on remote servers hosted on the internet), robotics (i.e., robots used to automate processes, for example, in construction or design, etc.), smart devices (e.g., smart sensors, smart thermostats, etc.), big data analytics (e.g., data mining and predictive analysis), high-speed infrastructure, and blockchain.

Innovation: Respondents were asked if the firm had introduced an innovation during the past 12 months. The variable equals 1 if yes, and 0, otherwise. The innovation adopted can be: a new or significantly improved product or service to the market, a new or significantly improved production process or method, a new organization of management or a new business model, a new way of selling the goods or services, an innovation with an environmental benefit, including innovations with energy or resource efficiency benefit, and social innovation, such as new products, services or processes that aim to improve society or any other type of innovation.

3) Control Variables: The firm's size, growth, location, and country were controlled, as they have been shown to have an influence on firm innovation in previous literature (e.g., [62]). The firm's size is measured as follows: very small firm if less than ten employees (60.24% of the sample), small firm if the number of employees is between ten and 49 (21.17%), medium firm if the number of employees is between 50 and 249 (14.41%), and big firm if the size is more than 249 (4.18%). The firm's growth is measured by the increase in the number of employees and turnover since 2016. The variable growth_employees takes the value 0 if the number of employees has decreased, 1 if the number of employees remains stable, 2 if it has grown by less than 30%, and 3 if it has grown by at least 30%. The variable growth_turnover takes the value 0 if the turnover has decreased, 1 if the turnover remains stable, 2 if it has grown by less than 30%, and 3 if it has grown by at least 30%. A set of mutually exclusive binary variables are used for a geographic area: large town/small town and rural area/industrial area.

Tables II and III provide, respectively, a summary of the independent variables used in the model and the descriptive statistics of dependent and independent variables.

C. Model

The data analysis has followed different stages. A descriptive analysis and a univariate analysis were performed to explore the sample profile, and then multivariate analysis techniques and ordered logit regression were applied to address the research questions.

The steps involved in data analyses using Stata Software are introduced in the following.

1) Ordered Logit Model: Because the dependent variable is ordered (no adoption, difficulty to adopt, adoption of basic technologies, and adoption of advanced technologies), an ordered logit regression was used to estimate the following models:

$$Y_i = \text{Business}_i\ \beta_1 + \ \varepsilon_i \tag{1}$$

where Y_i is the level of digital adoption of firm *i*, Business_i indicates the rating of the business environment, β is the vector of coefficients, and ε_i is a normally distributed random error term.

$$Y_i = \text{Internal}_i\ \beta_1 + \ \varepsilon_i \tag{2}$$

where Y_i is the level of digital adoption of firm *i*, Internal_i indicates the areas that pose problems for the enterprise, β is the vector of coefficients, and ε_i is a normally distributed random error term.

$$Y_i = \text{Innovation}_i\ \beta_1 + \ \varepsilon_i \tag{3}$$

TABLE II
DESCRIPTIONS OF INDEPENDENT VARIABLES

Variable	Description
Business environment	Rating the business environment according to eight measures.
Internal environment	Eight key areas that pose the biggest problems for the enterprise.
Innovation	The introduction of an innovation during the past 12 months according to six types of innovation.
Digital tools	Type of digital technologies adopted.
Control variables	
Size	The size of the firm, three dummy variables.
Location	Four dummy variables: large town or a small town, in a rural or an industrial area.
Growth	The growth of the number of employees and turnover since 2016. The variable growth_employees takes the values from 0 to 2.
Country	In total, 39 dummy variables referring to the 27 European Union countries and additional 12 non-EU countries and territories

where Y_i is the level of digital adoption of firm *i*, Innovation_i indicates the type of innovation introduced during the last year, β is the vector of coefficients, and ε_i is a normally distributed random error term.

$$Y_i = \text{Tools}_i\ \beta_1 + \ \varepsilon_i \tag{4}$$

where Y_i is the level of digital adoption of firm *i*, Tools_i indicates the type of digital technologies adoption, β is the vector of coefficients, and ε_i is a normally distributed random error term.

$$Y_i = \text{Business}_i\ \beta_1 + \text{Internal}_i\beta_2 + \text{Innovation}_i\beta_3 + \text{Tools}_i\beta_4 + \ \varepsilon_i \tag{5}$$

where Y_i is the level of digital adoption of firm *i,* Business_i indicates the rating of the business environment, Internal_i indicates the areas that pose problems for the enterprise, Innovation_i indicates the type of innovation introduced during the last year, Tools_i indicates the type of digital technologies adoption, β is the vector of coefficients, and ε_i is a normally distributed random error term.

$$Y_i = \text{Business}_i\ \beta_1 + \text{Internal}_i\beta_2 + \text{Innovation}_i\beta_3 + \text{Tools}_i\beta_4 + X_i\beta_5 + \varepsilon_i \tag{6}$$

where Y_i is the level of digital adoption of firm *i*, Business_i indicates the rating of the business environment, Internal_i indicates the areas that pose problems for the enterprise, Innovation_i indicates the type of innovation introduced during the last year, Tools_i indicates the type of digital technologies adoption, X_i is a vector containing the values of the size, the location, and the growth of the firm, β is the vector of coefficients, and ε_i is a normally distributed random error term.

$$Y_i = \text{Business}_i\ \beta_1 + \text{Internal}_i\beta_2 + \text{Innovation}_i\beta_3 + \text{Tools}_i\beta_4 + Z_i\beta_5 + \varepsilon_i \tag{7}$$

where Y_i is the level of digital adoption of firm *i*, Business_i indicates the rating of the business environment, Internal_i indicates the areas that pose problems for the enterprise, Innovation_i indicates the type of innovation introduced during the last year, Tools_i indicates the type of digital technologies adoption, Z_i is a vector containing the values of the size, the location, the growth, and the country of the firm, β is the vector of coefficients, and ε_i is a normally distributed random error term.

IV. RESULTS

The results of the logistic regressions are reported in Table IV. Because cross-sectional data were relied upon, it was not possible to account for endogeneity among the variables and the links between variables are correlational. The relationship between variables is explained instead of causality. To ensure the robustness of our results, seven model specifications were performed, showing the results in blocks. The largest VIF ranged from 1.01 to 2.02, and the average VIF ranged from 1.01 to 1.56. Since none of the VIF values exceeds 10 and none of the average VIF exceeds 6, it was concluded that there was no multi-collinearity problem.

TABLE III
DESCRIPTIVE STATISTICS

Type of variable	Description	Mean	Std dev.	Min.	Max.
Dependent variables					
Digital Adoption		1.732	1.053	0	3
Independent variables					
Business environment	All	2.004	.693	0	3
	Finance	1.781	.796	0	3
	Support	1.767	.745	0	3
	Partners	1.976	.694	0	3
	Skills	1.684	.859	0	3
	Sustainability	1.599	.811	0	3
	Legal	1.873	.757	0	3
	Infrastructure	2.216	.695	0	3
Internal environment	Innovation issue	.099	.299	0	1
	Regulation	.467	.498	0	1
	Data Access	.068	.252	0	1
	Internationalization	.078	.268	0	1
	Finance	.188	.390	0	1
	Payment issue	.325	.468	0	1
	Skills	.214	.410	0	1
	Digitalization issue	.111	.315	0	1
Innovation		.615	.486	0	1
Digital tools	AI	.076	.265	0	1
	Cloud	.478	.499	0	1
	Robotics	.085	.279	0	1
	Smart	.277	.448	0	1
	Big Data	.144	.351	0	1
	Infrastructure	.337	.472	0	1
	Blockchain	.033	.178	0	1
Size		.625	.879	0	3
Location	Large town	.491	.499	0	1
	Small town	.356	.479	0	1
	Rural	.102	.303	0	1
	Industrial	.128	.334	0	1
Growth	Employees	1.567	.855	0	3
	Turnover	1.581	.983	0	3

The first model gives results using the business environment as the only independent variable. The second model introduces internal environment variables measures. In the third model, the link of digital adoption with the innovation variable was measured. In the fourth model, digital tools available are included. In the fifth model, all the variables of interest are tested. In the sixth model, the control variables are added, and in the last model, the country is added. Empirical findings from these models show substantial robustness across the seven performed model specifications.

According to Table IV, Model (1) shows that regarding the business environment, finance ($\beta = .076, z = 3.59; p < .01$), partners ($\beta = .049, z = 2.10; p < .05$), skills ($\beta = -.047, z = -2.55; p < .05$), and infrastructure ($\beta = .122, z = 5.47; p < .01$)

TABLE IV
DIGITAL ADOPTION—ORDERED LOGISTIC REGRESSION RESULTS

	(1) Digital Adoption		(2) Digital Adoption		(3) Digital Adoption		(4) Digital Adoption		(5) Digital Adoption		(6) Digital Adoption		(7) Digital Adoption	
Business Environment														
All	0.039	(0.024)							-0.029	(0.025)	-0.042*	(0.025)	-0.034	(0.026)
Finance	0.077***	(0.021)							0.006	(0.022)	-0.002	(0.023)	0.016	(0.023)
Support	0.020	(0.024)							0.021	(0.025)	0.019	(0.025)	0.027	(0.025)
Partners	0.049**	(0.023)							0.025	(0.024)	0.021	(0.024)	0.002	(0.025)
Skills	-0.048**	(0.019)							-0.029	(0.020)	-0.032	(0.020)	-0.000	(0.021)
Sustainable	0.050**	(0.022)							0.018	(0.023)	0.015	(0.023)	0.022	(0.023)
Legal	0.005	(0.023)							0.006	(0.024)	0.006	(0.024)	-0.009	(0.025)
Infrastructure	0.123***	(0.022)							0.068***	(0.023)	0.064***	(0.023)	0.044*	(0.024)
Internal Environment														
Innovation issue			0.027	(0.048)					-0.066	(0.048)	-0.074	(0.048)	-0.003	(0.049)
Regulation			0.168***	(0.029)					0.084***	(0.031)	0.076**	(0.031)	0.086***	(0.032)
Data access			0.078	(0.061)					-0.102	(0.063)	-0.104*	(0.063)	-0.078	(0.064)
Internationalization.			0.219***	(0.057)					0.044	(0.057)	0.040	(0.058)	0.078	(0.058)
Finance			-0.215***	(0.036)					-0.189***	(0.039)	-0.182***	(0.039)	-0.095**	(0.040)
Payment issue			-0.045	(0.031)					-0.029	(0.032)	-0.023	(0.032)	-0.017	(0.032)
Skills			0.209***	(0.037)					0.067*	(0.039)	0.049	(0.039)	0.084**	(0.041)
Digitalization issue			-0.002	(0.045)					0.007	(0.046)	-0.001	(0.047)	0.009	(0.047)
Innovation					0.576***	(0.029)			0.296***	(0.031)	0.282***	(0.031)	0.302***	(0.032)
Digital tools														
AI							0.489***	(0.071)	0.463***	(0.071)	0.457***	(0.071)	0.466***	(0.072)
Cloud							0.511***	(0.032)	0.468***	(0.032)	0.453***	(0.032)	0.441***	(0.033)
Robotics							0.454***	(0.065)	0.399***	(0.066)	0.335***	(0.066)	0.320***	(0.067)
Smart							0.315***	(0.037)	0.271***	(0.037)	0.251***	(0.038)	0.267***	(0.038)
Big Data							0.498***	(0.052)	0.461***	(0.052)	0.420***	(0.053)	0.468***	(0.054)
Infrastructure							0.400***	(0.035)	0.372***	(0.035)	0.368***	(0.035)	0.390***	(0.037)
Blockchain							0.235**	(0.098)	0.225**	(0.097)	0.223**	(0.098)	0.240**	(0.099)
Size											0.126***	(0.019)	0.129***	(0.019)
Growth														
Employees											0.003	(0.018)	0.001	(0.019)
Turnover											0.043**	(0.017)	0.036**	(0.017)
Location														
Small town											*Ref.*		*Ref.*	
Large town											0.029	(0.030)	0.088***	(0.032)
Rural											*Ref.*		*Ref.*	
Industrial											0.011	(0.048)	0.028	(0.049)
Country														
France													*Ref.*	
Belgium													-0.107	(0.126)
Netherlands													0.260**	(0.125)
Germany													0.147	(0.132)
Italy													0.488***	(0.114)
Luxembourg													0.030	(0.184)
Denmark													-0.408***	(0.148)
Ireland													-0.339**	(0.134)
UK													-0.201	(0.137)
Greece													-0.273**	(0.118)
Spain													-0.347***	(0.134)
Portugal													0.009	(0.135)
Finland													0.541***	(0.129)
Sweden													0.389***	(0.131)
Austria													0.169	(0.125)
Cyprus													-0.229	(0.161)
Czech Republic													-0.491***	(0.138)
Estonia													0.300***	(0.109)
Hungary													0.143	(0.132)
Latvia													-0.343***	(0.124)
Lithuania													-0.139	(0.127)
Malta													0.254	(0.164)
Poland													0.069	(0.125)
Slovakia													-0.131	(0.128)
Slovenia													0.215*	(0.129)
Bulgaria													-0.202*	(0.121)
Romania													-0.505***	(0.128)
Turkey													-0.125	(0.131)
Croatia													0.207*	(0.123)
Makedonia													-0.113	(0.147)
Serbia													0.327***	(0.122)
Norway													0.507***	(0.152)
Iceland													0.180	(0.166)
Japan													-0.245*	(0.131)
USA													-0.408***	(0.138)
Brazil													-0.767***	(0.144)
Bosnia and Herzegovina													0.278**	(0.132)
Kosovo													-0.159	(0.125)
Canada													-0.468***	(0.137)
cut1 _cons	-0.905***	(0.066)	-1.435***	(0.033)	-1.184***	(0.028)	-1.001***	(0.025)	-0.702***	(0.079)	-0.651***	(0.082)	-0.618***	(0.123)
cut2 _cons	0.070	(0.066)	-0.462***	(0.028)	-0.206***	(0.024)	0.000	(0.022)	0.304***	(0.077)	0.356***	(0.081)	0.412***	(0.122)
cut3 _cons	1.589***	(0.068)	1.055***	(0.028)	1.323***	(0.025)	1.624***	(0.025)	1.939***	(0.078)	1.994***	(0.082)	2.079***	(0.123)
N	15346		15346		15346		15346		15346		15346		15346	

Standard errors in parentheses
* p<.10, ** p<.05, *** p<.01

have significant link with digital adoption meaning that business environment is linked to digital adoption. Model (2) reveals significant links of regulation ($\beta = .168, z = 5.73; p < .01$), internationalization ($\beta = .219, z = 3.82; p < .01$), finance ($\beta = -.214$, $z = -5.93; p < .01$), and skills ($\beta = .208, z = 5.71; p < .01$) with digital adoption reflecting that some internal factors are linked to digital adoption. Model (3) indicates a significant link between innovation and digital adoption. Model (4) reveals a significant link between all the digital tools and digital adoption.

Model (7) shows that, concerning the impact of the business environment context, only business infrastructure has a positive and significant predictive power of digital adoption ($\beta = .043$,

$z = 1.82$; $p < .1$); meaning that the business infrastructure is the most relevant external trigger of the adoption decision. As far as the internal environment is concerned, the regression model results show that corporate regulation ($\beta = .086$, $z = 2.66$; $p < .01$) and human skills ($\beta = .084$, $z = 2.08$; $p < .05$) have positive and significant links with digital adoption, emphasizing that firms adopting the most advanced digital technologies have a high level of skills to deal with new technologies, as well as internal laws/norms that enhance new digital technology adoption. Financial difficulties are negatively linked to the dependent variable adoption ($\beta = -.095$, $z = -2.40$; $p < .05$) meaning that the lack of financial resources is one of the most important barriers to the adoption decision. The innovation level is positively linked to digital technology adoption ($\beta = .302$, $z = 9.45$; $p < .01$), showing that firms adopting digital technologies are those who have the highest rates of innovation. Finally, digital tools are positively linked to the dependent variable adoption: AI ($\beta = .466$, $z = 6.47$; $p < .01$), cloud ($\beta = .440$, $z = 13.27$; $p < .01$), robotics ($\beta = .319$, $z = 4.76$; $p < .01$), smart ($\beta = .266$, $z = 6.94$; $p < .01$), big data ($\beta = .467$, $z = 8.61$; $p < .01$), infrastructure ($\beta = .389$, $z = 10.40$; $p < .01$), and blockchain ($\beta = .240$, $z = 2.43$; $p < .05$). This result shows that firms who are familiar with digital tools are more likely to adopt recent digital technologies. In particular, technology infrastructure, as a technology resource, has been shown in our findings to be an important driver of digital technology adoption. Digital technology infrastructure aims to secure the firm's information, ensure higher data processing capacity, and enable a superior overall technology that is appropriate for the firm's business [63]. At a strategic level, digital technology infrastructure includes the existence of policies that secure the integration of digital technologies throughout the organization [46].

Taken together, the results of this study demonstrate that digital technology adoption is predominantly shaped by two contexts: the technological and the organizational. The environmental context is shown to have little influence on the adoption decision.

With regard to the firm size, results show a positive and significant link. This result corroborates studies arguing that larger firms are more likely to adopt technology innovation because they have more resources and capabilities to support the digital technologies adoption process [64]. Larger companies can absorb risks and initial costs [65], [66], and tend to be innovators in technology [67]. Results also indicate that digital technologies have more potential to be adopted by firms who are located in a large town (as compared with those in a small town), and by those who have the greatest turnover. Finally, it was found that, in comparison to the reference *country* – France, firms operating in The Netherlands, Italy, Finland, Sweden, Estonia, Croatia, Serbia, Norway, and Bosnia and Herzegovina adopt more advanced digital technologies, whereas individuals living in Denmark, Ireland, Greece, Spain, Czech Republic, Latvia, Bulgaria, Romania, Japan, USA, Brazil, and Canada adopt less advanced digital technologies.

V. Discussion

Decisions regarding whether or not to adopt digital technologies are of strategic importance to SMEs' growth and survival. Our paper aims to offer an integrative view of what factors directly affect the adoption of digital technologies in SMEs while considering a wide range of technologies.

Our findings show that digital technology adoption is prominently driven by internal factors. Indeed, the adoption decision is dependent foremost on the technological context (the existing IT infrastructure and previous digital technology exposure of organization members), followed by the organizational context (i.e., innovation rate, employee skills, corporate regulation, and financial resources). The external environment is shown to have the lowest impact on the level of digital technology adoption. Indeed, only business infrastructure is perceived as a significant driver. No significant evidence was found of the impact of pressure from external partners. This finding is counterintuitive, as previous research underlined the relevance of external partners (e.g., customers and competitors) in the decision to adopt specific digital technologies, e.g., blockchain [12] and social media [15]. One explanation for this divergent result could be that the adoption of certain types of technologies may occur under external pressure, given, for example, data security concerns (e.g., blockchain) or the emergence of disruptive competing business models (e.g., social media commerce).

Furthermore, among organizational drivers, the significant impact of corporate regulation (internal norms and laws) is particularly relevant as this finding is in line with increasing research emphasizing the importance of cultural and identity aspects when adopting digital technologies, e.g., culture of innovativeness [29], role and domain identity (self-image) that makes the organization different from the others in the eyes of its members [7], and a culture of knowledge sharing [36]. Corporate regulation has been associated with corporate social responsibility to the adoption of Industry 4.0 technologies [46], which offer immense opportunities for the realization of sustainable manufacturing. Our findings echo this argument and lend empirical support to corporate regulation as a driver of digital technology adoption. Also, the positive association between employee skills and financial resources, on the one hand, and technology adoption, on the other hand, is supported by previous work highlighting the importance of digital assets [6] and capabilities [1], [14] for firms aiming to transform digitally.

Interestingly, the most significant association among organizational drivers is between the existing level of innovation and digital technology adoption. At a similarly high level is the association between the technological drivers (i.e., existing level of digital tools and IT infrastructure) and digital technology adoption. This result offers relevant insights into the investigated topic. Indeed, this result suggests that the main driver of technology adoption is "organization preparedness" for digitalization. This result aligns with previous studies highlighting the prominence of the technological and organizational aspects in "organization readiness" to digital technology adoption, defined by the degree to which an organization is ready to digitally transform the current organization (e.g., [29], [50], and [68]). This body of research put forward the relevance of available resources and capabilities, knowledge, culture, existing data, and the strategic alignment between technology adoption and the business strategy.

In light of the discussed literature and our findings previously described, it might be the case that companies in specific contexts

may be prompted to adopt digital technologies under external stakeholders' pressure in order to be competitive [12], [15]. This may appear irrational and driven by mimetic behavior. Therefore, previous studies, as well as the results of the current research, refer to the importance of digital technology readiness that depends on technological and organizational factors (see [29] and [50]). As the digital adoption of companies in our sample is driven by organizational and technological aspects, a high degree of digital would be expected readiness for those companies. In order to further advance our understanding of digital technology adoption, it would be interesting to compare the success of the adoption decision in firms having different drivers (for instance external versus internal). This would inform managers about the relevance and the timeliness of their adoption decision. Longitudinal studies would be helpful for this purpose.

A. Implications for Theory

This study makes three contributions to digital transformation literature. First, it contributes to advancing the conversation related to factors that drive the organization's decision to adopt digital technologies. Although previous research has considerably improved our knowledge on this topic, most studies only provide a fragmented picture of the phenomena by focusing either on organizational, technological, or environmental factors. By considering different categories of drivers, it was possible to notice the important weight of internal factors compared with external ones. It was possible to demonstrate that the adoption decision is foremost dependent on the resources and capabilities available within the firm. These findings bring the discussion on digitalization drivers into organization boundaries and open the way for cross-fertilization between technology adoption theories and other organizational theories (e.g., the resource-based view and the dynamic capabilities approach) in order to extend our understanding of the digital transformation process. The need for more theories in the digital technology field is recently underlined by academicians. Indeed, a recent systematic literature review on digital technology adoption reveals that amongst the selected 55 papers, only 22 of them discussed their studies from a theoretical perspective [11]. This gap indicates that more theoretical underpinnings are required in the field. Second, contrary to previous research which has focused on a unique digital technology (e.g., [12] and [35]), a large range of technologies that are increasingly implemented in SMEs (AI, blockchain, cloud, etc.) was targeted. This would allow the generalizability of the results and ultimately the building of a theory of digital technology adoption. Third, quantitative analysis from a large dataset across different EU and non-EU countries was used. Our quantitative large-scale panel dataset allowed us to complement existing qualitative and conceptual work, which is likely to provide a better understanding of the digital technology adoption decision.

B. Practical Implications

Overall, the factors identified provide guidance for practitioners adopting digital technologies in SMEs, by suggesting they assess the readiness of their firms before investing in digital technology. For example, our findings indicate that the potential benefit of a preexisting IT infrastructure for new digital technology adoption has been realized by the participants in this study. SMEs have to overcome the challenges associated with constructing an IT infrastructure capable of implementing new technologies. Indeed, while striving to adopt new digital technologies (e.g., AI, Big data, IoT), many SMEs are still unprepared. Therefore, rather than adopting mimetic behaviors based on external pressure, SMEs that aim for digitalization should first assess their existing technologies, and further develop a meticulous technological roadmap that includes skills upgrades and investments in upskilling employees' capabilities. Therefore, developing a fully integrated strategic approach is crucial before the adoption of digital technologies. Finally, our results highlight the need for firms to help their people embrace the right behaviors and values for working in a digital environment.

In response to these challenges, national and international associations must develop digital technology supportive policies, similar to what the OECD has initiated via the OECD Going Digital Project awareness-raising program[1] to stimulate the digitalization of SMEs. Although the basic level of technology resources, especially IT structure, could be sufficient for many SMEs seeking to adopt recent digital technologies, our findings suggest that firms should continue to build their technological resources and competencies. For this purpose, more employees with digital-related knowledge need to be recruited to facilitate the adoption and implementation of new technologies. Firms should also rise the digital awareness of their employees by communicating values and regulations that enhance the adoption and use of new technologies. Finally, SMEs should be able to find the needed financial resources and prioritize their digital transformation strategies, despite their resource constraints.

VI. Conclusion

Our current understanding of what drives SMEs' digital transformation is limited by the lack of integrative research that covers issues beyond contextual imperatives (i.e., economic, technological, legal, and financial infrastructure). Using a quantitative large-scale panel dataset across different EU and non-EU countries, this study intended to complement the existing qualitative and conceptual works on digital technology adoption drivers. Investigating a variety of categories of drivers allowed us to overcome the fragmented picture provided by previous research that focused on separate aspects of the adoption decision. Our research helps advance the conversation on digitalization drivers especially by bringing the discussion into the organization boundaries, as our findings highlight the predominance of organizational drivers over the technological and environmental ones. The engaged discussion opens the way for cross-fertilization between technology adoption theories and other organizational theories (e.g., the resource-based view and the dynamic capabilities approach) in order to extend our understanding of the digital transformation process.

[1] [Online]. Available: https://www.oecd.org/digital/going-digital-project/

As with every research, of course also this study is associated with several limitations opening opportunities for further research that replicates and/or extends this study. Due to the cross-sectional nature of data, it was not possible to identify the causal relationship between environmental, organizational, technological contexts, and digital technology adoption. Future research should further study causality and identify heterogeneous digital adoption behavior between SMEs. Also, further longitudinal research is needed that examines the influence of drivers of digital transformation beyond the adoption decision (e.g., by assessing the adoption success). In addition, longitudinal studies would help understand the evolution of digital technology drivers over time. Companies may be prompted to adopt a digital technology under external pressure; however, the adoption success will be contingent on their organizational and technological readiness. In this perspective, "organizational readiness" could be introduced as a moderator factor in order to offer further insights on digital technology adoption outcomes.

Moreover, the identified digital technology adoption drivers in this study provide a theoretical basis for further investigating the intention to adopt digital technologies within SMEs. It is deemed that future research can use the resource-based view and dynamic capabilities theories to investigate skills and resources to improve the capabilities of successful adoption of digital technologies. Finally, the results of this study highlight the need for further research on how corporate social responsibility influences the organization's decision on digital technology adoption.

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