International Journal of Business Intelligence Research
Volume 17 • Issue 1 • January-December 2026

The Paradox Between Concept Knowledge and Digital Maturity Level for Industry 4.0: The Portuguese Case

André Guimarães
http://orcid.org/0000-0001-6346-5719
CISE – Electromechatronic Systems Research Centre, Portugal

Rosivalda Pereira
http://orcid.org/0000-0002-6316-2432
Universidade Federal do Maranhão, Brazil

Maria Teresa Pereira
Associate Laboratory for Energy, Transports, and Aerospace (LAETA-INEGI), Portugal

Afonso Carvalho
Associate Laboratory for Energy, Transports, and Aerospace (LAETA-INEGI), Portugal

Pedro Reis
CISeD - Research Centre for Digital Services, Portugal

Antonio J. Marques Marques Cardoso
http://orcid.org/0000-0001-8737-6999
CISE – Electromechatronic Systems Research Centre, Portugal

Received: September 17th, 2025 | **Accepted:** March 18th, 2026

ABSTRACT

This study examines whether companies' knowledge of the Industry 4.0 concept, geographic location, and size influence the digital maturity of Portuguese industrial firms. Data were collected through a self-assessment questionnaire based on the IMPULS model and analyzed using ordinal logistic regression and chi-square tests to test three hypotheses. The results show that none of these factors significantly affects digital maturity, suggesting that isolated variables do not fully explain digital progress and that broader contextual elements, such as support programs and internal digital strategies, may play a more decisive role. The study meets its objectives and contributes to understanding digital readiness in the Portuguese industrial context. Future research should incorporate additional variables, employ longitudinal or sector-specific approaches, and utilize qualitative methods to enhance the analysis further.

KEYWORDS

Concept Knowledge, Digital Maturity, Industry 4.0, Regional Disparities, Portugal

INTRODUCTION

Modern companies stand out in the new era of digital transformation by using emerging Industry 4.0 technologies, such as the Internet of Things (IoT), artificial intelligence (AI), and big data analytics in production processes (Jagatheesaperumal et al., 2021). These technologies increase production efficiency, boost competitiveness, and promote economic sustainability across different business models (Ghobakhloo, 2020). Furthermore, they optimize complex systems and improve productivity by applying smart sensors, providing companies a competitive advantage (Javaid et al., 2021).

DOI: 10.4018/IJBIR.406104

Digital maturity has become a critical driver of business competitiveness, as the adoption of digital solutions enables companies to streamline operations, enhance customer experience, and expand their commercial reach (Ghobakhloo, 2020; Verhoef et al., 2021). Opening digital channels increases visibility and allows a 24/7 presence, improving sales potential, customer retention, and Net Promoter Score performance (Lemon & Verhoef, 2016). Moreover, integrating digital technologies into operations enables faster decision-making, process automation, and greater operational flexibility, resulting in measurable gains in productivity and long-term value creation (Bharadwaj et al., 2013; Vial, 2021; Guimarães et al., 2025a). These benefits underscore the importance of accelerating digital transformation efforts and highlight the relevance of assessing digital maturity in the Portuguese context.

Some initiatives related to adopting Industry 4.0, namely in digital transformation, have gained prominence in Portugal, but many companies still face significant challenges (De Jesus & Lima, 2021; Guimarães et al., 2023). Portuguese companies face barriers in implementing Industry 4.0, namely the need for investment and strategic management focused on effective change (Pereira et al., 2023; Guimarães et al., 2024). However, technological challenges persist, and it is necessary to face them to obtain new opportunities to improve production processes, leading to a more efficient use of resources (Rikalovic et al., 2022).

Portuguese companies' digital readiness level for Industry 4.0 remains low, presenting notable weaknesses in areas such as smart infrastructures and data-based services (Guimarães et al., 2023). Portuguese companies' knowledge regarding their preparation level for integrating Industry 4.0 is considered moderate. To increase this level, it is necessary to consider some critical success factors, such as strategy, leadership, and customer experience (Da Fonseca et al., 2024).

This research explores an existential paradox in the relationship between knowledge of the Industry 4.0 concept and Portuguese companies' digital maturity level. This paradox is particularly troubling given that leaders play a critical role in developing strategies, adopting digital technologies, and making company decisions. It is essential to analyze the knowledge of entrepreneurs and leaders about the concept of Industry 4.0 with perceptions about the level of digital maturity of their companies for different regions of Portugal, various sectors of economic activity, and different sizes of companies.

This research also allows us to identify and analyze existential disparities regarding theoretical knowledge of the concept of Industry 4.0, which can influence business practices, causing barriers and loss of opportunities in accelerating the digital transition of companies. This research also highlights the influence of investments in digital technologies on increasing productivity, flexibility, employee well-being, and international competitiveness. Furthermore, this research analyzes the empirical results to create strategic directions to improve the level of digital readiness for Industry 4.0 of Portuguese companies. It can become a reference for other studies in other European countries in similar contexts.

Although digital transformation challenges in Portugal have been widely discussed, little empirical research has examined whether conceptual knowledge of Industry 4.0 is reflected in companies' actual digital maturity. Existing studies identify barriers and readiness gaps (De Jesus & Lima, 2021; Guimarães et al., 2023; Pereira et al., 2023; Guimarães et al., 2025b, 2025d) but do not analyze whether theoretical awareness translates into adoption. International reviews also note that awareness does not guarantee implementation, and empirical evidence linking the two dimensions remains limited (Ghobakhloo, 2020; Vial, 2021). This study addresses this gap by empirically testing this paradox and providing new evidence on how knowledge aligns with digital readiness.

We first provide an introduction to relevance. Next, we detail our research motivation and hypotheses development and review the literature. Then, we describe the research methodology before we analyze and discuss the results. Finally, we present conclusions, practical implications, and future research directions.

RESEARCH MOTIVATION AND HYPOTHESES DEVELOPMENT

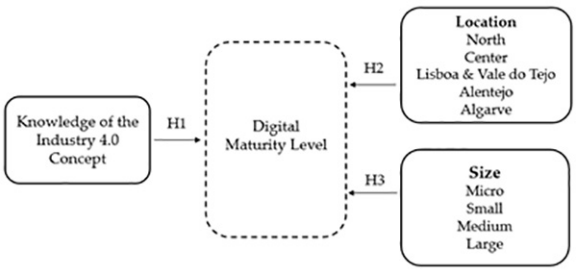
Building on the literature, this study addresses several gaps that remain insufficiently explored in the context of digital transformation. Although Industry 4.0 is widely recognized as a driver of competitiveness, empirical evidence linking knowledge of the Industry 4.0 concept to actual digital maturity remains limited, particularly in regional contexts such as Portugal. Prior studies suggest that conceptual understanding does not always lead to practical implementation, indicating a potential paradox between knowing the concept and achieving higher levels of digital maturity.

Research has also shown that factors such as company size and geographic location may influence digitalization outcomes, but findings are inconsistent and highly context dependent. Given Portugal's industrial structure, dominated by micro and small firms and characterized by regional disparities, these relationships require closer examination.

Considering the gaps identified in this research, the following research question was addressed: What is the relationship between the level of knowledge of the Industry 4.0 concept and the level of digital maturity?

A conceptual model was developed to answer the research question and validate the formulated hypotheses, as illustrated in Figure 1. This model provides a clear and logical structure that facilitates understanding the paradox between knowledge of the Industry 4.0 concept and the level of digital maturity in Portuguese companies.

Figure 1. Conceptual Model



The research gap focuses on the lack of studies that comprehensively analyze the relationship between concept knowledge of Industry 4.0 and the digital maturity level of Portuguese companies of different sizes and from various regions. The mismatch between the understanding of the concept and the actual digital capabilities of companies, despite the growing dissemination of the Industry 4.0 framework, presents an opportunity to explore several research hypotheses.

- Hypothesis 1 (H1): Knowledge of the Industry 4.0 concept correlates positively with the level of digital maturity of Portuguese companies in Industry 4.0.
- Hypothesis 2 (H2): Portuguese companies' geographical location positively impacts the digital maturity level in Industry 4.0.
- Hypothesis 3 (H3): Portuguese companies' size positively impacts the digital maturity level in Industry 4.0.

LITERATURE REVIEW

Industry 4.0 is an innovative concept that redefines business models and production processes. It drives innovation through digitalization, network integration, and customer-centric approaches, leading to four main paths: process optimization, the creation of new value networks, and the development of innovative products (Ibarra et al., 2018). In small and medium-sized enterprises (SMEs) in the manufacturing sector, Industry 4.0 impacts the creation, capture, and delivery of value, with innovation strategies influenced by various motivations and market pressures (Müller et al., 2018).

Key elements of Industry 4.0, such as automation, digitalization, robotics, and artificial intelligence, enable manufacturing companies to remain competitive (Krulický et al., 2024). IoT and big data increase production efficiency, process collaboration, and financial performance, promoting greater competitiveness and economic sustainability (Nagy et al., 2018). However, despite its vast potential, the implementation of Industry 4.0 faces significant challenges, such as insufficient technological infrastructure, resistance to organizational change, lack of digital skills in the workforce, and limited financial resources (Silva et al., 2019; Herceg et al., 2020; Bajić et al., 2021; Rikalovic et al., 2022).

Digital maturity reflects the degree of integration of digital technologies into organizational processes and the ability of companies to strategically take advantage of increased competitiveness and cost optimization (Machado et al., 2020; Sobolev, 2024). The challenges fuel the drive for digital transition and the need for more agile and flexible approaches for companies to remain more competitive in a constantly changing and evolving market (Jain & Jain, 2022).

The level of digital maturity measures a company's readiness to integrate advanced technologies, identifying gaps between strategic vision and practical implementation (Çınar et al., 2021; Zamlynskyi et al., 2023; Guimarães et al., 2025c). According to studies by Melnik et al. (2021), Kilic et al. (2023), and Iribarren et al. (2024), digital maturity plays a crucial role in the effective adoption of Industry 4.0. However, many companies are still in the early stages of their digital transformation process. Furthermore, regional disparities and company size significantly impact digital maturity levels (Chirkunova et al., 2019; Zentner et al., 2022; Zou & Ali, 2024). Understanding this dynamic is essential to adapt digital transformation strategies to the specificities of each business context.

Leaders and managers play a crucial role in companies' transition to Industry 4.0, driving the implementation of new technologies and promoting organizational culture internally (Van Dun & Kumar, 2023). According to Ramchander (2019), Colli et al. (2021), and Santos et al. (2021), managers' knowledge and understanding of the concept of Industry 4.0 are essential to prioritize digital investments and ensure the future success of business strategies. However, managers' lack of digital literacy related to Industry 4.0 represents a significant challenge, particularly for SMEs (Azevedo & Almeida, 2021; Santos et al., 2021). This problem is even more pronounced in less industrialized regions, where limited access to training resources and technological innovation further hinder progress.

Portugal has launched several initiatives to promote business digitalization, namely the Action Plan for Digital Transition (Guimarães et al., 2023) and the Industry 4.0 program (Porfírio et al., 2021). Digitalization is crucial for the internationalization of SMEs in Portugal, positively affecting their organizational structure and competitive advantages (Pereira & Cardoso, 2023).

In both Portugal and Spain, the digitalization of administrative reforms was driven by networked political entrepreneurship, the use of multiple policy instruments, the integration of shared values, and efforts to overcome resistance to change (Secchi et al., 2024). Despite efforts, many Portuguese companies still face significant challenges in integrating into Industry 4.0, mainly due to limited management knowledge and low digital maturity (De Jesus & Lima, 2021). Portuguese SMEs, in particular, are currently resisting digital transformation and data-driven management, highlighting the need to strengthen the adoption of technology and increase digital literacy among managers to

boost competitiveness (Pinto & António, 2023), as well as increase training and knowledge of human resources on this topic.

Recent international frameworks for assessing digital maturity provide useful benchmarks to contextualize the Portuguese case. Models such as the IMPULS Readiness Index, Deloitte's Digital Maturity Model, and the Digital Economy and Society Index by the European Commission have been widely applied in Europe to measure progress (Wagner et al., 2023). These tools evaluate aspects like strategy, infrastructure, culture, and skills, offering comparative insights. Studies in Spain, Italy, and Germany show that while awareness is generally high, digital implementation varies significantly depending on sector, firm size, and regional policies. Integrating such frameworks and comparisons can help identify structural barriers and policy gaps hindering Portugal's digital transformation (Gherghin, 2025).

Some of the challenges shared by different SMEs vary significantly across regions and sectors of economic activity, highlighting the need for a tailored approach to promote digital maturity in a balanced way. Understanding the concept of Industry 4.0 aligned with the digital maturity of Portuguese companies can drive new technological investments. The practical implementation of digital solutions can lead to significant productivity gains, greater operational flexibility, better working conditions for employees (Dana et al., 2022; Asriandi et al., 2024), and greater international visibility for Portuguese companies.

The relationship between the level of knowledge of the concept of Industry and the level of digital maturity remains scarce in the existing literature and current research that considers regional and organizational specificities in specific contexts, namely in the Portuguese case. This study addresses these gaps by providing relevant data on the paradox between knowledge of the Industry 4.0 concept and the level of digital maturity across different regions and company sizes.

Although digital maturity is often linked to knowledge and awareness, studies show that awareness alone does not guarantee implementation. This disconnect, referred to as the awareness-action gap, has been explored in several theoretical models. The technology acceptance model (Davis, 1989) and the theory of planned behavior (Ajzen, 1991) explain how knowledge or positive attitudes toward innovation are insufficient for adoption, as contextual and organizational factors intervene. In the context of Industry 4.0, Vial (2021) emphasizes that successful digital transformation depends not only on awareness but also on strategic alignment, leadership, and organizational capabilities.

AI and Generative AI have become key enablers of Industry 4.0, supporting capabilities such as predictive analytics, automated decision-making, anomaly detection, and digital twin optimization. Alongside AI, other Industry 4.0 technologies, including IoT monitoring systems, real-time analytics, robotics and automation, and machine vision, also play a central role in strengthening digital maturity by enhancing operational efficiency and decision-making. However, the effective adoption of these technologies requires robust data infrastructures and specialized digital skills, which remain significant challenges for many firms, particularly SMEs (Vial, 2021). Recognizing this broader technological ecosystem is therefore essential when assessing companies' digital readiness.

This gap is especially pronounced in SMEs, where knowledge may be present, but implementation is limited due to a lack of resources, infrastructure, or digital skills. Understanding this paradox is essential to framing the empirical results of this study.

RESEARCH METHODOLOGY

Research Methods

This study applied ordinal logistic regression models and chi-square tests to evaluate the three proposed hypotheses. Ordinal logistic regression was used to model the relationship between an ordinal dependent variable (maturity level) and a set of independent variables (technology level, company size, and geographic location), allowing the estimation of the probability of different response levels occurring as a function of the predictors.

The statistical analysis relies on the null hypothesis that the regression coefficients are equal to zero, indicating the absence of an association between the predictors and digital maturity levels. This hypothesis is evaluated using the ordinal logistic regression model, which employs standard Wald statistics and likelihood-ratio tests to assess coefficient significance and overall model fit. In addition, chi-square tests were employed to examine associations between categorical variables, complementing the inferential analysis. All statistical analyses were conducted at a 5% significance level. The studies used the R package "ordinal" (Christensen, 2023).

Data Collection and Sample

The data were collected through an online questionnaire distributed to companies via email and made available on the Google Forms platform. The questionnaire followed the IMPULS model, and some variables were supplemented and extracted from the SABI platform. A total of 450 companies actively participated in this study, where quantitative data on companies' knowledge of the Industry 4.0 concept were analyzed, considering different sizes and locations. Descriptive data of the sample are presented in Table 1.

The concepts of "Industry 4.0 knowledge" and "digital maturity" were evaluated through self-reported responses to a standardized IMPULS-based questionnaire, which was distributed online using a Google Forms link. Knowledge of the Industry 4.0 concept was assessed using a 5-point ordinal scale, ranging from "(1) No, I have never heard of it" to "(5) We master the concept and already apply it across the company".

Digital maturity was assessed using a model based on IMPULS, which included 25 questions covering six key dimensions of digital transformation. Based on the companies' responses, a weighted average score was calculated for each organization, resulting in a final digital maturity index on a 0–5 Likert scale. This score was then mapped to a categorical framework consisting of six maturity levels: Outsider, Beginner, Intermediate, Experienced, Expert, and Top Performer (Guimarães et al., 2023). This method provides a structured and comprehensive assessment of digital readiness.

A 5-point ordinal scale was selected to assess digital maturity because it offers a precise balance between discriminatory power and ease of interpretation for respondents. This format is widely used in digital maturity assessments, ensuring comparability with previous studies. Although 7- and 10-point scales were considered, they were discarded as they tend to increase cognitive load and do not necessarily improve reliability or explanatory power, particularly in managerial surveys involving SMEs.

Some limitations in the sample should be noted. There is an uneven distribution of companies across regions, with more responses from Portugal's central and northern areas. In addition, the sample is mainly composed of SMEs, which may affect how well the results apply to larger firms. These imbalances can influence the interpretation of trends by region or company size. Future studies should aim for a more balanced representation across sectors, regions, and company sizes to improve the validity of the results.

Table 1. Sample Characteristics

Characteristic	Alentejo N=26[1]	Algarve N=3[1]	Center N=315[1]	Lisboa N=15[1]	North N =91[1]
Knowledge concept					
(1)	3 (11.5%)	0 (0.0%)	48 (15.2%)	1 (6.7%)	12 (13.2%)
(2)	2 (7.7%)	1 (33.3%)	35 (11.1%)	0 (0.0%)	6 (6.6%)
(3)	17 (65.4%)	0 (0.0%)	141 (48.8%)	9 (60.0%)	46 (50.5%)

continued on following page

Table 1. Continued

Characteristic	Alentejo N=26[1]	Algarve N=3[1]	Center N=315[1]	Lisboa N=15[1]	North N =91[1]
(4)	4 (154%)	2 (66.7%)	75 (23.8%)	5 (33.3%)	24 (26.4%)
(5)	0 (0.0%)	0 (0.0%)	16 (5.1%)	0 (0.0%)	3 (3.3%)
Digital maturity Level					
Outsider	6 (23.1%)	3 (100%)	131 (41.6%)	5 (33.3%)	25 (27.5%)
Beginner	15 (57.7%)	0 (0.4%)	134 (42.5%)	7 (46.7%)	56 (61.5%)
Intermediate	4 (15.4%)	0 (0.0%)	44 (14.0%)	2 (13.3%)	8 (8.8%)
Experienced	1 (3.8%)	0 (0.0%)	6 (1.9%)	0 (0.0%)	2 (2.2%)
Expert	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (6.7%)	0 (0.0%)
Top Performer	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Size					
Micro	7 (26.9%)	1 (33.3%)	52 (16.5%)	5 (33.3%)	41 (45.1%)
Small	9 (34.6%)	0 (0.0%)	128 (40.6%)	5 (33.3%)	25 (27.5%)
Medium	10 (38.5%)	2 (66.7%)	117 (37.1%)	5 (33.3%)	21 (23.1%)
Large	0 (0.0%)	0 (0.0%)	18 (5.7%)	0 (0.0%)	4 (4.4%)

Note: [1]n (%). (1) No, I have never heard of it. (2) Vaguely, and it is not important for the company. (3) Superficially, but I want to learn more to assess its potential for the company. (4) Sufficiently, as we already have some pilot projects underway. (5) We master the concept and already apply it across the company.

RESULTS AND DISCUSSION

Level of Knowledge of the Industry 4.0 Concept in Companies of Portugal

In addition to analyzing the motivation to face the challenges in adopting planned Industry 4.0 activities, this concept's knowledge level among industrial companies in Portugal was assessed. As illustrated in Table 2, this assessment clarified the positioning of companies, identifying gaps and opportunities for training.

The analysis highlighted differences based on company size and level of implementation, highlighting the need to develop strategies that promote awareness, training, and adoption of Industry 4.0 practices, thus contributing to increased competitiveness and economic development in the region.

Table 2. Level of Knowledge of the Industry 4.0 Concept

	Total	Micro	Small	Medium	Large
(1)	14.2%	5.6%	7.6%	1.1%	0.0%
(2)	9.8%	2.9%	4.9%	2.0%	0.0%
(3)	47.3%	12.7%	17.8%	16.2%	0.7%
(4)	24.4%	2.2%	5.8%	12.7%	3.8%
(5)	4.2%	0.2%	1.1%	2.4%	0.4%

Note: (1) No, I have never heard of it. (2) Vaguely, and it is not important for the company. (3) Superficially, but I want to learn more to assess its potential for the company. (4) Sufficiently, as we already have some pilot projects underway. (5) We master the concept and already apply it across the company.

The analysis shows that 81.4% of companies in Portugal are aware of the Industry 4.0 concept. Of these, 27.1% have implemented pilot projects, with medium-sized (36.6%) and large companies (85.7%) leading in progress. Additionally, 32.9% of companies have only a superficial understanding but are interested in learning more to explore its potential.

These findings highlight the need for tailored tools to raise awareness and support companies, considering sectoral needs and organizational size. Adopting Industry 4.0 practices is essential to boost business competitiveness and drive economic transformation. While most companies are familiar with the concept, more profound knowledge is needed. Full adoption is still limited, with only 7.3% of medium-sized and 7.1% of large companies fully applying it. Among small companies, 35.3% have only superficial knowledge, and 29.4% are completely unaware.

Relationship Between Knowledge of Industry 4.0 and Digital Maturity

An ordinal logistic regression model was used to test hypothesis H1, which proposes a relationship between knowledge of the Industry 4.0 concept and companies' level of digital maturity. The model was fitted using the polr function from the MASS package in R (Venables & Ripley, 2013), with maturity (digital maturity) as the dependent variable and concept (knowledge of Industry 4.0) as the independent variable. The estimated coefficients are presented in Table 3.

Table 3. Coefficients From the Ordinal Logistic Regression Model Assessing the Link Between Industry 4.0 Knowledge and Digital Maturity

	Value	Std. Error	t-value	p-value
Coefficients:				
Concept (Yes)	-0.0047	0.1939	-0.0241	0.9808
Intercepts:				
Beginner | Experienced	-0.1171	0.1112	-10.529	< 0.0001
Experienced | Expert	-0.0370	0.1112	-0.3325	0.7397
Expert | Intermediate	-0.0281	0.1112	-0.2526	0.8007
Intermediate | Outsider	0.4976	0.1136	43.796	< 0.0001

The results show that the coefficient for the variable concept (Yes) is -0.0047, with a standard error of 0.1939 and a t-value = -0.0241 (p-value of 0.9809). These values indicate that knowledge of the Industry 4.0 concept does not have a statistically significant effect on Portuguese companies' digital maturity level since the coefficient is close to zero and the Wald test is not important ($p > 0.05$).

The intercepts reveal the distribution of digital maturity levels, with the highest value observed between the "Intermediate" and "Outsider" levels (0.4976), suggesting that the main transition occurs in this category. The AIC of the model was 980.40, reflecting a reasonable fit. However, the low magnitude of the main coefficient suggests that other variables may play a more relevant role in explaining the digital maturity of companies, in addition to knowledge of the concept of Industry 4.0.

The model was also evaluated using the likelihood ratio test, comparing the null model with the model, including the concept variable. The statistical result of the test was 0.00058 (df = 1, Pr(Chi) = 0.98075), confirming that knowledge of the Industry 4.0 concept does not significantly explain the level of digital maturity. Therefore, there is no statistical evidence to support hypothesis H1. In other words, knowledge of the concept of Industry 4.0 alone does not appear to influence the digital maturity of the companies analyzed significantly.

Despite efforts to promote Industry 4.0 in Portugal, many industrial companies, especially SMEs, still struggle to understand and apply its concepts in practice. The available knowledge is often superficial and comes from isolated initiatives without being linked to a structured digital strategy. The lack of internal skills, limited resources, and resistance to change hinder implementation. Therefore, knowledge of Industry 4.0 alone cannot significantly influence companies' digital maturity, which helps explain the results.

A statistical analysis was conducted using categorical data to assess whether there is an association between companies' digital maturity level and their knowledge of the Industry 4.0 concept. The variables analyzed were: (i) digital maturity level, classified into categories such as Beginner, Experienced, Expert, Intermediate, and Outsider; and (ii) familiarity with the Industry 4.0 concept, rated on a 5-point scale: (1) No, I have never heard of it; (2) Vaguely, and it is not essential for the company; (3) Superficially, but I want to learn more to assess its potential for the company; (4) Sufficiently, as we already have some pilot projects underway; (5) We master the concept and already apply it across the company. This association is shown in Table 4.

Table 4. Inferential Analysis of the Relationship Between Industry 4.0 Knowledge and Digital Maturity Using Ordinal Logistic Regression

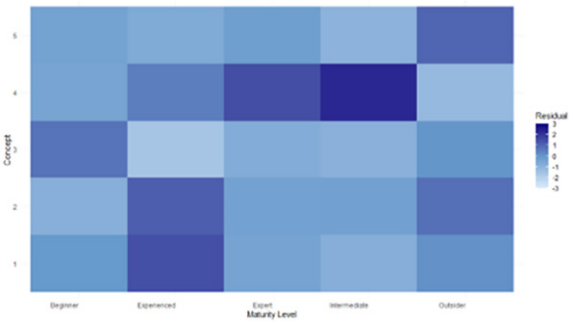
Concept[1]	Maturity level					Total
	Beginner	Experienced	Expert	Intermediate	Outsider	
1	30	3	0	6	25	64
2	17	2	0	5	20	44
3	108	1	0	23	81	213
4	49	3	1	23	34	110
5	8	0	0	1	10	19
Total	212	9	1	58	170	450

Note: (1) No, I have never heard of it. (2) Vaguely, and it is not important for the company. (3) Superficially, but I want to learn more to assess its potential for the company. (4) Sufficiently, as we already have some pilot projects underway. (5) We master the concept and already apply it across the company. $\chi^2 = 22.466$ · df = 16 · Cramer's V = 0.112 · Fisher's p = 0.080

The Chi-square test of independence was applied, resulting in $\chi^2 = 22.466$ with 16 degrees of freedom and a p-value of 0.080 (Fisher's exact test). Although the result does not meet the conventional 5% significance threshold, it can be considered marginally significant in a more flexible context (at the 10% level). The Cramer's V value of 0.112 indicates a weak association between the variables. Therefore, this association should not be overlooked in the analysis.

To better understand the association patterns, a standardized adjusted residuals plot was created (Figure 2). This chart shows the deviations between observed and expected frequencies under the independence assumption. Cells with positive residuals indicate higher-than-expected occurrences, while harmful residuals reflect lower-than-expected frequencies, suggesting a possible association between the variables.

Figure 2. Heatmap of Adjusted Standardized Residuals From the Chi-Square Test



Note: For concept: (1) No, I have never heard of it. (2) Vaguely, and it is not important for the company. (3) Superficially, but I want to learn more to assess its potential for the company. (4) Sufficiently, as we already have some pilot projects underway. (5) We master the concept and already apply it across the company.

In Figure 2, each cell represents the combination of a knowledge level (vertical axis) and a digital maturity level (horizontal axis). The color intensity reflects the residual value: darker cells indicate more substantial positive deviations, while lighter cells indicate more substantial negative deviations. For example, cells corresponding to knowledge level 4 combined with the "Intermediate" and "Expert" maturity levels show more intense positive residuals. In contrast, combinations involving lower knowledge levels display lighter or neutral tones, indicating more minor deviations.

Although many companies claim to be familiar with the Industry 4.0 concept, the results show no significant link with their actual digital maturity. This points to a gap between awareness and action, where knowledge does not translate into effective implementation.

Companies may overestimate their understanding due to superficial exposure to initiatives or training. However, real progress requires internal actions like digitizing processes, investing in infrastructure, and training staff.

Policy makers should offer more than awareness campaigns to close this gap, providing practical support such as sector-specific roadmaps, workshops, and mentoring. Managers should also assess operational readiness and focus on areas like business intelligence and analytics, which are essential but still underused.

Relationship Between Geographical Location and Digital Maturity

To analyze the relationship between company location and digital maturity level, the chi-square test (χ^2) was used to assess associations between categorical variables and test hypothesis H2.

The result was $\chi^2 = 8.141$ (df = 4), with a p-value of 0.086, indicating a statistically significant relationship. However, the strength of this relationship, measured by Cramer's V (0.163), means a weak association. Figure 3 illustrates the distribution of the variables.

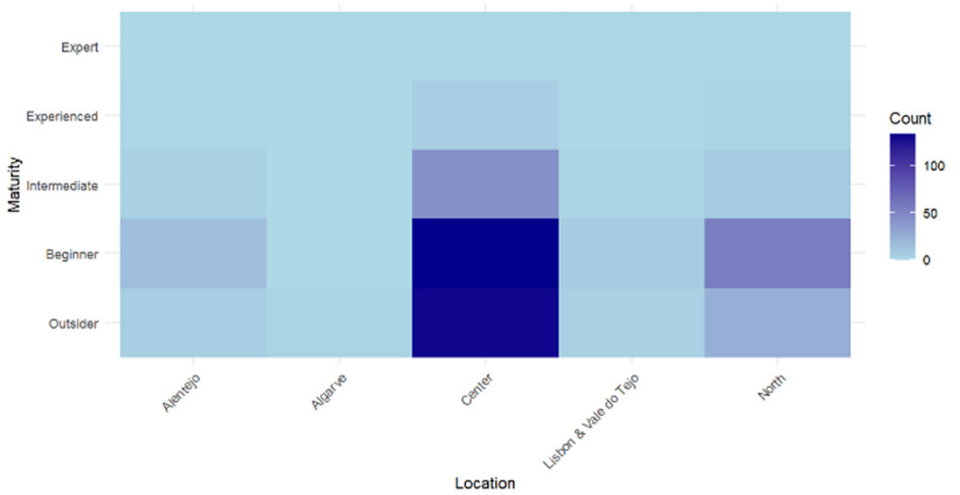
In Portugal, although there are regional differences in economic development, these are not always reflected in the digital maturity of industrial companies. Regions such as Lisbon and Porto have more resources and technological infrastructure. Still, companies located in peripheral or inland areas, such as the Centro region, manage to bridge this gap through support networks, partnerships, and public programs such as *Plano de Recuperação e Resiliência* (PRR, 2024), Compete2030 (Compete2030, 2024), IAPMEI (IAPMEI, 2024) and Portugal 2030 (Portugal, 2024), which enable them to achieve higher levels of digital maturity.

Initiatives such as the Operational Programme for Competitiveness Factors (COMPETE-2030) and support from the Portuguese Foundation for Science and Technology provide essential funding for

digitalization projects (Luu et al., 2019). Although these initiatives are promising, challenges such as security risks and digital exclusion remain significant barriers to achieving comprehensive digital transformation across all sectors in Portugal (Benga & Elhamma, 2024).

Moreover, many industries are integrated into value chains that promote digitalization regardless of location. This context contributes to a certain uniformity in digital maturity levels, which explains the lack of a statistically significant relationship with the location variable.

Figure 3. Distribution of Companies' Digital Maturity Levels by Region in Portugal



Relationship Between Company Size and Digital Maturity

An ordinal logistic regression model was used to test H3, which analyses whether company size influences their level of digital maturity. The dependent variable maturity represents the level of digital maturity, and the independent variable size classifies companies as Micro, Small, Medium, or Large. The results are presented in Table 5.

Table 5. *Results of the Ordinal Logistic Regression*

	Value	Std. Error	t-value	p-value
Coefficients:				
sizeMedium	-0.2741	0.4180	-0.6558	0.5123
sizeMicro	-0.3634	0.4309	0.8432	0.3996
sizeSmall	0.1678	0.4168	0.4027	0.6874
Intercepts:				
Beginner | Experienced		-0.2405	0.3910	0.5328
Experienced | Expert		-0.1598	0.3908	0.6828
Expert | Intermediate		-0.1508	0.3908	0.6998
Intermediate | Outsider		0.3820	0.3910	0.3291

The model presented an AIC of 977.756, indicating a similar fit to the previous model. None of the coefficients for the company size categories were statistically significant, as the p-values were greater than 0.05, indicating non-significance at the 5% level.

The negative coefficients for sizeMedium (-0.2741) and sizeMicro (-0.3634) suggest that medium and small-sized companies may have a slightly lower probability of reaching higher levels of digital maturity compared to large companies (reference category). However, these effects are not statistically significant ($p > 0.05$), indicating that company size alone does not consistently explain the level of digital maturity.

The model was also tested using the likelihood ratio test, which compares the null model with the model, including the size variable. The test statistics were 6.641 ($df=3$, $p = 0.08$), showing a marginally non-significant difference between the models. Therefore, it is concluded that company size has no statistically significant impact on digital maturity, and H3 is rejected.

In Portugal, the industrial sector is mainly made up of micro, small, and medium-sized enterprises, which, despite limited resources, have shown great adaptability by adopting simple and accessible digital solutions. Larger companies, although better resourced, face greater internal complexity, which can hinder or delay digitalization. This diversity tends to balance out the impact of company size, explaining the lack of a statistically significant relationship with the level of digital maturity. Furthermore, public support programs or digitalization help to reduce the differences between companies of different sizes.

CONCLUSION

This study examined whether knowledge of the Industry 4.0 concept, geographic location, and company size influence the digital maturity of Portuguese industrial companies. The results show that none of these variables has a significant effect, which may reflect the limited operationalization of conceptual knowledge, the widespread availability of public support initiatives, and the heterogeneity of Portuguese firms.

International studies suggest that digital maturity is primarily driven by internal capabilities, including strategy leadership, skills, and investment capacity (Ghobakhloo, 2020; Vial, 2021). The absence of significant effects in this study reinforces the idea that deeper organizational capabilities are more decisive than structural characteristics, highlighting a gap between awareness and effective implementation.

Portugal continues to face barriers in advancing digital transformation, particularly regarding organizational readiness and the integration of digital strategies. These challenges stress the importance of sustained policy support and continuous investment in digital skills and infrastructure.

The findings also carry political, practical, and social implications. Politically, they highlight the need for policies that strengthen internal digital capabilities, especially in SMEs. Practically, they show that conceptual knowledge alone is insufficient to drive transformation, underscoring the importance of structured strategies, workforce training, and technologies such as business intelligence and analytics. Socially, low digital maturity may widen skill gaps, reinforcing the need for digital literacy initiatives.

Evidence from digitally advanced regions, such as Northern and Central Europe, shows that broader capability-building efforts, namely investment in digital infrastructures, strong innovation ecosystems, and coordinated public and private initiatives, are key enablers of successful digital adoption (OECD, 2019; Verhoef et al., 2021; European Commission, 2022). These insights help contextualize the Portuguese results.

To support organizations in monitoring their digital progression, simple indicators such as workforce digital readiness, technology investment intensity, the share of digital sales, and operational efficiency gains can serve as early signals of adoption.

This study has some limitations. It relies on self-reported data; the cross-sectional design prevents the assessment of causality, and only three explanatory variables were considered, excluding other organizational or technological factors. These limitations suggest caution in generalizing the results.

Future work should expand the set of explanatory variables, explore sectoral and regional differences, and use longitudinal or mixed methods approaches. More detailed analyses of technologies such as business intelligence and data analytics may also clarify how specific digital capabilities influence transformation outcomes in the Portuguese industrial sector.

ACKNOWLEDGMENT

This research was funded by the Portuguese Foundation for Science and Technology (FCT), through projects UID/4131/2025 (https://doi.org/10.54499/UID/04131/2025), UID/PRR/4131/2025 (https://doi.org/10.54499/UID/PRR/04131/2025), through the CEECINST/00096/2021 grant and the UIDB/50022/2020 project (LAETA Basic Funding), UIDB/05583/2020, and UI/BD/154507/2022 (https://doi.org/10.54499/UI/BD/154507/2022). The authors also thank the Associated Laboratory for Energy, Transport, and Aerospace (LAETA-INEGI), the CISE Research Centre for Electromechanical Systems of the University of Beira Interior (UBI), and the CISeD Research Centre for Digital Services of the Polytechnic Institute of Viseu (IPV).

DECLARATION OF CONFLICTING INTERESTS

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

FUNDING STATEMENT

This research was funded by the Portuguese Foundation for Science and Technology (FCT), through projects UID/4131/2025 (https://doi.org/10.54499/UID/04131/2025), UID/PRR/4131/2025 (https://doi.org/10.54499/UID/PRR/04131/2025), through the CEECINST/00096/2021 grant and the UIDB/50022/2020 project (LAETA Basic Funding), UIDB/05583/2020, and UI/BD/154507/2022 (https://doi.org/10.54499/UI/BD/154507/2022).

CORRESPONDING AUTHOR

Correspondence should be addressed to André Guimarães: andre.m.guimaraes@ubi.pt.

REFERENCES

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211. DOI: 10.1016/0749-5978(91)90020-T

Asriandi, A., Sitompul, G., & Sangaji, J. (2024). Transforming workforce dynamics: The role of remote work flexibility, technological adoption, and employee wellbeing on productivity of state owned enterprise employee. *International Journal of Business, Law, and Education*. https://doi.org/DOI: 10.56442/ijble.v5i2.896

Azevedo, A., & Almeida, A. (2021). Grasp the challenge of digital transition in SMEs—A training course geared towards decision-makers. *Education Sciences*, *11*(4), 151. Advance online publication. DOI: 10.3390/educsci11040151

Bajić, B., Rikalovic, A., Suzć, N., & Piuri, V. (2021). Industry 4.0 implementation challenges and opportunities: A managerial perspective. *IEEE Systems Journal*, *15*(1), 546–559. DOI: 10.1109/JSYST.2020.3023041

Benga, B., & Elhamma, A. (2024). Navigating the digital frontier: A literature review on business digitalization. *European Scientific Journal*, *27*(10), 107. Advance online publication. DOI: 10.19044/esj.2024.v20n10p107

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

Chirkunova, E., Khmeleva, G., Koroleva, E., & Kurnikova, M. (2019). *Regional digital maturity: Design and strategies*. Lecture Notes in Networks and Systems. DOI: 10.1007/978-3-030-27015-5_26

Christensen, R. H. B. (2023). *ordinal*: Regression models for ordinal data (R package version 2023.12-4.1) [Computer software]. https://CRAN.R-project.org/package=ordinal

Çınar, Z., Zeeshan, Q., & Korhan, O. (2021). A framework for Industry 4.0 readiness and maturity of smart manufacturing enterprises: A case study. *Sustainability (Basel)*, *13*(12), 6659. Advance online publication. DOI: 10.3390/su13126659

Colli, M., Stingl, V., & Waehrens, B. V. (2021). Making or breaking the business case of digital transformation initiatives: The key role of learnings. *Journal of Manufacturing Technology Management*. Advance online publication. DOI: 10.1108/JMTM-08-2020-0330

Compete 2030. (2024). *Compete 2030*. https://www.compete2030.gov.pt/

Da Fonseca, L., Pereira, T., Oliveira, M., Ferreira, F., & Buşu, M. (2024). Manufacturing companies Industry 4.0 maturity level: A multivariate analysis. *Journal of Industrial Engineering and Management*, *17*(1), 196. Advance online publication. DOI: 10.3926/jiem.6333

Dana, L., Salamzadeh, A., Mortazavi, S., & Hadizadeh, M. (2022). Investigating the impact of international markets and new digital technologies on business innovation in emerging markets. *Sustainability (Basel)*, *14*(2), 983. Advance online publication. DOI: 10.3390/su14020983

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *Management Information Systems Quarterly*, *13*(3), 319–340. DOI: 10.2307/249008

De Jesus, C., & Lima, R. (2021). Study of the Portuguese challenges in the context of European Union to identify adaptation strategies for the Industry 4.0. In *Innovations in Industrial Engineering*. DOI: 10.1007/978-3-030-78170-5_3

European Commission. (2022). *Digital economy and society index (DESI) 2022*. Publications Office of the European Union.

Gherghin, C. A. (2025). Public policies for the digitalization of public services in the European Union: From foundations to contemporary challenges. *Technium Social Sciences Journal*, *67*(1), 528–539. Advance online publication. DOI: 10.47577/tssj.v67i1.12453

Ghobakhloo, M. (2020). Industry 4.0, digitization, and opportunities for sustainability. *Journal of Cleaner Production*, *252*, 119869. Advance online publication. DOI: 10.1016/j.jclepro.2019.119869

Guimaraes, A., Moura, L. R., & Marques Cardoso, A. J. (2025d). Industry 4.0 readiness assessment—A comparative analysis of Portuguese and Brazilian companies. *Journal of Industrial Integration and Management*. DOI: 10.1142/S2424862225500046

Guimarães, A., Oliveira, E., Oliveira, M., & Pereira, T. (2025a). Effects of lean tools and Industry 4.0 technology on productivity: An empirical study. *Journal of Industrial Information Integration*, *44*, 100787. Advance online publication. DOI: 10.1016/j.jii.2025.100787

Guimarães, A., Reis, P., & Cardoso, A. J. M. (2024). Industry 4.0 in Portugal—Economic sectors maturity. In *2024 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)* (pp. 496–500). IEEE. DOI: 10.1109/IEEM62345.2024.10857249

Guimarães, A., Reis, P., & Cardoso, A. J. M. (2025c). Bibliometric analysis of studies on Industry 4.0 maturity assessment in SMEs. *Millenium–Journal of Education, Technologies, and Health*, (16e), Article e36472. DOI: 10.29352/mill0216e.34672

Guimarães, A., Reis, P., & Charrua-Santos, F. (2023). Industry 4.0 – Assessment of digital readiness of manufacturing companies in Portugal. In *2023 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)* (pp. 557–561). IEEE. DOI: 10.1109/IEEM58616.2023.10406601

Guimarães, A., Reis, P., Pereira, T., & Marques Cardoso, A. J. (2025b). Industry 4.0 in Portugal: Validation of a readiness assessment model through an empirical approach. *Benchmarking*, 1–27. DOI: 10.1108/BIJ-02-2025-0121

Herceg, I., Kuč, V., Mijušković, V., & Herceg, T. (2020). Challenges and driving forces for Industry 4.0 implementation. *Sustainability (Basel)*, *12*(10), 4208. Advance online publication. DOI: 10.3390/su12104208

IAPMEI. (2024). *IAPMEI*. https://www.iapmei.pt/

Ibarra, D., Ganzarain, J., & Igartua, J. (2018). Business model innovation through Industry 4.0: A review. *Procedia Manufacturing*, *22*, 4–10. DOI: 10.1016/j.promfg.2018.03.002

Iribarren, M., Garay-Rondero, C., Lemus-Aguilar, I., & Peimbert-García, R. (2024). A review of Industry 4.0 assessment instruments for digital transformation. *Applied Sciences (Basel, Switzerland)*, *14*(5), 1693. Advance online publication. DOI: 10.3390/app14051693

Jagatheesaperumal, S. K., Rahouti, M., Ahmad, K., Al-Fuqaha, A., & Guizani, M. (2021). The duo of artificial intelligence and big data for Industry 4.0: Applications, techniques, challenges, and future research directions. *IEEE Internet of Things Journal*, *9*(15), 12861–12885. DOI: 10.1109/JIOT.2021.3139827

Jain, P., & Jain, N. (2022). *Assessing the digital readiness of a company: An exploratory qualitative study*. The Business and Management Review. DOI: 10.24052/BMR/V13NU02/ART-14

Javaid, M., Haleem, A., Singh, R., & Suman, R. (2021). Significant applications of big data in Industry 4.0. *Journal of Industrial Integration and Management*. DOI: 10.1142/S2424862221500135

Kilic, H., Kalender, Z., Korkmaz, C., & Kaya, B. (2023). Integrated methodology for the assessment of industry 4.0 maturity level. *International Journal of the Analytic Hierarchy Process*, *15*(2). Advance online publication. DOI: 10.13033/ijahp.v15i2.1096

Krulický, T., Apanovych, Y., & Rodová, V. (2024). The impact of Industry 4.0 on business results. *Entrepreneurship and Sustainability Issues*, *11*(4), 205–218. Advance online publication. DOI: 10.9770/jesi.2024.11.4(13)

Lemon, K. N., & Verhoef, P. C. (2016). Understanding customer experience throughout the customer journey. *Journal of Marketing*, *80*(6), 69–96. DOI: 10.1509/jm.15.0420

Luu, H., Ferreira, F., & Marques, A. D. (2019). Digitisation and Industry 4.0 in the Portuguese T&C sector. *Industria Textila (Bucuresti)*, *70*(4), 342–345. Advance online publication. DOI: 10.35530/IT.070.04.1612

Machado, C., Almström, P., Öberg, A., Kurdve, M., & Almashalah, S. (2020). *Maturity framework enabling organizational digital readiness*. Advances in Transdisciplinary Engineering. DOI: 10.3233/ATDE200204

Melnik, S., Magnotti, M., Butts, C., Putman, C., & Aqlan, F. (2020). Developing a maturity model and an implementation plan for industry 4.0 integration. In *Proceedings of the International Conference on Industrial Engineering and Operations Management,* Harare, Zimbabwe (pp. 7-10).

Müller, J. M., Buliga, O., & Voigt, K.-I. (2018). Fortune favors the prepared: How SMEs approach business model innovations in Industry 4.0. *Technological Forecasting and Social Change*, *132*, 2–17. Advance online publication. DOI: 10.1016/j.techfore.2017.12.019

Nagy, J., Oláh, J., Erdei, E., Máté, D., & Popp, J. (2018). The role and impact of Industry 4.0 and the Internet of Things on the business strategy of the value chain—The case of Hungary. *Sustainability (Basel)*, *10*(10), 3491. Advance online publication. DOI: 10.3390/su10103491

OECD. (2019). *Going digital: Shaping policies, improving lives*. OECD Publishing. DOI: 10.1787/9789264312012-

Pereira, L., Gonçalves, R., Costa, R., Pereira, A., & Dias, Á. (2023). Industry 4.0 in Portugal—The state of the art. *International Journal of Internet Manufacturing and Services*. DOI: 10.1504/IJIMS.2023.129286

Pereira, R., & Cardoso, A. R. (2023). Qual a relevância da digitalização e adoção de componentes da indústria 4.0 para a internacionalização de pequenas e médias empresas portuguesas? *Future Studies Research Journal: Trends and Strategies*, *15*(1), e0694. Advance online publication. DOI: 10.24023/FutureJournal/2175-5825/2023.v15i1.694

Pinto, J., & António, N. (2023). Minding the gaps: Constraints and opportunities for digital transformation in Portuguese SMEs. In *2023 18th Iberian Conference on Information Systems and Technologies (CISTI)* (pp. 1–7). IEEE. DOI: 10.23919/CISTI58278.2023.10211746

Porfírio, J. A., Carrilho, T., Felício, J. A., & Jardim, J. (2021). Leadership characteristics and digital transformation. *Journal of Business Research*, *124*, 610–619. DOI: 10.1016/j.jbusres.2020.10.058

Portugal 2030. (2024). *Portugal 2030*. https://portugal2030.pt/

PRR. (2024). *Plano de Recuperação e Resiliência – Recuperar Portugal*. https://recuperarportugal.gov.pt/

Ramchander, M. (2019). Industry 4.0: A systematic review of surveys. *Southern African Business Review*, *23*(1). Advance online publication. DOI: 10.25159/1998-8125/6032

Rikalovic, A., Suzć, N., Bajić, B., & Piuri, V. (2022). Industry 4.0 implementation challenges and opportunities: A technological perspective. *IEEE Systems Journal*, *16*(4), 2797–2810. DOI: 10.1109/JSYST.2021.3101673

Santos, G., Sá, J., Félix, M., Barreto, L., Carvalho, F., Doiro, M., Zgodavová, K., & Stefanovic, M. (2021). New needed quality management skills for quality managers 4.0. *Sustainability (Basel)*, *13*(11), 6149. Advance online publication. DOI: 10.3390/su13116149

Secchi, L., Caeiro, J., Pinto, R., & Sáez, M. (2024). Administrative reforms in Portugal and Spain: From bureaucracy to digital transition. *International Review of Administrative Sciences*. Advance online publication. DOI: 10.1177/00208523241250314

Silva, V. L., Kovaleski, J. L., Pagani, R. N., De Matos Silva, J. M., & Corsi, A. (2019). Implementation of Industry 4.0 concept in companies: Empirical evidences. *International Journal of Computer Integrated Manufacturing*, *33*(4), 325–342. DOI: 10.1080/0951192X.2019.1699258

Sobolev, A. (2024). Strategies and methods for assessing the organization's digital maturity. *Science, Education, Society: Trends and Prospects*. DOI: 10.21661/r-562079

Van Dun, D. H., & Kumar, M. (2023). Social enablers of Industry 4.0 technology adoption: Transformational leadership and emotional intelligence. *International Journal of Operations & Production Management*, *43*(13), 152–182. Advance online publication. DOI: 10.1108/IJOPM-06-2022-0370

Venables, W. N., & Ripley, B. D. (2013). *Modern applied statistics with S-PLUS*. Springer Science & Business Media. DOI: 10.1007/978-0-387-21706-2

Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Dong, J. Q., Fabian, N., & Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research*, *122*, 889–901. DOI: 10.1016/j.jbusres.2019.09.022

Vial, G. (2021). Understanding digital transformation: A review and a research agenda. In *Managing Digital Transformation* (pp. 13–66). Routledge. DOI: 10.4324/9781003008637-4

Wagner, C., Verzar, V. K., Bernnat, R., & Veit, D. J. (2023). Digital maturity models. In *Digitalization and Sustainability* (pp. 193–215). Edward Elgar Publishing. DOI: 10.4337/9781800888807.00018

Zamlynskyi, V., Zhuk, N., Osyk, S., & Martiyanova, M. (2023). Modern business diagnostics: Digital maturity and ecosystem recovery. *Ukrainian Journal of Applied Economics and Technology*. DOI: 10.36887/2415-8453-2023-3-2

Zentner, H., Gračan, D., & Sotošek, M. (2022). Impacts of company factors on digital business model maturity for yachting tourism agencies. *Pomorstvo*, *36*(2), 347–358. Advance online publication. DOI: 10.31217/p.36.2.18

Zou, X., & Ali, K. (2024). Regional differences and digital transformation of manufacturing companies in China: A systematic literature review. *Journal of Internet Services and Information Security*, *14*(4), 195–208. Advance online publication. DOI: 10.58346/JISIS.2024.I4.011

Rosivalda Pereira holds a PhD in Management from the University of Beira Interior (Portugal), a Master's degree in Management from the Federal University of Santa Maria (Brazil), and a Bachelor's degree in Librarianship from the Federal University of Maranhão (Brazil). Her research focuses on information management, bibliometrics, scientific communication, industry 4.0 and university-industry cooperation. She currently serves as a Librarian at the Federal University of Maranhão, Brazil.

Antonio J. Marques Cardoso received the Dipl. Eng., Dr. Eng., and Habilitation degrees from the University of Coimbra, Coimbra, Portugal, in 1985, 1995 and 2008, respectively, all in Electrical Engineering. From 1985 until 2011 he was with the University of Coimbra, Coimbra, Portugal, where he was Director of the Electrical Machines Laboratory. Since 2011 he has been with the University of Beira Interior (UBI), Covilhã, Portugal, where he is Full Professor at the Department of Electromechanical Engineering and Director of CISE - Electromechatronic Systems Research Centre (http://cise.ubi.pt). He was Vice-Rector of UBI (2013-2014). His current research interests are in fault diagnosis and fault tolerance in electrical machines, power electronics and drives. He is the author of a book entitled Fault Diagnosis in Three-Phase Induction Motors (Coimbra, Portugal: Coimbra Editora, 1991), (in Portuguese), editor of a book entitled Diagnosis and Fault Tolerance of Electrical Machines, Power Electronics and Drives (IET/SciTech, UK, 2018) and also author of more than 650 papers published in technical journals and conference proceedings. Prof. Marques Cardoso currently serves as Editor in Chief of the MDPI journal Machines, Co-Editor in Chief of the IEEE Transactions on Power Electronics, Editor of the IEEE Transactions on Energy Conversion and IEEE Power Engineering Letters, and Associate Editor of the IEEE Transactions on Industry Applications, IEEE Journal of Emerging and Selected Topics in Power Electronics, IEEE Open Journal of the Industrial Electronics Society, IET The Journal of Engineering, as well of the Springer journal Electrical Engineering and the International Journal of Systems Assurance Engineering and Management.