

Going resilient with digital transformation, human capabilities and innovation readiness: empirical evidence from the energy sector

Digital
transformation
and human
capabilities

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Abstract

Purpose – The present study investigated organizational resilience (OR) in the United Arab Emirates (UAE's) energy sector to identify impactful technological and human variables and assess the hermeneutic effect of digital transformation on value co-creation and OR. The study also investigates the mediating role of value co-creation on a few covariates of OR.

Design/methodology/approach – The questionnaire was sent out to 311 professionals in the energy sector, all affiliated with governmental organizations, using quota sampling. A total of 206 collated responses corresponding to the tested variables regarding the influences of digital transformation, employee resilience, innovation readiness, cyber resilience and value co-creation on OR were analyzed using structural equation modeling. Accordingly, a model of eight constructs and their 27 indicators was tested.

Findings – Instituting flexibility and adaptability to technological advancements, as well as cyber resilience, was found to enhance digital transformation. The sense of self-efficacy of the professionals who participated in the study led them to develop innovation readiness and thus embrace creativity and encourage co-creation while maintaining collaborative efforts with customers and stakeholders. This mediated several technological and human variables, such as the importance of managers' understanding of customer needs, preferences and pain points, which involves actively seeking and valuing customer feedback to inform decision-making.

Practical implications – When iterative prototyping, continuous learning, and OR are integrated into an organization's culture, they create a robust foundation for a customer-centric mindset. This mindset becomes ingrained in how employees approach their work and make purposeful decisions.

Originality/value – The present study drew empirical insights into OR in the UAE's energy sector from a resource-based theory perspective. By identifying potential vulnerabilities and implementing appropriate mitigation measures, organizations can reduce the likelihood and impact of disruptions, which can ultimately help them maintain customer satisfaction and loyalty.

Keywords Cyber resilience, Digital transformation, Innovation readiness, Organizational resilience, Structural equation modeling, Value Co-Creation

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1. Introduction

Today's precursory business landscape has made organizations leverage the transformative power of digital technologies. Digital transformation is an indispensable impetus for organizations to stay competitive, enhance operational efficiency, and exceed customer experiences (Mathur *et al.*, 2023). Organizations explore plausible avenues for value co-creation and organizational resilience (OR) to improve efficiency. Value co-creation is the collaborative process between organizations and their stakeholders in which mutual value is generated by exchanging resources, knowledge, and experiences. Digital technologies have revolutionized value co-creation, enabling new engagement, participation, and innovation (Lokuge *et al.*, 2019; Lokuge and Duan, 2023).

As organizations confront disruptions, their adaptation, response, and recovery from them should be consummated. Digital technologies help organizations improve their agility, anticipate market changes, and quickly pivot in the face of microturbulence and uncertainties by adopting strategies to deal with them (Deng *et al.*, 2022).

However, the relationships between digital transformation, innovation readiness, value co-creation, and OR are multilayered. Organizational culture, leadership, and external market conditions confound these congeries (Darmani and Jullien, 2017; Halpern *et al.*, 2021). How value co-creation mediates these factors shapes OR in the face of digital transformation. However, there is a research gap regarding the optimal degree of technology integration into the human workforce and the role of human workers, although vital, can sometimes lead to workflow delays, and organizations introduce automation into the workplace motivated by the desire to enhance efficiency (Ajmal *et al.*, 2023). However, excessive automation may diminish human roles and institute machinery dominance; thus, automation must be carefully managed. Implementing technology with caution is imperative to prevent unintended consequences. Thus, "co-value" is the stabilizing force between automation and human involvement.

Given the preceding, the present study investigated a set of covariates impacting digital transformation, value co-creation, and OR, which are needed for managing resilience in energy enterprises. The research questions were as follows: (1) How does digital transformation impact value co-creation and OR? And (2) How does value co-creation mediate the relationships of various human factors with OR and innovation readiness?

2. Background studies and hypothesis development

Organizational resilience (OR) has been defined as the ability of an organization to "anticipate, prepare for, respond and adapt to incremental change and sudden disruptions in order to survive and prosper" (Hollnagel, 2010), "recover from disruptive events, whether caused by nature, technology, or human actions" (Linnenluecke, 2017), "maintain or rapidly return to normal functioning after experiencing an adverse event" (Herrero and Kraemer, 2022; Williams *et al.*, 2017), and "respond positively to change, adapt to new challenges and opportunities, and sustain or enhance its performance over time" (Vogus and Sutcliffe, 2007). Despite the varying perspectives associated with these definitions, they all highlight the importance of OR, which prompts organizations to prepare for, adapt to, and recover from disruptive events. To be resilient, an organization must accept the changing horizon. This requires senior managers to actively seek out firsthand experiences of change and think about the consequences of what they witness. Additionally, managers hardly consider the benefits of changing the business model. Instead, they constantly resist reallocating resources to new initiatives and tend to prioritize their programs involving overinvesting classically and jettisoning risky, innovative ideas (Saputri and Agustina, 2022).

As a result, the allocation of investment funds across business units is often unrelated to the relative attractiveness of investment opportunities within those units. Alternatively, it

combines aspects of both systemic and personal resilience research (Agliardi *et al.*, 2023). Given that OR encodes organizational capacity to withstand disruptive events or changes and to continue functioning effectively under such conditions, some features of OR include:

- (1) Anticipation: OR involves the ability to anticipate potential threats and to prepare for them proactively.
- (2) Adaptability: OR requires the ability to adapt and respond to changes in the environment, whether sudden or gradual.
- (3) Robustness: OR involves building robust systems and processes that can withstand disruptions without completely failing.
- (4) Learning: OR requires a willingness to learn from past experiences and to use that knowledge to improve future responses.
- (5) Collaboration: OR often involves collaboration across different departments, organizations, and stakeholders.

Alternatively, organizational coping, thriving, or growth is not the same. Organizational coping refers to an organization's strategies to deal with stress, adversity, or change. Coping strategies can range from reactive to more proactive, long-term measures. Organizational thriving denotes an organization's ability to grow and overcome challenges rather than simply surviving or coping (Miceli *et al.*, 2021). Thriving organizations are adaptable, innovative, and continually improving. They embrace change and actively seek out new opportunities. Organizational growth refers to an increase in an organization's size, reach, or revenue. Growth can be achieved through various means, such as expanding into new markets, acquiring other companies, or developing new products or services (Duchek, 2020; Miceli *et al.*, 2021).

Enterprise resilience is moderated by many factors, including external factors such as economic and relational resources and internal factors such as resource reallocation and leadership style (Zahari *et al.*, 2022). Other confounding factors include organizational culture (Potrich *et al.*, 2022), employee demographics (Franken *et al.*, 2020), industry dynamics (Codara and Sgobbi, 2023), and regulatory environment. Resource-based theory suggests organizations can gain a sustainable competitive advantage by leveraging their internal resources and capabilities (Varadarajan, 2023). Resources and capabilities would include digital technologies, resilient employees, strong relationships, co-created value, innovation readiness, and overall organizational resilience.

2.1 Digital transformation

Over time, digital transformation has adapted to meet specific industry indicators and challenges. Digital transformation focuses on automating and optimizing distribution processes by leveraging technology in the energy sector. This involves leveraging digital solutions to monitor, control, and manage the distribution of energy resources efficiently and in real-time. It includes implementing intelligent systems and automation tools to enhance the reliability and flexibility of distribution networks (Chawla and Goyal, 2022). Digital transformation encompasses integrating and optimizing energy storage systems with digital technologies. This involves leveraging data analytics and advanced algorithms to manage and optimize the performance of energy storage units, enabling efficient energy utilization, grid stability, and demand response capabilities (Ke *et al.*, 2017). They utilize cloud computing, scalable infrastructure, and agile methodologies to enable flexibility and agility (Warner and Wäger, 2019). Organizations can leverage cloud platforms to store and analyze large volumes of data, access software-as-a-service (SaaS) solutions, and facilitate

collaboration and data sharing across departments and locations (Raza and Khan, 2022). It is anticipated that digital technology will make the energy sector worldwide intelligent, connected, reliable, efficient, innovative, and sustainable. However, several challenges are associated with digital transformation, such as increased privacy and security risks. It presents enormous changes in business, market, and employment (Dupont, 2019). Thus, digital transformation can also contribute to enhancing organizational resilience. Organizations can become more agile and adaptable by embracing digital technologies and modernizing their operations. Digital transformation enables organizations to improve their ability to sense and respond to market trends, customer demands, and competitive pressures, mitigate risks, and seize new opportunities in the digital era. Nevertheless, business executives, policymakers, and other related stakeholders in the energy sector face issues in making decisions (Saunders *et al.*, 2021). Digital solutions such as asset management systems, customer billing and information apps, and predictive analytics enable energy companies to streamline operations, enhance customer engagement, optimize energy usage, and improve overall business performance (Viskovic and Franki, 2021).

There is no singular solution for policymakers, business executives, and researchers that guarantees guiding the development of strategies for a resilient, efficient, and sustainable energy future. More often than not, a combination of performance metrics related to system reliability, automation, digitization, innovation, and readiness intelligence should be interpreted. Incorporating renewable energy sources (such as solar or wind power) and adopting energy-efficient technologies within an organization's operations can bolster its ability to withstand and recover from disruptions (Cao, 2022). These sustainable energy solutions contribute to operational stability and positively impact the environment. Organizations can mitigate carbon emissions and minimize their ecological footprint by relying less on traditional fossil fuels and reducing energy consumption. This dual effect of improving resilience and reducing environmental harm makes integrating renewable energy and energy-efficient technologies valuable. It is anticipated that digital technology can make the energy sector worldwide intelligent, connected, reliable, efficient, innovative, and sustainable. However, several challenges are associated with digital transformation, such as increased privacy and security risks. It presents enormous changes in business, market, and employment (Dupont, 2019).

Value creation focuses on the company's unilateral efforts to create customer value. In contrast, value co-creation emphasizes collaborative and interactive processes between customers and companies, leading to more personalized and mutually beneficial value outcomes. Digital transformation enables greater customer engagement and collaboration (Çakıcı, 2022). Through digital platforms and tools, companies can gather real-time feedback, conduct interactive discussions, and co-create value by leveraging customer insights. Integrating digital tools enhances the collaboration between consumers and companies, fostering a more interactive and engaging customer experience. Digital agility plays a crucial role in value co-creation in digital transformation. It involves the ability of organizations to quickly respond to changing customer needs, market trends, and technological advancements. Digital technologies provide the flexibility and adaptability necessary to co-create customer value effectively. By combining all, companies can continuously adapt and improve their value propositions, enhancing the value co-creation process (Edvardsson and Tronvoll, 2022). By embracing digital transformation and leveraging digital solutions, energy companies can adapt to the changing landscape and unlock significant benefits for their customers and business operations. We propose that:

H1. Digital transformation has a positive effect on value co-creation.

Through DT initiatives, organizations can streamline processes, automate workflows, and optimize operations, improving efficiency and effectiveness. Digital technologies also provide

organizations with real-time data and analytics, enhancing their ability to sense and respond to market trends, customer demands, and competitive pressures. By harnessing these digital capabilities, organizations can quickly adapt to changing circumstances, mitigate risks, and identify new opportunities (He *et al.*, 2023). Moreover, digital transformation promotes a culture of innovation and continuous learning within organizations. It encourages experimentation, collaboration, and the adoption of emerging technologies, enabling organizations to stay ahead of the curve and proactively respond to disruptions (Vial, 2019). This proactive approach to change and innovation contributes to building OR. Based on these arguments, we propose that digital transformation empowers organizations to embrace change, leverage digital capabilities, and navigate uncertainties in a dynamic business environment. So, with the above background, we can propose the following:

H2. Digital transformation has a positive effect on organizational resilience.

2.2 Cyber resilience

Cyber resilience refers to an organization's ability to anticipate, withstand, and recover from cyber threats, incidents, and disruptions while delivering its essential functions and services. It encompasses a holistic approach to managing cyber risks, focusing on preventing attacks and effectively responding to and recovering from them (Hausken, 2020). Cyber resilience involves a combination of preventive, detective, responsive, and recovery measures, maintaining business continuity and adapting to changing cyber threat landscapes. It aims to ensure the organization's ability to withstand and recover from cyber incidents, minimize the impact of attacks, and maintain the trust of stakeholders (Tsen *et al.*, 2022).

Effective cybersecurity measures help protect organizations from potential threats, mitigate risks, and ensure the continuity of operations during disruptions. By surveying 124 Swiss energy market participants self-assessed their cybersecurity maturity levels, along with a detailed comparison of cybersecurity measures in Switzerland and neighboring European countries, it was concluded that the overall cybersecurity maturity in the Swiss electricity sector is considered deficient in information and operation technology (Heymann *et al.*, 2022). Rather than strengthening infrastructure against specific issues like cybersecurity, a proactive approach is steered to prevent and manage the consequences of disruptive events. The electric power system comprises IT infrastructures, electrical systems, cyber systems, people, physical components, and financial elements. Addressing cybercrimes and attacks in the energy sector presents significant challenges that require mitigation rather than elimination (Venkatachary *et al.*, 2017).

Customers are likely to perceive an energy provider positively if they are transparent about their cybersecurity measures, actively communicate efforts to safeguard customer data, and continuously invest in improving their security posture. Given the UAE's status as a highly digitized and interconnected city, the risk of cyberattacks on critical energy infrastructure is a significant consideration. Cyberattacks can target power grids, control systems, and communication networks, potentially causing blackouts, data breaches, or physical damage. Safeguarding these systems against cyber threats is crucial to maintaining a resilient energy supply. Technical deficiencies pose another challenge to the energy supply in the UAE. Poorly maintained power plants, transmission lines, and distribution networks are more susceptible to breakdowns, leading to power outages and service disruptions. Therefore, prioritizing robust technical systems, investing in infrastructure upgrades, and ensuring proper maintenance are essential for maintaining a resilient energy supply in the city. The UAE's energy markets are not immune to market volatility. Geopolitical tensions, economic instability, and changes in energy demand and supply can result in significant price fluctuations and supply disruptions (Griffiths, 2019). These factors can affect the availability and affordability of energy resources for consumers and energy providers. By prioritizing

cybersecurity measures, organizations minimize cyber incidents, maintain critical functions, and ensure overall resilience. Based on this argument, we postulate the following.

H3. Cyber resilience has a positive effect on organizational resilience.

2.3 Employee resilience

Employee resilience is the capacity to persist in adversity and to adapt to new circumstances, using personal resources such as positive emotions, optimism, self-efficacy, and social support. Employee resilience, in a way toward OR, is a concept in behavioral capability that enables employees to manage and adapt to ever-changing working conditions, focusing primarily on individual reintegration or improving personal resources. It also focuses on developing organizational resources that ensure employees' essential and flexible resilience (Cooke *et al.*, 2020).

Customers tend to appreciate energy providers that are transparent about their cybersecurity measures, communicate efforts to safeguard customer data and invest in improving their security postures. Although the organizational integration of learning, resilience, and engagement makes them adaptive, there is a lack of research exploring the connection between organizational learning, employee resilience, and work engagement. Kohn (2020) developed and tested a mediation model investigating how learning organization influences employee resilience and work engagement to address this gap. Survey data from 300 IT professionals in India was analyzed using structural equation modeling and mediation analyses. The findings revealed a significant positive relationship between learning organization, employee resilience, and work engagement. Moreover, it was discovered that employee resilience partially mediates the relationship between learning organization and work engagement (Kohn, 2020).

Employee resilience is a scalable and improved ability that requires an organization that enables sophisticated employee training. Resilient individuals tend to have more remarkable neural plasticity in adapting to changes and reorganizing neural connections. Mindfulness practices, which can help promote employee and relationship resilience, can also lead to changes in brain structure and function, such as increased gray matter density in the prefrontal cortex and decreased activity in the amygdala (Kuntz *et al.*, 2017).

Building employees' resilient capabilities contributes to individual and collective resilience within the organization. By leveraging social networks, employees can access resources, solve problems collectively, and engage in pro-social behaviors. Adaptability enables employees to respond effectively to threats, find innovative solutions, and manage stress. Learning goals and exchanging knowledge among employees promote individual growth, mastery of new situations, and the ability to navigate challenges. Additionally, employee motivation and control over learning decisions promote engagement, self-efficacy, and individual performance, collectively contributing to organizational resilience. Organizations can thus adapt to change, overcome obstacles, and contribute to the overall resilience of the organization (Malik and Garg, 2017). Resilient employees stay present, focused, and emotionally balanced during times of uncertainty and contribute to project outcomes even under psychological distress. Learning from experiences and overcoming challenges are associated with improved neuroplasticity and cognitive control. Managers should prompt continuous learning, use coping strategies, adaptability, and innovation among employees, and prioritize value co-creation with customers, suppliers, and other relevant stakeholders. Organizations should develop innovation readiness, risk-taking, openness to change, and proactivity among employees (Plimmer *et al.*, 2022). Accordingly, the following hypotheses were proposed.

H4. Employee resilience has a positive effect on value co-creation.

H5. Employee resilience has a positive effect on organizational resilience.

2.4 Innovation readiness

The concept of organizational readiness for innovation has been explored in the literature, with various dimensions and criteria identified. Stewart proposed vital elements to assess an organization's adaptability and barriers to innovation, while Egan *et al.* focused on evaluating hospital readiness for research programs. Organizational readiness refers to the promptness to develop, adopt, and implement new products, services, or processes, with members' beliefs and attitudes playing a crucial role (Helfrich *et al.*, 2011). It encompasses four dimensions: culture of innovation, innovative behavior, innovation strategy, and innovation infrastructure. Measuring organizational readiness has shown positive outcomes, such as increased patient engagement and successful implementation of programs and evidence-based practices (Lam, 2011). Organizational readiness embraces digital transformation to adapt to new technologies and remain competitive. Successful digital innovation involves multiple adjustments to resources, staffing, and reward systems. Continuous organizational learning enhances innovation readiness for strategic clarity, effective partnering, and internal capabilities (Lokuge *et al.*, 2019). Nevertheless, extensive research is needed to establish specific performance metrics related to digital innovation.

Different types of readiness are necessary for organizational change, including resource, IT, cognitive, partnership, innovation, cultural, and strategic readiness. Each type focuses on different aspects such as resources, technology infrastructure, knowledge and skills, collaboration with external partners, openness to change, cultural values, and strategic vision. Innovation readiness refers to the ability of firms to innovate and adapt to changes in the environment.

Innovation readiness refers to an organization's preparedness and capability to embrace and implement innovative solutions. Smart grid implementation involves the integration of advanced technologies and novel approaches in energy distribution. More innovation-ready organizations are likely to be better positioned to leverage the benefits of Smart grid implementation, such as improved operational efficiency, enhanced grid reliability, and increased adaptability (Thomas and Mishra, 2022). Organizations with high innovation readiness can enhance their resilience by utilizing intelligent grid technologies and embracing innovation. Nonetheless, linking customer satisfaction to innovation is debated. Breakthrough innovations may initially receive mixed reviews, especially considering that innovation hackathons could misrepresent the quality of ideas generated. The value of innovation is not accurately represented by traditional return on investment. Organizations may engage in wasteful spending without achieving meaningful outcomes. The following hypothesis was formulated.

H6. Innovation readiness has a positive effect on organizational resilience.

2.5 Value co-creation

Value co-creation is an innovative and collaborative process between an organization's stakeholders and the organization itself to end with an increase in the product or service value (s). It is the joint realization of mutual value by multiple actors, such as customers, employees, partners, and organizations. It denotes a dynamic collaboration between a service or coordinated activities of an organization and its customers, enabled by technology and other resources, which enhances the value of products and services provided by the organization (Payne *et al.*, 2008; Spitzack and Hansen, 2010). Engaging in joint activities to create value by integrating resources and knowledge facilitates the emergence of new service ecosystems enabled by digital technologies and emerging business models (See-To and Ho, 2014; Vargo *et al.*, 2008).

Value co-creation involves the active involvement of customers, employees, and other stakeholders in creating and delivering value. Organizations that engage in value co-creation

are more likely to be resilient, as they can adapt to changing customer needs and preferences. However, effective value co-creation requires a solid organizational culture that values collaboration, learning, and experimentation (Ramaswamy and Ozcan, 2018).

Value co-creation emphasizes the collaborative efforts between organizations and stakeholders to create mutual value. Resilient employees contribute to the overall value co-creation process with adaptability, problem-solving skills, and customer focus (Grönroos, 2012). By engaging in value co-creation activities, organizations can enhance their relationships with stakeholders, improve their responsiveness to changing customer needs, and develop robust support networks, strengthening organizational resilience. It is rational to hypothesize the following:

- H7.* Value co-creation has a positive effect on organizational resilience.
- H8.* Value co-creation mediates the positive relationship between innovation readiness and organizational resilience.
- H9.* Value co-creation mediates the positive relationship between digital transformation and organizational resilience.
- H10.* Value co-creation mediates the positive relationship between cyber resilience and organizational resilience.
- H11.* Value co-creation mediates the positive relationship between employee and organizational resilience.

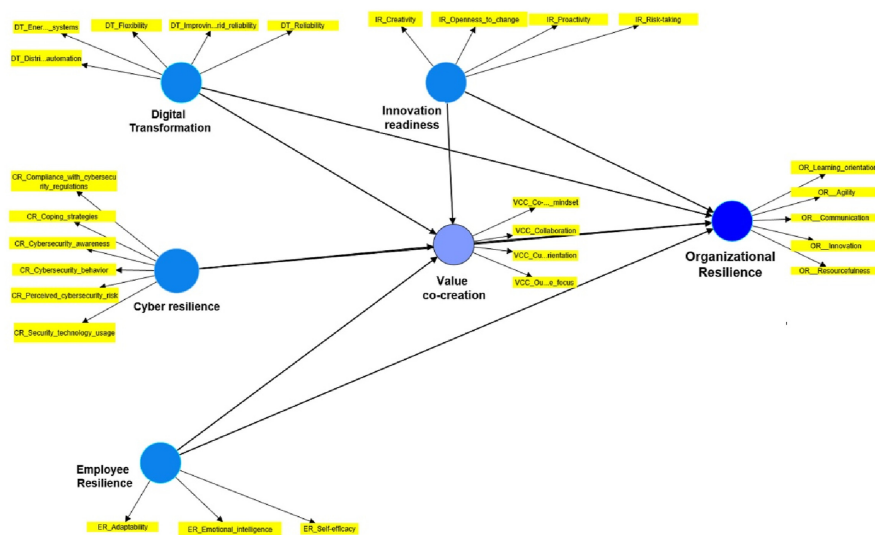
3. Method

The UAE's energy sector sampling process involved several steps to obtain a representative sample. Initially, the target population was identified as employees working in the energy sector of various companies in the UAE. A sampling frame was then created, comprising a comprehensive list of all the UAE's energy sector companies. This sampling frame served as the basis for selecting the sampling units: individual employees from each company.

A random, convenient sampling strategy was employed to ensure diversity and representation within the sample. The companies in the sampling frame were categorized into strata based on their size, such as small, medium, and large companies. This stratification aimed to account for potential differences within the energy sector. From each stratum, a proportionate number of sampling units were randomly selected. These selected individuals formed the final sample for the study.

The sampling size was determined using G-power software after piloting (Faul *et al.*, 2007). The software considered factors such as desired statistical power, effect size, and significance level to estimate the sample size needed. A power analysis was performed to determine the sample size that would enable the detection of anticipated relationships between variables with a specified level of confidence. Based on the analysis, a sample size of 204 participants was sufficient for the study. The conceptual model connects several variables in relation to the hypotheses (Figure 1). A structured 80-item questionnaire was utilized to measure the six primary constructs of interest in the study and their 27 indicators.

An exploratory factor analysis (EFA) was performed to identify the underlying factor structure and relationships among the items. A statistical software package, such as SPSS, was used to conduct the analysis. SPSS helped extract factors, determine the number of factors to retain and assess the factor loadings and communalities of the items. Confirmatory factor analysis (CFA) was conducted using structural equation modeling (SEM) to confirm and validate the factor structure identified. The model was specified with the latent factors and their corresponding observed indicators (items). The model's goodness-of-fit was evaluated using fit



Source(s): Created by authors

Figure 1.
Conceptual model

indices such as chi-square, comparative fit index (CFI), Tucker-Lewis index, root mean square error of approximation (RMSEA), and standardized root mean square residual. When the initial CFA model did not meet the desired fit criteria, the model was modified by adding or removing paths, allowing correlated errors between items, or making other adjustments to improve model fit. The model was modified based on statistical and theoretical considerations. The items' factor loadings, standard errors, and significance levels were examined to understand the relationships between the latent factors and observed indicators.

SEM was employed to test the hypotheses in this study. To avoid overfitting the model, a different dataset was used, separate from the pilot study data, and analyzed by the study objectives. To test the proposed model and its hypotheses, partial least squares structural equation modeling (PLS-SEM) was utilized with the assistance of SmartPLS software version 4. We examined the interplay between innovation readiness, digital transformation, value co-creation, relationship resilience, employee resilience, and organizational resilience. These relationships may explain how these variables influence the organization's ability to adapt and thrive in a dynamic environment.

4. Results

We examined the relationships between digital transformation, value co-creation, OR, and their underlying factors. The analysis assessed the proposed model's fit and tested the hypothesized relationships. The reliability and validity measures are given in Tables 1 and 2. The outer loadings and VIF values are displayed in Table 3. The reliability measures, including Cronbach's Alpha, rho_A, composite reliability, and average variance extracted (AVE), indicate that the items within each construct are internally consistent and reliable.

The first hypothesis (H1) proposed that digital transformation positively affects value co-creation. The indicators of digital transformation (i.e. cloud service usage, cost savings, reliability, and flexibility) all displayed significant positive associations with OR, with flexibility and reliability showing the strongest positive associations (0.915 and 0.873, respectively). The path analysis between digital transformation and value co-creation yielded a positive

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Table 1.
Reliability measures

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Value co-creation	0.923	0.927	0.946	0.815
Cyber resilience	0.886	0.892	0.913	0.638
Digital transformation	0.89	0.898	0.92	0.699
Employee resilience	0.89	0.891	0.932	0.819
Innovation readiness	0.809	0.826	0.875	0.638
Organizational resilience	0.829	0.839	0.882	0.604
Source(s): Authors' own work				

Table 2.
Fornell matrix for
validity

	1	2	3	4	5	6
Value co-creation	0.903					
Cyber resilience	0.754	0.799				
Digital transformation	0.86	0.818	0.836			
Employee resilience	0.744	0.834	0.746	0.905		
Innovation readiness	0.778	0.832	0.812	0.803	0.799	
Organizational resilience	0.742	0.847	0.802	0.686	0.753	0.777
Source(s): Authors' own work						

Table 3.
Outer loadings and VIF
for all indicators

Construct	Indicator	Outer loading	VIF
Cyber resilience	Compliance with cybersecurity regulations	0.897	3.971
	Coping strategies	0.814	2.685
	Cybersecurity awareness	0.788	2.859
	Cybersecurity behavior	0.701	1.839
	Perceived cybersecurity risk	0.798	2.983
	Security technology usage	0.783	2.335
Digital transformation	Distribution automation	0.882	3.162
	Energy storage systems	0.754	1.884
	Flexibility	0.915	4.997
	Improving grid reliability	0.742	1.813
	Reliability	0.873	4.233
Employee resilience	Adaptability	0.915	2.954
	Emotional intelligence	0.876	2.178
	Self-efficacy	0.923	3.121
Innovation readiness	Creativity	0.855	2.061
	Openness to change	0.836	1.89
	Proactivity	0.681	1.402
	Risk-taking	0.811	1.842
	Learning orientation	0.581	1.232
Organizational resilience	Agility	0.878	3.008
	Communication	0.814	2.183
	Innovation	0.851	2.934
	Resourcefulness	0.726	1.63
	Co-creation mindset	0.938	4.821
Value co-creation	Collaboration	0.931	4.639
	Custom orientation	0.819	1.962
	Outcome focus	0.918	3.996
Source(s): Authors' own work			

coefficient ($\beta = 0.642, p < 0.001$). Thus, the results support H1a, suggesting that the respondents believe that a high level of digital transformation can enhance value co-creation. H2 proposed that digital transformation positively affects OR. A path analysis was conducted between the indicators of digital transformation and OR. The path analysis results indicated that all digital transformation indicators displayed significant positive associations with OR. Among the indicators, flexibility, and reliability showed the strongest positive associations, with outer loading values of 0.915 and 0.873, respectively. These findings suggest that the respondents perceive a high level of digital transformation to positively impact OR.

Furthermore, the path analysis between cloud computing performance, as a specific indicator of digital transformation, and OR yielded a positive coefficient ($\beta = 0.25, p = 0.012$). This result supports hypothesis H1b, indicating that the respondents believe that a high level of digital transformation can enhance OR, as reflected in cloud computing performance. Both H1 and H2 were supported.

Regarding the fourth hypothesis, the coefficient for the relationship between cyber resilience and OR is significant ($\beta = 0.65, p < 0.001$), further supporting H3. This suggests that cyber resilience aids in enhancing overall OR. Organizations that effectively manage and protect their digital assets and systems are better equipped to withstand and recover from cyber threats.

Additionally, the coefficient for the relationship between employee resilience and Value co-creation is significant ($\beta = 0.193, p = 0.017$), supporting H4. This finding highlights the positive effect of employee resilience on value co-creation efforts within the organization. Resilient employees who adapt and thrive in challenges contribute to collaborative processes that generate mutual value. Furthermore, the coefficient for the relationship between employee resilience and OR is significant ($\beta = 0.184, p = 0.022$), supporting H5. This indicates that employee resilience has a positive impact on overall OR.

However, the analysis did not find a significant coefficient for the relationship between innovation readiness and OR ($\beta = 0.053, p = 0.42$), indicating that H6 is unsupported. This suggests that innovation readiness, as measured in this study, does not significantly impact OR. This can be understood given the underestimation of its value by stakeholders seeking short-term profit monetization. Thus, innovation routes might not advance an organization's overall resilience smoothly. The results, however, demonstrated significant coefficients and provided support for several hypotheses. The coefficient for the relationship between value co-creation and OR is significant ($\beta = 0.133, p = 0.026$), indicating a positive impact of value co-creation on OR, thus supporting H7.

These findings showcase how value co-creation, cyber resilience, employee resilience, innovation readiness, and OR interact. Thus, organizations can implement strategies that promote value co-creation, strengthen cyber resilience, and nurture employee resilience to boost their overall OR. The path analyses are shown in Figure 2.

The loadings reported in Table 3 suggest a strong relationship between the latent constructs and their respective indicators. Specifically, the highest loadings are observed for compliance with cybersecurity regulations (0.897) for cyber resilience, flexibility (0.915) for Digital transformation, self-efficacy (0.923) for employee resilience, creativity (0.855) for Innovation readiness, and co-creation mindset (0.938) for value co-creation. These high loadings indicate a strong association between the latent constructs and their indicators. The findings support hypothesis H8, indicating that value co-creation partially mediates the relationship between innovation readiness and OR ($\beta = 0.02, p = 0.035$). Similarly, hypothesis H9 is supported, as the coefficient for the relationship between digital transformation and OR, mediated by value co-creation, is significant ($\beta = 0.085, p = 0.022$). However, hypothesis H10 is not supported, as the relationship between cyber resilience and OR, mediated by value co-creation, is insignificant ($\beta = 0.008, p = 0.0583$). Lastly, hypothesis H11 is supported, as the coefficient for the relationship between employee resilience and OR, mediated by value co-creation, is significant ($\beta = 0.026, p = 0.025$). These findings suggest that value co-creation

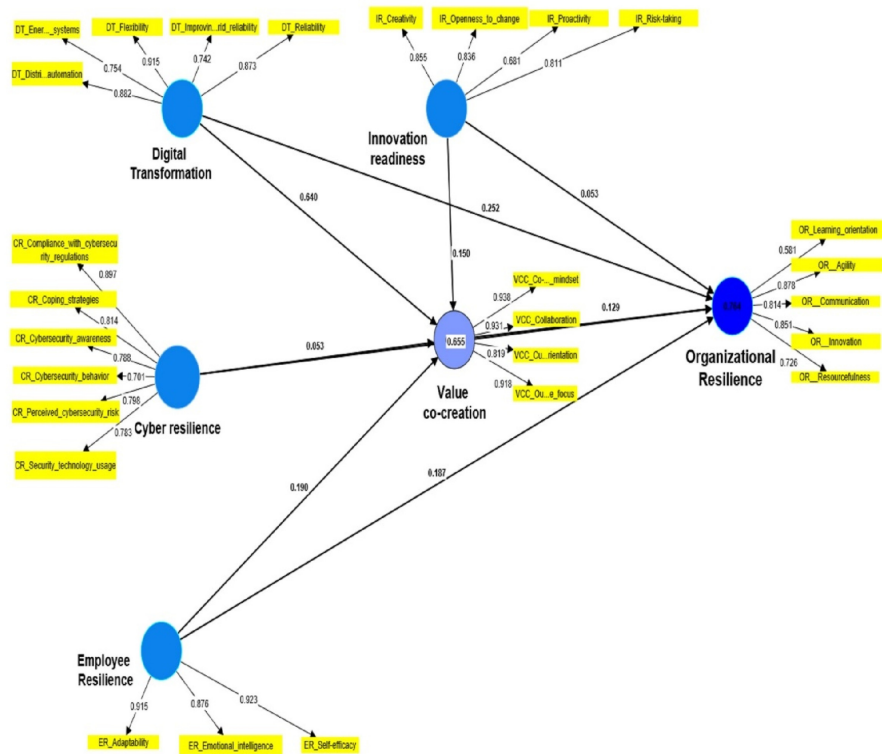


Figure 2.
Measurement model

Source(s): Created by authors

partially mediates the relationships between innovation readiness, digital transformation, and employee resilience with OR. Hypothesis validation is displayed in [Table 4](#).

The measurement model showcased a satisfactory fit with a Comparative Fit Index (CFI) of 0.95 and a Tucker–Lewis index of 0.92. The chi-square value 250.09 corresponded to a statistically significant difference between the model and the observed data. The root mean square error of approximation was 0.06 (below the 0.08 cutoff). The standardized root mean square residual was 0.04 (acceptable range is up to 0.05). Therefore, these diverse fit indices support the validity of the measurement model.

The findings mentioned here encourage organizations to develop a holistic approach to enhancing their OR considering various factors. Managers should prompt continuous learning, use coping strategies, adaptability, and innovation among employees, and prioritize value co-creation with customers, suppliers, and other relevant stakeholders. Organizations should develop innovation readiness, risk-taking, openness to change, and proactivity.

5. Discussion

Several factors enhance the resilient use of energy. Promoting awareness and educating communities about energy resilience instills a culture of preparedness and responsible energy practices. Engaging citizens in energy-saving behaviors, encouraging distributed generation, and supporting local energy initiatives contribute to building resilience at the community level.

							Digital transformation and human capabilities
Hypothesis	β -value	Mean	SD	t -test	p	Validation	
H1. Digital transformation has a positive effect on value co-creation	0.642	0.631	0.063	10.144	0.000	Supported	
H2. Digital transformation has a positive effect on organizational resilience	0.25	0.241	0.098	2.554	0.012	Supported	
H3. Cyber resilience has a positive effect on organizational resilience	0.133	0.123	0.109	1.217	0.026	Supported	
H4. Employee resilience has a positive effect on value co-creation	0.65	0.657	0.111	5.86	0.000	Supported	
H5. Employee resilience has a positive effect on organizational resilience	0.193	0.185	0.079	2.43	0.017	Supported	
H6. Innovation readiness has a positive effect on organizational resilience	0.184	0.157	0.079	2.329	0.022	Supported	
H7. Value co-creation has a positive effect on organizational resilience	0.053	0.04	0.066	0.809	0.42	Not supported	
<i>Mediation</i>							
H8. Value co-creation mediates the relationship between innovation readiness and organizational resilience positively	0.02	0.021	0.021	0.936	0.035	Supported	
H9. Value co-creation mediates the relationship between digital transformation and organizational resilience positively	0.085	0.078	0.07	1.22	0.022	Supported	
H10. Value co-creation mediates the relationship between cyber resilience and organizational resilience positively	0.008	0.008	0.014	0.55	0.0583	Not supported	
H11. Value co-creation mediates the relationship between employee resilience and organizational resilience positively	0.026	0.022	0.022	1.158	0.025	Supported	
Source(s): Authors' own work							

Table 4.
Hypotheses validation

By digitalizing platforms, organizations enhance collaboration, communication, and interaction with various stakeholders, including customers, partners, and employees. This increased connectivity and engagement fostered by digital transformation create opportunities for value co-creation. In the UAE, the impact of climate change on energy supply is a significant concern. The city’s energy infrastructure can face stress with increasing temperatures and extreme weather events, leading to power generation, transmission, and distribution disruptions (El Anshasy and Khalid, 2023). As the UAE is on the coast, rising sea levels and changing precipitation patterns jeopardize coastal power plants and hydropower facilities. Furthermore, the transition to cleaner energy sources as part of climate change mitigation efforts reduces the availability of energy supply during the transition period. A successful cyberattack on the UAE’s energy sector threatens the supply chain (Griffiths, 2019).

The research findings revealed that digital transformation positively impacts value co-creation and organizational resilience within the energy sector in the UAE. Value co-creation mediated the relationships between innovation readiness, digital transformation, and employee resilience with organizational resilience (Borah *et al.*, 2023; Russo-Spena *et al.*, 2023). However, the mediation between cyber resilience and organizational resilience was not supported.

To interpret these relationships, the resource-based theory provides a suitable framework as organizational resourcing enables firms to withstand and recover from adverse events. Highly innovative organizations are resilient and adaptive to volatile changes. Tolerating organizational risk-taking can moderate the relationship between innovation readiness and organizational resilience (Wojtczuk-Turek and Turek, 2015).

Resilient employees exhibit resourceful problem-solving behaviors when faced with constraints such as high workloads or rigid organizational climates (Bamel *et al.*, 2013). They seek alternative solutions, challenge the status quo, introduce novel ideas, and disrupt prevailing norms and practices (De Clercq and Pereira, 2019). Organizations can enhance their resilience by improving human resource management practices through training workshops, offering flexible work arrangements, involving employees in decision-making during organizational changes, implementing crisis response plans, and addressing mental health and work-life balance in occupational health and safety systems (Bardoel *et al.*, 2014).

In conclusion, the findings emphasize the significance of digital transformation, value co-creation, and cyber and employee resilience in enhancing organizational resilience within the energy sector. Organizations can benefit from strategies that promote collaboration, a co-creation mindset, and a learning orientation to strengthen their resilience. However, the limited impact of innovation readiness on organizational resilience calls for further exploration of factors influencing resilience, particularly innovation.

6. Implications

Researchers and policymakers are investigating how organizations can best handle and respond to cyber threats to enhance organizational cyber resilience and devise strategies that leverage technology to improve performance and competitiveness. To do so, individual-level factors (e.g. employees' capacity to navigate and thrive in dynamic work through adaptability, emotional intelligence, and self-efficacy) and organizational-level factors must combine to boost overall resilience. Research on value co-creation has recently guided organizations in developing customer-centric strategies and nurturing beneficial stakeholder relationships. These variables form a homogeneous set, as they are all related to resource resilience and provide a holistic view of the factors that enhance an organization's ability to withstand and recover from adverse events.

The study's practical implications provide valuable insights for managers and organizations aiming to cultivate a committed workforce by building employee resilience. Furthermore, the study contributes to the existing literature by investigating the underlying motivational and cognitive processes through which resilience relates to organizational commitment's affective, normative, and continuance (Paul *et al.*, 2020).

Managers can develop effective strategies and practices to safeguard their organizations against cyber threats (Dupont, 2019). This involves ensuring compliance with relevant regulations to maintain security standards, encouraging appropriate behaviors to minimize security risks, and leveraging advanced security technologies to detect and respond to potential cyberattacks (Rasekh *et al.*, 2016). Managers can design training programs and workshops to develop these qualities in their workforce and provide support systems and resources to help employees cope with challenges and thrive in dynamic and ever-changing work environments.

In addition, research on value co-creation provides valuable insights for managers on engaging customers and stakeholders in creating value (Abdalatif and Yamin, 2022; Geng and Xu, 2024; Isensee *et al.*, 2023). Organizations can develop customer-centric strategies tailored to their needs and preferences by involving customers and stakeholders in co-creating products and services. This improves customer satisfaction, loyalty, and retention. Moreover, building mutually beneficial relationships with stakeholders through co-creation can facilitate collaboration and enhance overall organizational performance.

7. Conclusion

Resilience benchmarking assesses the performance of digitalized energy systems under normal operating conditions and during disruptive events. It involves measuring and analyzing

parameters such as response time, system availability, load balancing capabilities, and overall system efficiency. This study investigated the impact of digital technologies on value co-creation and their contribution to OR in the UAE's energy sector. Multiple hypotheses were formulated to examine these relationships, and digital technologies positively affected value co-creation. Adopting and implementing digital technologies in the energy sector optimizes collaborative value co-creation among stakeholders. The second research question explored how digital transformation contributes to OR within the energy sector. The study's results supported the hypothesis proposing a positive relationship between digital transformation and OR. Digital transformation significantly enables organizations to adapt, withstand disruptions, and recover quickly from challenges. Leveraging digital technologies and strategies empowers energy sector organizations to enhance their resilience. The third research question examined the mediating role of value co-creation between innovation readiness and OR in the UAE's energy sector. Also, the mediation of value co-creation between DT and OR and between employee resilience and OR was supported. Nevertheless, the mediation between cyber resilience and OR through value co-creation was not supported.

Risk management practices, crisis response plans, organizational flexibility, and other confounding factors govern the success of resilience at the employee, organizational, and sector levels. Stakeholders, including executives and investors, often have a shorter-term focus when assessing organizational performance. Addressing the challenge of a time lag in observing resilience impacts requires resilience and leniency in anticipating outcomes or seeing how change permeates an organization.

The study focused on the energy sector of the UAE, which limits the generalizability of the findings to other industries or geographic regions. The unique characteristics of the energy sector in the UAE may be affected by digital transformation, value co-creation, and OR more than other public sectors. Other factors could also have moderated the investigated relationships. They include regulatory frameworks, market dynamics, or cultural influences that were not explicitly examined. Future studies could incorporate other confounders that may influence the axiomatic relationships between human and technological variables.

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