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DIGITAL TECHNOLOGY INFRASTRUCTURE MANAGEMENT AND BUSINESS STRATEGIC ALIGNMENT AS ENABLERS OF DIGITAL CAPABILITIES IN ENERGY SMES

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ABSTRACT: **Purpose**: The aim of this paper is to examine the impact of digital technology infrastructure management (DTIM) on digital capabilities (DC) in small and medium-sized energy enterprises, with digital technology business strategic alignment (DTBSA) as a mediating variable. **Methodology**: By analysing data collected from Polish and German companies using the CAWI method (197 correctly completed feedback questionnaires) and structural equation modelling (SEM), we determined the importance of digital technology infrastructure management and digital technology business strategic alignment for digital capabilities. **Findings**: The research procedure confirmed the hypotheses about the impact of DTIM and DTBSA on DC. Somewhat unexpectedly, only a slightly higher influence of DTBSA as a mediating variable was observed, suggesting further research directions on the digitalisation process of energy companies. The results of our study also indirectly address environmental aspects by paying particular attention to the importance of the digital transformation of the energy sector as a process that supports environmental protection. The cognitive results obtained in the course of the conducted research made it possible not only to formulate practical implications for managers of energy companies referring to the economic aspect of the operation of this sector, but also positive and negative implications for the environment resulting from the digitalisation of the energy industry. **Originality**: Although the energy sector is still perceived as slow to adapt, our study shows that digital technology infrastructure management positively impacts the digital capabilities of energy SMEs.

KEYWORDS: digital capabilities, digital technology infrastructure management, digital technology business strategic alignment, Industry 4.0, energy companies

Introduction

Digital capabilities (DC) are employed in the process of the organisation adapting to changes in the environment. The literature identifies this category of capabilities as those that allow for the broad management of information technology, simultaneously relating the category of digital capabilities to dynamic capabilities, i.e. those that are key to keeping up with, as well as designing, the business environment (Baiyere et al., 2024). Although DC can also be analysed at the level of individuals (e.g., in terms of information, software and communication skills) (Scuotto et al., 2021), this article takes the perspective of the digital capabilities of organisations.

The growing importance of digital solutions in the business world brings with it not only the need to consider the category of capabilities that are employed in the digital innovation of products and services (Wiesböck et al., 2020), but also the development of digital business strategies that take into account the proper alignment of overall organisational capabilities (Park & Mithas, 2020). An analysis of the literature shows the importance of digital capabilities from the perspective of organisational performance, digital innovation and business model innovation (Khin & Ho, 2018; Scuotto et al., 2021; Veiga et al., 2024).

As IT management processes are seen as an opportunity to deliver the expected benefits for today's organisations (Joshi et al., 2022), a very important issue in this context is also adequate technological infrastructure, which facilitates an organisation's capabilities required to survive in a competitive market (Mikalef et al., 2021). However, an organisation operates properly when its key resources, including technology and infrastructure, are properly aligned with its business strategy and organisational structure, resulting in the proper deployment and engagement of organisational resources (Coltman et al., 2015). The misalignment between business and IT strategies leads to lower levels of organisational performance (Al-Surmi et al., 2020). However, despite the growing discussion and research on digitalisation and digital technology business strategic alignment, there is still insufficient analysis of how organisations benefit from a strategic digital orientation (Kindermann et al., 2021).

The research perspective of digital transformation is particularly relevant from a sustainability point of view. Recent research shows that digital transformation facilitates the realisation of sustainable practices, as well as improving environmental well-being (Awad & Martín-Rojas, 2024). Digital technologies enable better resource management in nature-based industries (Frau et al., 2022), and they contribute to better resource use and achieving sustainable development (Trieu et al., 2023). However, research also confirms that the impact of digital technologies on the environmental performance of organisations is curvilinear. Initially, it may improve it, but in subsequent stages, it may worsen it (Li, 2022). Therefore, it is important for today's organisations to consciously and appropriately recognise digital transformation processes and to externally align with changes in the organisation's environment.

In view of the above, based on analysis of the literature, we have identified a research gap regarding the role of digital technology business strategic alignment (DTBSA) in the relationship between digital technology infrastructure management (DTIM) and an organisation's digital capabilities (DC). Consequently, the aim of this paper is to examine the impact of DTIM on DC in small and medium-sized energy enterprises, with DTBSA as a mediating variable.

The logical structure of the article is as follows. Section 2 outlines the theoretical aspects of digital technology infrastructure management, digital capabilities and digital business strategic alignment. Section 3 provides the characteristics of the research procedures, while section 4 presents the results. The discussion and conclusions, together with further research directions, are presented in section 5.

Theoretical background

Digital technology infrastructure (DTI) comprises physical and software-based components that work together to transfer information and digital products and services from one location to another (Matli & Wamba, 2023). The main goal of DTI is to ensure the efficient sharing and consumption of data using a data infrastructure that enables the sharing, storage and use of data (Jayalath & Premaratne, 2021).

DTIM therefore, means using digital technology infrastructure to effectively protect a company's information (Marchand et al., 2000) while providing superior storage and data transmission, increasing processing capacity, and reducing response time to changes in the environment (Chen et al., 2012). DTIM provides the highest level of technology overall, which should be consistent and appropriate for both the sector and the company. It also includes the formulation of actions to ensure the integration and flexibility of digital technology services across the organisation (Ross et al., 1996). By implementing DTIM, organisations are able to efficiently reconfigure their digital technologies and adapt them to sudden changes (Li et al., 2021).

Digital technologies are transforming the energy industry, becoming one of its most important resources. They enable smart energy management by providing consumers with information on energy volumes, enabling remote control and more economical management of resources (Lyu & Liu, 2021; Wu et al., 2022). Accurate data analysis translates into more accurate forecasts, which in turn help suppliers to meet customer needs (Wierzchowski, 2019). Digital technologies contribute to the use of renewable energy sources by enabling energy storage (Zhao & You, 2020). Among the technological resources in the energy sector, a special role is played by information and communication technologies, which allow for the collection, processing and transmission of information in digital form, enabling efficient communication between people and between people and devices (Zuppo, 2012).

Referring to the issue of DTIM in the energy sector, while the consideration of digital assets and digital technology infrastructure is increasingly being discussed (Bin Amin & Rahman, 2019; Bastida et al., 2019; Lyu & Liu, 2021; Shabalov et al., 2021), there is a lack of publications directly addressing digital technology infrastructure management.

Digital technology-business strategic alignment

Strategic alignment in the area of IT is understood as the degree to which the goals and plans in the organisation's strategy are supported by and shared with the IT strategy (Cheng et al., 2023). The essence of strategic alignment is the harmonisation of the information system with the business strategy, and the effective use of information system resources to support business strategies (Shao, 2019). Nowadays, strategic alignment requires consideration of technological solutions (Panda & Rath, 2018) since it contributes to innovation processes (Sarwar et al., 2023). However, change does not always have to take a radical form, but should focus on updating, optimising and aligning current digital technology solutions (Mahboub & Sadok, 2023). DTBSA improves an organisation's ability to respond to turbulent changes in the environment (Li et al., 2021).

Since changes in the digitalisation process of energy enterprises are dynamic (You & Yi, 2021), the importance of strategic adaptation from a digital perspective turns out to be an important issue for this group of enterprises. Research conducted in energy companies shows the involvement of digital technologies in the efficiency and streamlining of the organisation's operations (Latapí et al., 2021).

Digital capabilities

Digital capabilities (DC) refer to an organisation's ability to manage digital technologies for new product or service development (Khin & Ho, 2018). DC are not 'just IT-based capabilities', but are oriented towards facing new dynamic changes in the business environment. In this regard, Luu (2023) points out that DC improve the organisational potential for the development and effective use of resources, processes, knowledge management and customer relations by leveraging digital technologies. DC relate not only directly to innovation issues, but also to organisational aspects from both operational and strategic perspectives (Annarelli et al., 2021).

Zhang et al. (2024) suggest that DC are a manifestation of dynamic capabilities in the era of digitalisation. They focus on DC from the perspective of digital sensing, digital seizing and digital reorganising. A study by Heredia et al. (2022) suggests that, thanks to DC, organisations are able to generate technological innovation faster than with the use of traditional capabilities. Therefore, the quicker an organisation digitalises, the quicker it becomes more efficient. Notably, DC encompass such activities as Zhou and Wu (2010): identifying new digital opportunities; acquiring important digital technologies; responding to digital transformation; developing innovative products/services/processes using digital technology; and mastering state-of-the-art digital technologies.

The use of digital technology is one of the characteristics of the energy company of the future (Latapí et al., 2021). Since developing DC is key from an improvement perspective as part of an organisation's digital transformation (González-Varona et al., 2021), it appears justified to identify more precisely what affects the digital capabilities of energy companies.

Digital technology infrastructure management and digital technology-business strategic alignment

DTIM integrates the digital technology infrastructure used in an organisation in order to make the best, flexible use of its digital technologies. By increasing information processing capacity and reducing response times, it enables more effective decision-making (Li et al., 2021; Ross et al., 1996). DTBSA, on the other hand, enables close collaboration between IT experts and business managers, ensuring that the technologies used contribute to the company's strategic business value creation (Clemons & Row, 1991; Lu & Ramamurthy, 2011). However, only the integrated and flexible use of existing digital technologies provided by the implementation of a DTIM will enable value creation and effective implementation of the digital business strategy, which is the goal of the DTBSA. Collaboration between the management domain and the IT area is more effective when DTIM is applied, as it enables the effective use of IT in the business (Njanka et al., 2021; Willcocks & Feeny, 1998).

DTIM encompasses data and systems protection, which promotes operational and, consequently, strategic continuity and stability (Pashutan et al., 2022). It also ensures the high performance of the digital technology infrastructure, thereby supporting the business strategy by providing fast and reliable access to data and applications (Jayalath & Premaratne, 2021). It allows the scaling of digital technology assets in response to changing business needs, enabling rapid response to market changes and strategic challenges. Successful implementation of DTIM provides opportunities to implement innovative technologies, which can translate into the creation of new products, services and business models, which in turn can be a source of competitive advantage – one of the most common business goals of companies (Njanka et al., 2021).

In view of the above considerations, the following hypothesis is proposed.

Hypothesis 1: DTIM has a direct positive impact on DTBSA among SMEs in the energy sector.

Digital technology infrastructure management and digital capabilities

Due to the fact that the construct of digital technology infrastructure management has been relatively unexplored (Li et al., 2021), there is a lack of publications directly analysing its impact on digital capabilities (DC). However, there are studies in the literature that provide evidence of a link between IT infrastructure capability and digital capabilities (Van De Wetering et al., 2018).

Assuming that DC are a type of dynamic capabilities in the digital area, and as such allow an organisation to adapt faster to changing environments (Khin & Ho, 2018; Zhang et al., 2024), DTIM can have a significant impact on their development. Effective management of digital technology infrastructure ensures optimal use of technological resources, especially those that increase an organisation's ability to respond quickly to change (Chen et al., 2012). Implementing DTIM in an organisation enhances its information processing capabilities while at the same time reducing the response time to change by increasing its flexibility. Through the implementation of DTIM, organisations are able to efficiently reconfigure their digital technologies and adapt them to the requirements of the environment (Li et al., 2021). In addition, an effectively implemented DTIM provides the space and conditions for experimenting with new technologies, which is crucial for the development of new capabilities, especially as dynamic capabilities involve not only the process of integrating and reconfiguring resources, but also the development of new resources and the modification of the existing resource base (Helfat et al., 2007; Helfat & Peteraf, 2009).

Based on the above considerations, it can be concluded that DTIM has an impact on the integration, development and reconfiguration of resources, thus amplifying digital capabilities. As a consequence of the above considerations, the following hypothesis was posed.

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Hypothesis 2: DTIM has a direct positive impact on DC among SMEs in the energy sector.

Digital technology-business strategic alignment and digital capabilities

Among the micro-foundations of digital capability, the following are highlighted: digital audience segmentation and digital future forecasting (for digital sensing); strategic agility and adaptability, balancing digital cost and benefit, and balancing portfolios (for digital seizing); and redesigning organisational structures and establishing a seamless digital environment (for digital transforming) (Balta et al., 2024). An inherent aspect of the digital transformation process is that it is of a strategic nature. The implementation of the digital strategy by the individual participants in the organisation translates into its digital performance (Luu, 2023). Introducing digital change in an organisation cannot be done unreflectively, as it requires both a bottom-up and a top-down approach (AlNuaimi et al., 2022), which demonstrates the crucial importance of strategic alignment directed towards digitalising improvements in the organisation. On the basis of these considerations, the following hypothesis was formulated.

Hypothesis 3: DTBSA has a direct positive impact on DC among SMEs in the energy sector.

All three hypotheses developed from the literature review are presented in Figure 1.

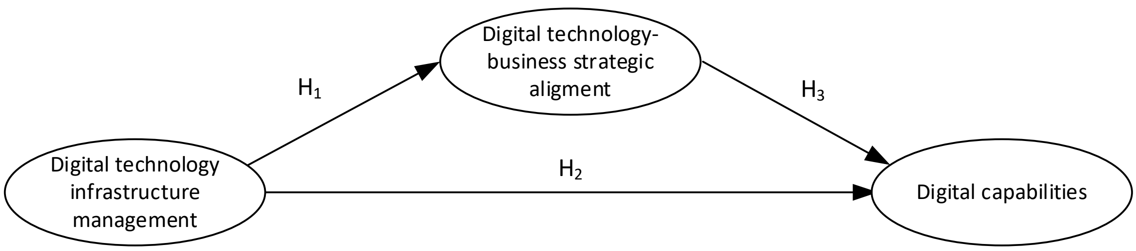

Figure 1. Research hypotheses

Research methods and sampling

Achieving the stated research objective and verifying the hypotheses required a rigorous research procedure consisting of four main stages. In the first stage, a literature analysis was conducted to confirm the existence of a research gap. This stage was also aimed at identifying existing constructs for measuring latent variables and selecting a specific measurement tool. The research objective was pursued by undertaking an analysis based on structural equation modelling (SEM). The research tool comprised scales previously validated by researchers addressing the issue of digitalisation: digital technology infrastructure management (DTIM)(Li et al., 2021; Xie et al., 2022); digital technology-business strategic alignment (DTBSA) and digital capability (DC) (Zhou & Wu, 2010). All items were measured on a 5-point Likert scale from 1 = "strongly disagree" to 5 = "strongly agree."

In the second phase, twelve energy industry experts were consulted (seven energy industry practitioners and five energy industry academics). The aim of this stage was to check the accuracy of the questions and the clarity of their phrasing.

The third phase was a baseline survey of energy companies operating in Central European countries. A total of 197 fully completed questionnaires were received (the sample structure is presented in Table 1). Only small and medium-sized companies were included in the survey. It was assumed that the specifics of micro-enterprises are quite different from those of large enterprises, which could hinder attempts to capture the phenomena analysed. However, this is a research limitation that the authors are aware of. As indicated in the last part of the article, it would be worthwhile in the future extending the research to both micro and large enterprises in the energy sector.

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Table 1. Sample structure

Size of enterprises	Percentage of the sample
Small	55.84%
Medium	44.16%

The fourth main stage of the research process involved analysing the data and formulating conclusions. Following the survey, a data table was created containing all respondents' responses. The next step was to perform a data validity analysis to eliminate outliers due to incorrect data entry, and afterwards to carry out the statistical analyses presented in the following section of the article. In particular, exploratory analyses of the proposed measures (factor analyses) and confirmatory analyses of the constructs were carried out. Finally, in order to verify the hypotheses, an analysis based on structural equation modelling (SEM) was carried out. STATISTICA v.13.3 software was used for each of these final stages.

Results

In order to achieve the objectives and verify the hypotheses, synthetic indicators of the phenomena under study were created on the basis of the literature review. After data collection and verification, exploratory analyses were carried out. A summary of the eigenvalues and the percentage of total variance explained for all the phenomena studied is presented in Table 2.

Table 2. Eigenvalues and percentage of total explained variance

Construct	Component	Eigenvalue	Cumulative % of explained variance
Digital technology-business strategic alignment	1	2.95	73.75
	2	0.43	84.42
	3	0.34	92.89
	4	0.28	100.00
Digital technology infrastructure management	1	2,43	80.86
	2	0,29	90.43
	3	0,29	100.0
Digital capabilities	1	3.60	71.99
	2	0.52	82.38
	3	0.34	89.23
	4	0.29	95.01
	5	0.25	100.00

Analysis of the results using the Kaiser criterion and Cattell's scree plot confirms the univariate nature of all three latent variables examined. The next step was confirmatory factor analysis, the results of which are presented in Table 3.

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Table 3. Confirmatory factor analyses

Construct	Item	Std. Factor loadings	SRMR	Goodness of Fit Indexes
Digital technology-business strategic alignment	DTBSA1	0.82**	0.04	GFI=0.93 AGFI=0.90 NFI=0.95 CFI=0.98 IFI=0.98
	DTBSA2	0.82**		
	DTBSA3	0.84**		
	DTBSA4	0.75**		
Digital technology infrastructure management	DTIM1	0.84**		
	DTIM2	0.84**		
	DTIM3	0.85**		
Digital capabilities	DC1	0.81**		
	DC2	0.72**		
	DC3	0.88**		
	DC4	0.84**		
	DC5	0.78**		
**p<0.01				

All goodness-of-fit indices (GFI, AGFI, NFI, CFI AND IFI) for the measurement model were within the recommended ranges (above 0.9). Similarly, the SRMR and p-values for the model were at satisfactory levels (0.0044 and 0.001 respectively). In addition, the Cronbach's alpha reliability coefficient values for each scale reached high values (0.88 for DTBSA and DTIM; 0.90 for DC).

Having established the validity and reliability of the constructs used, an SEM analysis was carried out. A control variable (the size of the organisation) was added to the basic model (see Figure 2).

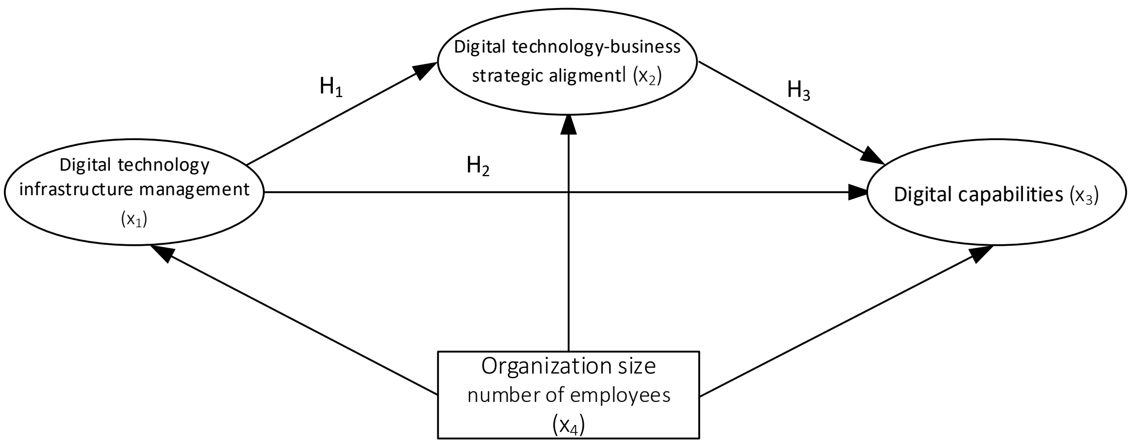

Figure 2. The final research concept

After initial analysis and elimination of the path with the lowest p-value (elimination due to lack of degrees of freedom in the model), the final model was obtained, as shown in Figure 3.

For the model presented, the goodness-of-fit indices, that is GFI, AGFI, NFI, CFI and IFI, were respectively: 0.99, 0.96, 0.99, 0.99, 0.99. The p-value for the model was 0.20, and the SRMR was 0.02. The values of the above indices indicate a good fit of the model to the correlation matrix.

The values of the specific paths in the model indicate a surprisingly small impact of the control variable, organisation size, on the other variables. The only statistically significant value in this case relates to the effect of organisational size on the management of digital technology infrastructure.

The analysis also confirmed the impact of DTIM on DTBSA (0.61) and on DC (0.25).

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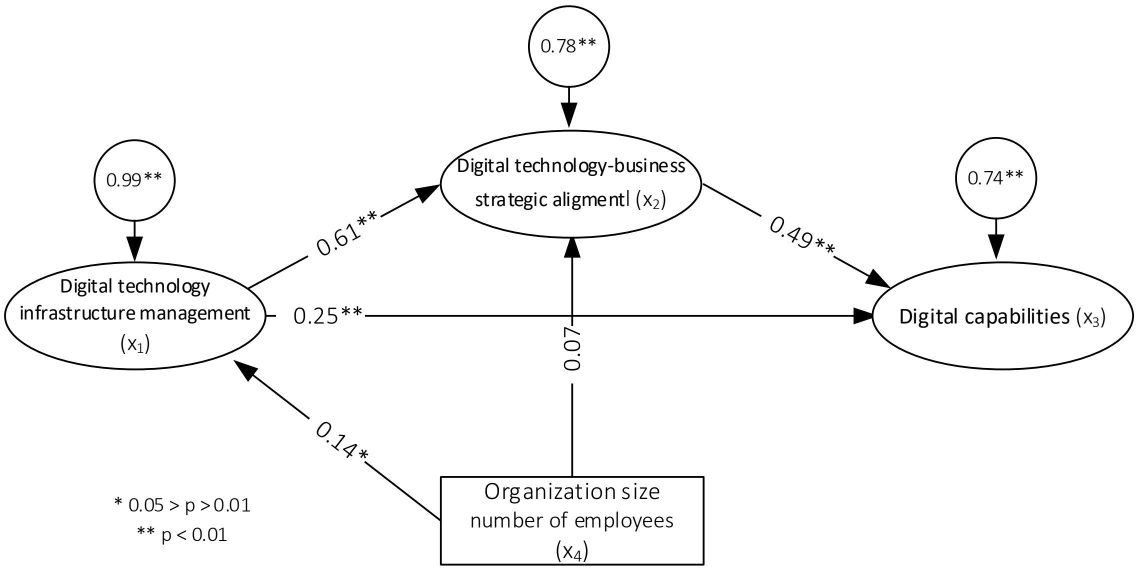

Figure 3. Results of the SEM analysis

A moderate, statistically significant value was also obtained for the path describing the direct impact of DTBSA on DC. These values show the important role of the variable DTBSA, which in the presented model acts as a mediator between DTIM and DC. The value of the influence of DTIM on DC through the mediating variable DTBSA is 0.30, which is a stronger influence than the direct influence of DTIM on DC.

Discussion

The aim of our article was to examine the impact of DTIM on DC in small and medium-sized energy enterprises, with DTBSA as a mediating variable. Hypothesis H2, according to which *DTIM has a direct positive impact on DC among SMEs in the energy sector*, was confirmed. However, the obtained result is difficult to compare with previous studies, due to the fact that DTIM is a relatively unexplored construct (Li et al., 2021). Nevertheless, our results are in line with the conclusions of Wang and Ahmed (Wang & Ahmed, 2007), who assume that DC are a category of dynamic capabilities in the digital domain, enabling the development, reconfiguration and reconstitution of digital resources, thus increasing the flexibility of organisations. In turn, DTIM allows the optimal use of digital resources, especially those enabling rapid response to a changing environment (Chen et al., 2012; Ross et al., 1996). On the one hand, an effectively implemented DTIM, by increasing information processing capabilities and reducing response time to changes, enables digital resources to adapt to the requirements of the environment (Li et al., 2021). On the other hand, it also contributes to the creation and development of new digital resources by providing a facilitating environment for experimenting with new technologies (Helfat & Peteraf, 2009). On this basis, it can be concluded that DTIM has a direct impact on the creation, development and reconfiguration of digital resources, especially those that enhance the adaptive capabilities of the organisation, i.e. DC.

Our research also confirmed the validity of hypothesis H1, according to *which DTIM has a direct positive impact on DTBSA among SMEs in the energy sector*. By integrating digital technology infrastructure, DTIM ensures better alignment of technology with the needs of the organisation, faster response to change and more effective decision-making (Li et al., 2021; Ross et al., 1996). Only in such conditions, ensured by the implementation of DTIM, are value creation and effective implementation of business strategy possible, which is the main goal of DTBSA. The impact of DTIM on DTBSA is to provide a high-performance digital technology infrastructure that supports the business strategy by enabling reliable access to data and applications (Jayalath & Premaratne, 2021). DTIM enables effective collaboration between management and IT, which translates into the integration of the information system with the organisation's business strategy (Njanka et al., 2021).

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The results of the study also support hypothesis H3, which states that: *DTBSA has a direct positive impact on DC among SMEs in the energy sector*. This conclusion is in line with previous research, according to which the strategic alignment of digital technology with business, which enables the effective harmonisation of the management and IT domains, enhances DC by enabling digital foresight and segmentation of digital customers, ensuring agility and adaptability, balancing digital benefits and costs, as well as changing the organisational structure and creating an appropriate seamless environment to foster digital capabilities (Balta et al., 2024).

The fourth observation from our study may appear somewhat disappointing, with only a slightly higher effect of the mediating variable on the relationship between DTIM and DC in the small and medium-sized energy company sector (from 0.25 to 0.30). An equally puzzling observation is that the size of an organisation has a statistically significant, but only small, effect on DTIM. Perhaps the context of the business competencies of managers responsible for aligning the organisation in the field of IT should be taken into account more strongly. Cheng et al. (2023) suggest that the benefits of IT require a managerial approach with business competencies. Our study did not draw particular attention to this, however, based on the findings of previous research on the importance of soft aspects of management in the digitalisation process in energy companies (Chwiłkowska-Kubala et al., 2023; Malewska et al., 2024), it would be worth considering this issue in further research.

In general, changes in the area of digitalisation are taking place more slowly in the energy sector than in other sectors (Maroufkhani et al., 2022). However, the pace of digitalisation in the energy sector has been accelerating in recent years, and this trend is forecast to continue (Li et al., 2023), especially as it is emphasised that this is a prerequisite for the survival of companies in the industry (Chwiłkowska-Kubala et al., 2023).

Conclusions, further research directions and research limitations

This study contributes to the development of management theory and practice regarding the shaping of digital capabilities. Firstly, our results suggest a direct impact of DTIM on DC. By enabling the optimal use of digital resources and reducing the reaction time to change by increasing information processing capacity (Chen et al., 2012; Ross et al., 1996), DTIM amplifies DC, understood as capacities that enable the development, reconfiguration and reconstruction of digital resources by increasing the flexibility of organisations (Wang & Ahmed, 2007).

Secondly, the results of our study show the direct impact of DTIM on DTBSA. This is in line with previous research, which shows that DTIM enables better alignment of technology with organisational goals (Li et al., 2021; Ross et al., 1996), integration of the information system with the organisation's business strategy (Njanka et al., 2021), as well as value creation and the effective implementation of business strategy (Aversano et al., 2012).

Thirdly, our results also support the hypothesis that DTBSA has a positive impact on DC. In an attempt to justify this conclusion, we refer to research by Balta et al., who argue that the strategic alignment of digital technologies with business strategy by combining the areas of IT and management enhances DC (Balta et al., 2024).

Fourthly, our research confirms the mediating role of DTBSA in the relationship between DTIM and DC. Therefore, it demonstrates the importance of mutual alignment between digital resources and business strategy. However, this impact is only slightly higher, which suggests that other factors may exist that enhance the role of DTBSA.

The identified relationships between the constructs analysed, and above all the important role of DTBSA in shaping DC, apply to small and medium-sized energy companies, providing practical implications for the managers of these organisations. The alignment of digital technologies with business strategy in energy companies requires managers to precisely define and prioritise business objectives in order to understand which areas are critical to the long-term success of the company, as well as assess current technologies so as to determine their alignment with business objectives and identify technology gaps. It is also important to integrate technology with business strategy by designing a system architecture that integrates new technologies with existing ones to ensure seamless operation and data exchange. For efficient integration of the IT and management domains, thus enhancing digital capabilities, change management is also important, including both employee training in the

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area of implemented new technologies and resistance management, as well as developing an innovation culture. It is also desirable to regularly monitor and improve the implemented technologies in terms of key performance indicators related to the implementation of the business strategy. Aligning digital technologies with business strategy in the energy industry is not only key to increasing efficiency and profitability, but also a necessary step towards sustainability and adapting to a rapidly changing market.

The results of our study also indirectly address environmental issues by drawing attention to the importance of digitalisation as a process that supports environmental protection. The International Energy Agency estimates that the adoption of digital technologies could reduce the cost of electricity generation by $80 billion, which is 5% of the total cost of electricity generation worldwide (Hao et al., 2023).

Digitisation of the energy industry offers great opportunities for environmental protection especially in terms of reducing greenhouse gas emissions (thanks to digital tools such as smart meters and energy management systems, energy consumption is better controlled, additionally optimization of energy generation and distribution minimizes the need to use high-carbon energy sources), promoting renewable energy sources (through their integration and energy storage), and optimizing energy consumption (the use of smart grids allows for the reduction of transmission losses and optimal matching of demand and supply, furthermore the digitisation of production processes reduces the consumption of energy and natural resources) (Angelopoulos et al., 2019; Coban, 2019; Kuzmin et al., 2024; Zhu & Zhang, 2022).

Digital transformation can also generate potential negative environmental implications, among them an increase in energy consumption by digital infrastructure, the generation of e-waste or the exploitation of natural resources needed, for example, for the production of batteries used in energy storage (Wang, 2025). However, it seems that the positive aspects of the environmental impact of the digital transformation in the energy industry outweigh its potential negative implications, and the key to sustainability will be investment in green energy sources for digital systems and the development of technologies that support efficient resource management.

Although our study sheds light on the importance of aspects of strategic alignment in the course of an organisation's digitalisation efforts, it has limitations that may suggest further directions for research. Firstly, we used a single respondent design. In the course of data analysis, it would be worthwhile extending further research to include multiple perspectives of the organisation during the study. In addition, qualitative research as well as in-depth interviews would provide a more complete picture of the issue under analysis, which is a second limitation and at the same time a research direction to consider. Linked to the above is a third limitation, namely, the lack of consideration of the level of digital competence of the managers who are involved in DTIM and DTBSA. Addressing this issue in further research would contribute to a better recognition of the soft aspects of management in energy SMEs. Fourthly, the issue of the dynamic capabilities of organisations was not included in our study. As digital capabilities are taken as an example of organisational capabilities, it would be worthwhile expanding further research to identify how energy companies develop dynamic capabilities in the area of digitalisation and how these are translated into the final performance of the organisation, both non-financial and financial. Based on such considerations, it seems reasonable to attempt to identify the opportunities and ways to improve the organisational factors that influence the digitalisation process in energy companies. In considering the potential benefits and opportunities, it would be worthwhile to take into account different stakeholder perspectives. A more complete picture of the issue of the digital capabilities of energy companies could also be developed by including micro and large firms. While this is undoubtedly a major research challenge, it is worth considering given the different characteristics of these groups of entities.

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The contribution of the authors

Conceptualisation, K.M. and A. Ch.-K.; literature review, K. M. and A. Ch.-K.; methodology, K.M., A.Ch.-K. and W.Sz.; formal analysis, W.Sz.; writing, K.M. and A. Ch.-K.; conclusions and discussion, K.M. and A.Ch.-K.

The authors have read and agreed to the published version of the manuscript.

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ZARZĄDZANIE INFRASTRUKTURĄ TECHNOLOGII CYFROWEJ ORAZ STRATEGICZNE DOPASOWANIE BIZNESOWE JAKO CZYNNIKI ZWIĘKSZAJĄCE ZDOLNOŚCI CYFROWE W MAŁYCH I ŚREDNICH PRZEDSIĘBIORSTWACH ENERGETYCZNYCH

STRESZCZENIE: Celem artykułu jest zbadanie wpływu zarządzania infrastrukturą technologii cyfrowych (DTIM) na zdolności cyfrowe (DC) w małych i średnich przedsiębiorstwach energetycznych, przy udziale strategicznego dopasowania biznesowego technologii cyfrowych (DTBSA) jako zmiennej pośredniczącej. Analizując dane zebrane od polskich i niemieckich przedsiębiorstw przy użyciu metody CAWI (197 poprawnie wypełnionych kwestionariuszy zwrotnych) i modelowania równań strukturalnych (SEM), określono znaczenie zarządzania infrastrukturą technologii cyfrowych i strategicznego dopasowania biznesu w zakresie technologii cyfrowych dla zdolności cyfrowych. W postępowaniu badawczym potwierdzono hipotezy dotyczące wpływu DTIM i DTBSA na DC. Nieco nieoczekiwanie zaobserwowano niewiele większy wpływ DTBSA jako zmiennej pośredniczącej, co sugeruje dalsze kierunki badań nad procesem cyfryzacji przedsiębiorstw energetycznych. Chociaż sektor energetyczny jest nadal postrzegany jako powolny w adaptacji, badanie pokazuje, że zarządzanie infrastrukturą technologii cyfrowych pozytywnie wpływa na możliwości cyfrowe małych i średnich przedsiębiorstw z branży energetycznej.

SŁOWA KLUCZOWE: zdolności cyfrowe, zarządzanie infrastrukturą technologii cyfrowej, strategiczne dopasowanie biznesu do technologii cyfrowej, Przemysł 4.0, firmy energetyczne