ECONOMICS
& Sociology

Bartuseviciene, I., & Butkus, M. (2024). The effect of digital governance to stimulate the antifragile capabilities of public sector organizations. *Economics and Sociology, 17*(3), 41-61. doi:10.14254/2071-789X.2024/17-3/3

THE EFFECT OF DIGITAL GOVERNANCE TO STIMULATE THE ANTIFRAGILE CAPABILITIES OF PUBLIC SECTOR ORGANIZATIONS

Ilona Bartuseviciene
Institute of Regional Development, Vilnius University Siauliai Academy. Siauliai, Lithuania
E-mail: ilona.bartuseviciene@sa.vu.lt
ORCID 0000-0001-6260-9370

Mindaugas Butkus
Institute of Regional Development, Vilnius University Siauliai Academy, Siauliai, Lithuania
E-mail: mindaugas.butkus@sa.vu.lt
ORCID 0000-0003-2381-5440

Received: January, 2024
1st Revision: June, 2024
Accepted: September, 2024

DOI: 10.14254/2071-789X.2024/17-3/3

ABSTRACT. This paper investigates whether and in what way digital governance can contribute to the development of antifragility in public sector organizations. In this study, antifragility is realized as a set of core capabilities that equips organizations with the knowledge and capacity to deal with and capitalize on uncertainty. A survey was conducted through structured interviews with the top managers of 400 organizations to investigate this phenomenon. The subsequent study then employed nonparametric structural equation modeling, indicating the following goodness-of-fit parameters: CMIN/DF – 2.476, TLI – 0.925, CFI – 0.933, and RMSEA – 0.043. The results of this study are significant and reveal that the facilitation of digital governance can be considered an enabler of antifragility development within organizations operating in the public sector. However, the overall effect is not so straightforward. The study's findings lead to a significant outcome, indicating that cybersecurity works as a mediator in the relationship between intangible digital governance components that covary with each other, i.e., leadership, digital services, and capacity building, as well as digital infrastructure and organizational antifragility. These findings highlight the need to align digital governance with strategy and skill development. Furthermore, they emphasize the potential of technological innovation to enhance an organization's level of antifragile capability when strategically invested.

JEL Classification: D73, D81, O33

Keywords: digital governance, antifragility, public sector, capabilities, effect, structural equation modeling, assessment instruments

Introduction

Increasing uncertainty makes strategic planning and resource allocation more difficult for public sector organizations, as prior information and experience are considered inaccurate predictors of future paths. Nonetheless, some organizations see uncertainty as a challenge that allows them to experiment with innovative methods of providing the results they are accountable for, such as efficient public services (Butkus et al., 2023). Such tactics may change perceptions of uncertainty, leading to it being seen as an asset rather than a burden and allowing organizations to reap benefits from volatile situations (Botjes et al., 2021). Taleb (2012), the founder of the concept of antifragility, emphasized the importance of randomness, stating that relying solely on previous information frequently causes organizations to fail to foresee significant adversities. As a result, he suggested establishing a robust yet transformative and emergent environment, which equips the system with the knowledge and capacity to deal with and capitalize on uncertainty. Munoz (2022) argued that antifragile organizations are better prepared to respond to crises and emerge more robust as they have a heightened awareness of managing risks beyond mere mitigation, transforming them into opportunities. An extensive body of literature (Bridge, 2021; Cañizares et al., 2021; Derbyshire & Wright, 2014) demonstrates that organizations inherently enhance their antifragile capabilities through flexibility and rapid responses. These capabilities become the catalysts for improving the organizational capacity to navigate volatility and embrace uncertainty (Markey-Towler, 2018) while also enhancing the ability to swiftly adapt to technical, societal, and global changes, transforming potential threats into opportunities for development and innovation (Fiorini, 2019).

While the benefits of antifragility are widely debated, the question of how organizations, particularly those in the public sector, can become antifragile remains unanswered. The specificity of the public sector, characterized by strong hierarchies, limited resources, budgetary constraints, formal procedures, and specialized roles, poses significant challenges to its journey toward antifragility (Butkus et al., 2024). However, Autio et al. (2021) argued that public sector organizations can enhance their capacity to cope with adversities by radically altering their work processes under the influence of digital governance. This, in turn, bolsters their ability to navigate uncertainty and disruptive events. This argument aligns with the findings of Kitsios et al. (2023), who revealed that the ability to respond and adapt to environmental changes represents a significant milestone for public administrations, acknowledging their unique challenges.

Antifragile organizations are adept at dealing with transformation, reconfiguration, and restructuring, also recognized as catalysts for developing digital governance. The transformative power of digital governance in the public sector is evident in the shift it brings to governance mechanisms. As digital technologies continue to play a critical role in the transformation of organizations and their chances of success, public sector organizations have been under severe pressure to digitalize their operations to increase public value (Bennich, 2024). Although the potential benefits of value creation through the stimulation of digital governance are undeniable, the challenge lies in whether public sector organizations recognize digital governance as an ongoing process that necessitates frequent adjustments across various areas, such as procedures, policies, services, etc. (Kitsios et al., 2023). Chen (2017) argued that digital governance extends beyond technology, initiating a perspective that acknowledges the broader scope and potential of the phenomenon, such as the involvement of better digital services, openness and collaboration, societal problem-solving, citizen well-being, and resource optimization (Danielsen et al., 2022). The effective delivery of value occurs through the execution of strategic digital governance initiatives; thus, establishing a digital ecosystem that involves processes, services, relationships, structure, and technology (Schwer et al., 2018) is a way to deliver value driven by digital transformation.

Aligning with Chen's (2017) claim that digital transformation is more about the "transformation" component of this phenomenon than the "digital," this study investigates the connections between digital governance and antifragility in public sector organizations. The research investigates the question of whether organizations with higher levels of digital governance are more antifragile.

The scientific literature reveals that the development of organizational antifragility in public sector organizations remains understudied. While ongoing debates persist regarding conceptual frameworks and indicators for exploring them, a limited number of studies have examined antifragility from an organizational perspective, with the majority focusing on either the private sector (Corvello et al., 2023; Codara & Sgobbi, 2021) or organizations in general (Ramezani & Camarinha-Matos, 2019a; Munoz et al., 2022). Additionally, the authors could not identify a single study exploring the interconnections between digital governance and antifragility that focuses on organizations operating in the public sector. This provides a gap in the scientific literature regarding the potential of digital governance to empower the antifragile capabilities of public sector organizations.

The novelty of this study lies in certain key areas. The initial focus will be on the conceptual framework of antifragile capabilities and digital governance, aiming to explore these phenomena in a broader sense. Subsequently, the study will reveal conceptual approaches to an organization's antifragile capability and methodological approaches to assess it. Finally, the potential of digital governance as an enabler of antifragile capability in Lithuanian public sector organizations will be empirically explored. The findings of this study could have significant implications for public sector organizations, providing insights into how they can leverage digital governance to enhance their antifragility and navigate uncertainty more effectively.

The paper is structured as follows: first, we present the analysis of scientific literature and the hypotheses formed based on it; second, we present the methodology; third, we deliver the empirical study; fourth, we reveal the results and initiate the discussion; and fifth, we complete the paper with conclusions, limitations, and further research directions.

1. Theoretical background

1.1. Structural components of antifragile organizations

Antifragility refers to an organization's ability to absorb and adapt to uncertainty, allowing it to survive and thrive in unexpected situations (Blečić & Cecchini, 2020; Ramezani & Camarinha-Matos, 2019b). Antifragility can be stimulated by several factors, including creativity, which provokes novel solutions, adaptability, and transformability, outlined as the ability to reinvent oneself (Bajaba, 2022; Corvello et al., 2023; Johnson & Gheorghe, 2013). It is observed that antifragile organizations perform positively when confronted with disorders, perturbations, stressors, volatility, randomness, and other forms of environmental variability (Aven, 2015; Eugen & Petru, 2018; de Bruijn et al., 2020). This occurs due to their ability to extract value from volatility, which, first and foremost, should be perceived as a source of valuable information for foresight (Botjes et al., 2021; Bridge, 2021; Cañizares et al., 2021; Derbyshire & Wright, 2014; Equihua et al., 2020; Guang et al., 2014; Markey-Towler, 2018; Ruiz-Martin et al., 2018). Interestingly, Fiorini (2019) explained the elevation of antifragility through evolution, where randomness and chaos play an essential role. Over time, antifragile organisms win, while fragile ones are eliminated from the ecosystem. The same principle extends to the organizational setting; those who learn to benefit from disorder ultimately thrive, unlike those who merely strive to survive. However, Ghasemi and Alizadeh (2017) argued that antifragile systems exhibit tolerance to stress up to a specific point, as excessive stress will result in antifragility degradation or even elimination. This argument supports the view introduced by Taleb (2012), who conceptualized antifragility through the symmetry between gains and losses. When confronted with difficult obstacles, antifragile organizations generate more gains than losses, whereas fragile organizations lose more than they gain. Equihua et al. (2020) argued that antifragile responses occur due to an enhanced ability to discover surrounding variations to cope with perturbations, which can be empowered within organizations by stimulating specific practices. In short, the higher an organization's antifragility, the better it deals with and harnesses uncertainty (Bridge, 2021).

A thorough literature review revealed five key components that enable organizational antifragility. The first deals with *redundancy*, in which organizations should maintain safety stock, secure alternative suppliers, allow for safety lead times, and duplicate critical human resources to ensure operational flexibility and prevent shortages during demand surges (Ramezani & Camarinha-Matos, 2020; Abbas & Munoz, 2021; Johnson & Gheorghe, 2013; Ghasemi & Alizadeh, 2017; Derbyshire and Wright; 2014; Kennon et al., 2015; Hole, 2022; O'Reilly, 2019). The second enabling component is associated with *small stressor induction*, where low-level stress can help organizations adapt to potential disruptions, improving their ability to withstand and recover from more significant stress in the future (Derbyshire & Wright, 2014; Munoz et al., 2021; Nikookar et al., 2021; Ramezani & Camarinha-Matos, 2019a; Russo & Ciancarini, 2017). The third enabler of antifragility reflects the ability to deliver *non-linear responses*, which acknowledge that a system's responses are not always directly proportional to its inputs. Learning is adaptive and involves unlearning/replacing old knowledge with new insights, and this cycle of continuous learning strengthens antifragile systems and fosters innovation (Ghasemi & Alizadeh, 2017; Ramezani & Camarinha-Matos, 2019a; Johnson & Gheorghe, 2013; Kennon et al., 2015; Aven, 2015; Bajaba, 2022; Corvello et al., 2023). *Diversity of responses*, the fourth enabler of antifragility, deals with the optionality of having more than one response to a possible threat to essential outcomes. It can be enhanced by cultivating a workforce with varied skills, adopting adaptable structures, implementing innovative processes, forming strategic partnerships, and maintaining efficient communication. Developing self-sustaining qualities such as self-organization, self-repair, self-adaptation, and self-management can amplify diverse responses (Fiorini, 2017, 2019; Gershenson, 2015; Ghasemi & Alizadeh, 2017; Johnson & Gheorghe, 2013; Kennon et al., 2015; Ramezani and Camarinha-Matos, 2019a). The final component that has been acknowledged as one of the five most significant enablers of antifragility is the *capacity for emergent behavior*, which can occur without manual interference as a result of the design of the organization's structure, leadership behaviors, support for diversity, team interactions, engagement in a silo-breaking culture, effective communication, and uniformity in individual attributes (Fulmer and Ostroff, 2016; Gershenson, 2015; Johnson and Gheorghe, 2013; Ramezani and Camarinha-Matos, 2019a; Ramezani and Camarinha-Matos, 2020).

In conclusion, antifragility manifests in a capability that equips organizations to undergo transformation and self-reinvention when confronted with uncertainties. It can be empowered through specific practices that, in this study, have been identified as endogenous components that enable organizational antifragility.

1.2. The conceptual construct of digital governance and its effect on antifragility

Digital governance equips organizations with the ability to be more adaptive and responsive to environmental turbulence (Alshourah et al., 2023). Linkov et al. (2018) argued that digital technology's enhanced information and decision-making capabilities empower adaptiveness. However, the authors also argued that maintaining digital technology alone does not guarantee effective adaptiveness. Thus, Linkov et al. (2018) advocated that an adaptive governance model could be one solution in which stakeholders, citizens, and government institutions could alter their best practices and codes of behavior to reap the benefits of digitalization while avoiding needless or unacceptable risks or losses. However, despite showing some promise, this strategy demands a deeper awareness of digital governance constituents. Nuryadin et al. (2023) suggested that to enhance the digital maturity of organizations operating in the public sector, it is necessary first to facilitate a digital leadership model, the implementation of which could be stimulated through digital leadership, digital competence, and digital service. The benefit of such an approach was also acknowledged in a study by Lember et al. (2018), which explored the e-profiles of public institutions in Estonia. The study results revealed that although Estonia has been internationally recognized as a country with a strong e-profile that is famous for its e-government developments, particularly electronic ID cards and a secure data exchange architecture, almost all of the senior civil servants interviewed acknowledged that their organizations were either very or relatively far from the technological frontier (in the sense of either creating new technological solutions or adapting existing approaches). Moreover, collaboration with other institutions was perceived as a threat in the sense of relocating power, leading to the reduced availability of open data, especially amongst organizations with static profiles. Lember et al. (2018) stated that technological capacities enable organizations operating in the public sector to be selective, meaning they can overlook users with low technological skills. This means that if access to public services is mostly provided using digital technology platforms, then public sector organizations indirectly become responsible for the level of digital capacity among both industry and citizens. As a result, with effective leadership, the establishment of strong e-service platforms, and supportive capacity-building mechanisms, organizations are better equipped to take full advantage of digital infrastructure, which is typically expensive and consumes a large portion of the budget. The partial utilization of digital infrastructure due to a lack of capacity leads to the unjustifiable and inefficient use of resources (Zhao & Ren, 2023). The same holds true for protecting digital assets: digital governance models must integrate cybersecurity elements, as cyber threats are becoming increasingly complex and affecting many users and organizations (Eugen & Petru, 2018).

To conclude, it becomes evident that the effective development of digital governance in public sector organizations requires a novel approach to digital governance transformation (Aras & Büyüközkan, 2023), which includes both technological and non-technological elements (Androniceanu & Georgescu, 2023). Nevertheless, existing approaches toward the constituents of digital governance advocate for the view that digital transformation is primarily associated with continuous change and transformation, not the digital component (Chen, 2017).

Corvello et al. (2022) argued that digital transformation catalyzes antifragility in SMEs. Moreover, they suggested that the relationship between digital technologies and antifragility is not linear; thus, enterprises must learn to navigate by becoming digitally competent. These arguments motivated the present study's authors to investigate the interconnections between digital governance and antifragility in public sector organizations and delve into the complexities of their interactions.

This study explores antifragility using its most commonly identified component enablers: redundancy, small stressor induction, non-linear responses, diversity of responses, and capacity for emergent behavior. The structure of digital governance in this research is consistent with other studies (Nuryadin et al., 2023; Kitsios et al., 2023; Fleron et al., 2021;

World Bank, 2020) that perceive it as being composed of the following components: leadership, digital public service, capacity building, digital infrastructure, and cybersecurity. In Figure **1**, we present our research model, which is used to test the following hypothesis.

$H_{1:}$ Digital governance consists of endogenous and positively related components, i.e., leadership, public service, capacity building, digital infrastructure, and cybersecurity, which positively affect all antifragility components, i.e., redundancy, stress inducement, non-linear responses, diversity of responses, and capacity for emerging behavior.

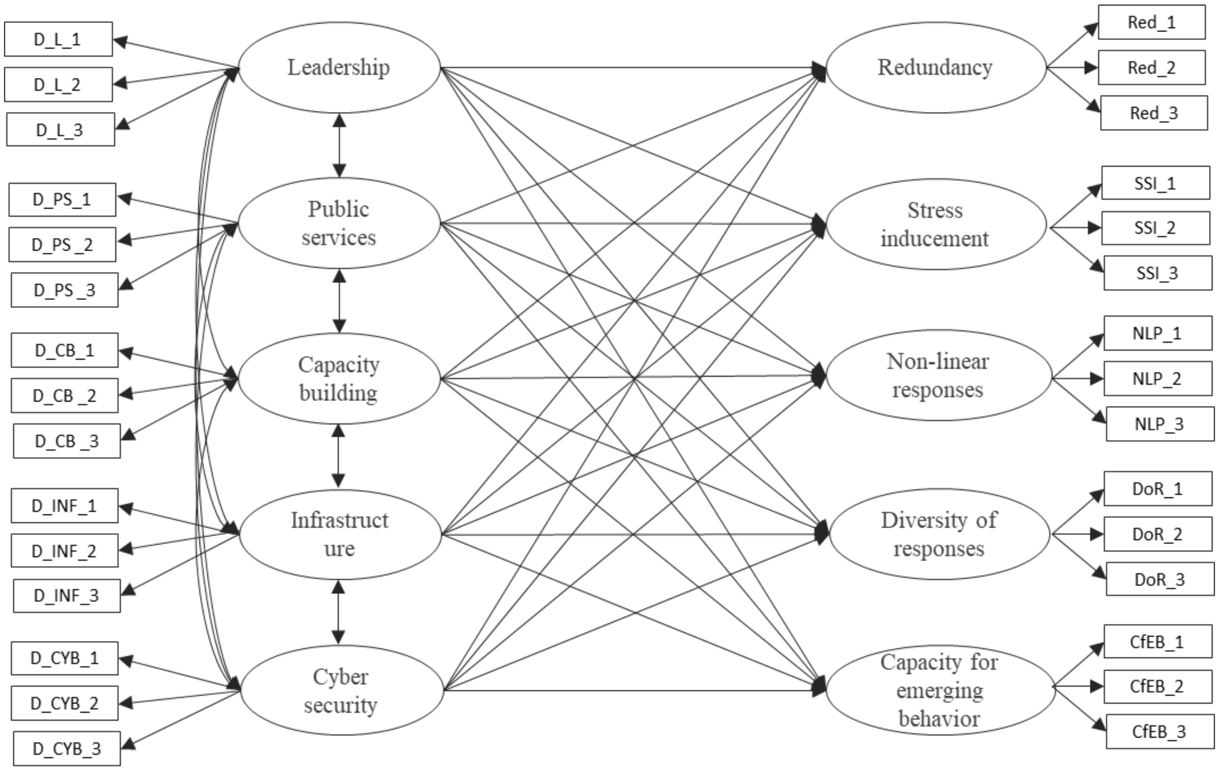

Figure 1. Model 1

Due to limited theoretical knowledge and a lack of empirical evidence regarding the possible interconnections between digital governance and organizational antifragility, we first explored whether effects exist between digital governance and antifragility. If linear interconnections do not exist, alternative models will be explored.

2. Methodological approach

2.1 Measurement instrument

Given the emerging significance of the capacity of digital governance to enhance an organization's ability to cope with adversity, we observed a surprising lack of comprehensive measurement instruments in the scientific literature. This study, therefore, presents a unique approach, utilizing two questionnaires specifically designed for this purpose (Table 1 and

Table **2**). Our review of existing studies also revealed that neither digital governance nor antifragility are directly observable phenomena. Instead, they can be measured through observable indirect variables (items). It is important to emphasize that both questionnaires underwent a rigorous pilot test, including completing them and providing feedback on unclear moments. The pilot test was conducted with managers of public sector organizations to ensure that the questionnaire was free of any ambiguities during the later data-gathering procedure.

Table 1. The structure of digital governance measurement instrument

Components			Items	Abbreviation
Leadership	Strategy	1.	Our organization's strategic plans include the development of digital governance.	D_L_1
	Project initiatives	2.	Specialists from various departments carry out projects to intensify digital governance initiatives in our organization.	D_L_2
	Funding	3.	We allocate separate funding for stimulating digital governance initiatives.	D_L_3
Digitalizing public services	Public service provision	4.	Essential public services are available digitally, allowing consumers to access them through internet platforms or digital means.	D_PS_1
	Stakeholder inclusion	5.	We encourage users of digital public services (citizens, employees, and other stakeholders) to share their opinions and test the future digital service solution before deployment.	D_PS_2
	Service Accessibility	6.	Our digital services are accessible to all users, regardless of their abilities, skills, disabilities, or geography.	D_PS_3
Capacity building	Awareness of competence	7.	We understand the competencies required to improve our organization's digital potential.	D_CB_1
	Competence Inventory	8.	We know what competencies we are lacking in order to improve digital governance.	D_CB_2
	Training	9.	We periodically conduct surveys to determine our employees' levels of digital literacy	D_CB_3
Digital infrastructure	Centralized IT inventory	10.	We have data storage and management technologies that centralize multiple datasets.	D_INF_1
	Centralized IT support	11.	A dedicated department or individual is responsible for providing IT support to staff within our organization when assistance is required.	D_INF_2
	IT inventory	12.	We conduct periodic inventories of our digital infrastructure to ensure a complete understanding of all digital assets within our firm.	D_INF_3
	Data analytics integration	13.	We use data analytics technologies across our organization.	D_INF_4
Cybersecurity	Management of digital assets	14.	We have formed a cybersecurity unit/center/working group responsible for supervising and preserving our digital assets.	D_CYB_2
	Partnerships	15.	We collaborate with other organizations to exchange information, synchronize activities, and confront and decrease cyber threats collaboratively.	D_CYB_3
	Cyber training	16.	Employees are regularly trained on how to handle a digital cyberattack.	D_CYB_1

Table 2. The structure of the organizational antifragility measurement instrument

Components	Item			Abbreviation
Redundancy	Planning resources	1.	Each year, we allocate resources (financial, human, and material) specifically for managing contingencies, emergencies, and crises.	RED_1
	Stockpiling routines	2.	When planning resources (material, financial, human), we deliberately incorporate surpluses to safeguard against a possible shortage in an unforeseen situation.	RED_2
	Critical resource duplication	3.	Within our organization, multiple employees can fulfill essential roles. If personnel changes are necessary, we can swiftly make transitions, ensuring the uninterrupted continuation of business operations.	RED_3
Small stressor inducement	Fault injection	4.	We regularly expose our employees to minor stressors to improve their capacity to cope with the disorder (e.g., carrying out tasks with less-than-optimal resources, rotating employees to perform activities different from their regular functions by artificially integrating errors, and monitoring whether and how employees respond to these situations).	SSI_1
	Risk segmentation	5.	In some of our activities, we only implement high-risk initiatives within limited segments of our operations (e.g., experimenting with new service delivery methods, optimizing internal and external processes, installing innovative technologies, etc.).	SSI_2
	Stress training	6.	How strongly do you agree with the statement that artificially induced uncomfortable/unforeseeable situations, where employees are compelled to step beyond their comfort zone, enhance their skills for managing large-scale crises?	SSI_3
Non-linear responses	Trial and error	7.	How strongly do you agree that errors made in your organization during work are regarded as opportunities to gain fresh insights?	NLP_1
	Adaptive learning	8.	In case of disruption, we evaluate what we did well and what could have been done differently. Subsequently, we integrate acquired experience and knowledge into our ongoing efforts to enhance the organization's operations.	NLP_2
	Unlearning	9.	Employees, within the limits of their competence, autonomously devise and execute short-term plans, establish implementation strategies, and suggest improvements to their tasks.	NLP_3
Diversity of responses	Individual properties	10.	Our employees can easily and quickly adapt to different roles or responsibilities.	DoR_1
	Complexity	11.	We have at least one solution for every conceivable risk management scenario.	DoR_2
	Collaborative ecosystems	12.	It is common for us to exchange relevant information with other organizations.	DoR_3
Capacity for emergent behavior	Tacit knowledge empowerment	13.	We involve employees in strategic decision-making, asking for suggestions and recommendations for further improvement within their competence.	CfEB_1
	Breaking silos	14.	To what extent do you agree with the statement that activities carried out in one department impact other departments and that successes and setbacks in one area of operation can impact the organization?	CfEB_2
	Diversity	15.	Collaborative efforts involving personnel possessing diverse skill sets are regularly observed within our organization.	CfEB_3

2.2. Sample

The survey for collecting the data necessary to explore the interconnections between digital governance and antifragility in organizations was conducted by interviewing the managers of Lithuanian public sector organizations between November 2023 and January 2024. Lithuania has over 4,000 public sector organizations; hence, with a confidence level of 95% and a margin of error equal to 5%, our sample size should be no less than 385. Data was collected from a total of 400 organizations. To ensure the representativeness of the sample data, the probabilistic stratified sampling method was used, where organizations were first divided into homogeneous groups according to the number of employees working in the organization: micro, small, medium, and large. Proportions (quotas) were maintained by county (see Table 3); with Lithuania consisting of ten counties (NUTS3 level regions), each needed to be represented proportionally.

Quotas were met by interviewing the managers of organizations or equivalent individuals with decision-making authority. Each manager interviewed represented a single organization. Organizations were contacted via phone or email based on publicly available information. Following a brief presentation about the survey's goals and the purposes of data collection, managers were asked to complete an electronic questionnaire.

Table 3. Sample of the research

Total	Frequency	Sample size %
By county	**400**	**100**
Vilnius	174	43.5
Kaunas	74	18.5
Klaipeda	40	10.0
Siauliai	24	6.0
Panevezys	21	5.3
Utena	16	4.0
Alytus	16	4.0
Telsiai	13	3.3
Marijampole	13	3.3
Taurage	9	2.3
By size of organization (number of employees)	**400**	**100**
Micro (less than 10)	132	33.0
Small (10–49)	157	39.3
Medium (50–250)	94	23.5
Large (more than 250)	17	4.3

2.3. Estimation strategy

To ensure greater granularity during the data analysis, this study employed a 10-point Likert scale, with 10 representing strong agreement and 1 representing strong disagreement. Wu and Leung (2017) proposed that a 7-point Likert scale is the minimum from which data may be viewed as having intervals, with certain reservations. Furthermore, Pearse (2011) contended that higher levers of granularity are more likely to produce more meaningful results. Cronbach's alpha was used to assess the reliability of the items on the scale, while Kaiser-Meyer-Olkin (KMO) was used to determine sample adequacy.

This study used Partial Least Squares-Structural Equation Modeling (PLS-SEM), which enables the modeling of complex phenomena and increases the possibility of predicting causal relationships between variables. Moreover, this method allows us to employ mediation analysis, which enables us to highlight the role of an intervening component in the statistical relationship between factors and outcomes (Nitzl et al., 2016). Specific requirements must be complied with when applying PLS-SEM, such as the normal distribution of the data and sufficient sample size (Signore et al., 2021). Skewness and kurtosis measures were used to test for normal distribution, following the rule that distribution can be considered normal if skewness and kurtosis values fall within the intervals of (−2; 2) and (−7; 7), respectively. The model's goodness-of-fit was measured using several indices (see Table 4), at least two of which should support the model's goodness-of-fit (Fan et al., 2016).

Table 4. Indices used to determine the model's goodness-of-fit

Index	Abbrev.	Threshold value
The ratio between chi-squared (χ^2) and degree of freedom (*df*)	CMIN/DF	<3.0
Comparative fit index	CFI	>0.9
Tucker–Lewis index	TLI	>0.9
Root mean square error of approximation	RMSEA	<0.08

3. Conducting research and results

The reliability of the data collected during the survey was tested through Cronbach's alpha. The findings revealed excellent reliability indices for questionnaires and individual items across all latent variables (see Table 5).

Table 5. Cronbach alpha measures for latent variables

Group of items	**Number of items**	**Cronbach's alpha**
Cronbach's alpha measures for latent variables of digital governance		
Leadership	3	0.957
Public services	3	0.970
Capacity building	3	0.898
Digital infrastructure	4	0.948
Cybersecurity	3	0.917
Total for digital governance	16	0.972
Cronbach's alpha measures for latent variables of antifragility		
Redundancy	3	0.919
Small stressor inducement	3	0.954
Non-linear responses	3	0.911
Diversity of responses	3	0.852
Capacity for emergent behavior	3	0.885
Total for antifragility	15	0.933

The KMO value of 0.935, which exceeds the threshold of 0.6, confirms that the sample is suitable for confirmatory factor analysis. The descriptive statistics indicate that both skewness and kurtosis fall within the ranges of (−2; 2) and (−7; 7), respectively, suggesting that all items are normally distributed; hence, the maximum likelihood estimator can be used to perform SEM (see Table 6).

Table 6. Descriptive statistics of the items

Components	Item abbrev.	Average	95% C.I.	Std. dev.	Skewness	Kurtosis
Descriptive statistics of digital governance items						
Leadership	D_L_1	7.35	(7.11, 7.58)	2.35	−0.68	−0.30
	D_L_2	7.45	(7.22, 7.68)	2.30	−0.79	−0.06
	D_L_3	7.54	7.32, 7.76)	2.22	−0.88	0.27
Digital public services	D_PS_1	7.36	(7.11, 7.60)	2.46	−0.81	−0.16
	D_PS_2	7.17	(6.92, 7.42)	2.50	−0.70	−0.46
	D_PS_3	7.35	(7.10, 7.60)	2.54	−0.80	−0.30
Capacity building	D_CB_1	7.50	(7.29, 7.71)	2.12	−0.75	0.17
	D_CB_2	7.43	(7.21, 7.65)	2.23	−0.78	0.01
	D_CB_3	6.99	(6.75, 7.23)	2.44	−0.66	−0.30
Digital infrastructure	D_INF_1	7.26	(7.03, 7.49)	2.34	−0.82	0.56
	D_INF_2	7.07	(6.83, 7.31)	2.48	−0.72	−0.26
	D_INF_3	7.16	(6.92, 7.40)	2.44	−0.79	−0.12
	D_INF_4	7.55	(7.33, 7.76)	2.21	−0.97	0.51
Cybersecurity	D_CYB_2	6.96	(6.71, 7.21)	2.49	−0.69	−0.30
	D_CYB_3	7.09	(6.85, 7.33)	2.45	−0.69	−0.30
	D_CYB_1	7.12	(6.88, 7.35)	2.40	−0.78	−0.02
Descriptive statistics of antifragility items						
Redundancy	RED_1	7.30	(7.08, 7.52)	2.22	−0.72	−0.07
	RED_2	7.61	(7.42, 7.80)	1.96	−0.78	0.31
	RED_3	7.50	(7.30, 7.70)	2.04	−0.72	0.15
Small stressor inducement	SSI_1	6.52	(6.27, 6.77)	2.55	−0.49	−0.57
	SSI_2	6.74	(6.50, 6.98)	2.43	−0.52	−0.58
	SSI_3	6.61	(6.36, 6.86)	2.60	−0.49	−0.62
Non-linear responses	NLR_1	8.42	(8.25, 8.59)	1.69	−1.10	0.97
	NLR_2	8.29	(8.13, 8.45)	1.65	−0.95	0.63
	NLR_3	8.19	(8.02, 8.36)	1.77	−0.92	0.36
Diversity of responses	DoR_1	7.97	(7.79, 8.15)	1.80	−0.73	0.17
	DoR_2	8.16	(7.99, 8.33)	1.72	−0.86	0.24
	DoR_3	7.95	(7.75, 8.15)	2.01	−0.98	0.54
Capacity for emergent behavior	CfEB_1	8.17	(8.01, 8.33)	1.63	−0.72	0.26
	CfEB_2	8.10	(7.93, 8.27)	1.69	−0.80	0.49
	CfEB_3	8.22	(8.06, 8.38)	1.59	−0.84	0.63

Next, we test our hypothesis that digital governance consists of endogenous and positively related components, i.e., leadership, public service, capacity building, digital infrastructure, and cybersecurity, which positively affect each antifragility component. The model's SEM results indicate a rather good fit, where CMIN/DF is 2.484, TLI – 0.924, CFI – 0.935, and RMSEA is below 0.043.

Estimated coefficients (see Appendix 1) partially align with our hypothetical model structure. The covariance between the components of digital governance, i.e., leadership, public services, capacity building, digital infrastructure, and cybersecurity, is positive and statistically significant. This result is promising as it validates the structure of digital governance, indicating that all components, by interacting individually, also positively influence the remaining components of the structure.

In addition, although antifragility components are considered exogenous variables in our model, we found it necessary to reveal that all of the components that measure antifragility and the variables that constitute them demonstrate a good fit (see CFA results in Appendix 1).

Further investigation aiming to assess the effect of each digital governance component on antifragility showed that not all of the components affect it. More specifically, the results confirmed no statistically significant effect of the digital governance components of leadership, digital public services, and capacity building on any of the components of antifragility. The results also indicated a significant yet negative effect of the digital infrastructure component on all five components of antifragility, and only cybersecurity demonstrated a positive and significant effect on all of the antifragility components. Based on these estimation results, we reject our main hypothesis, H1.

Nevertheless, since model fit parameters were good, we assumed that the effect paths might be more complex; hence, we explored an alternative, Model 2, where we hypothesized the following.

$H_{alt.}$: digital governance consists of endogenously and positively related intangible dimensions, such as leadership, public service, and capacity building, all of which positively affect tangible dimensions of digital governance – i.e., digital infrastructure and cybersecurity. Digital infrastructure and cybersecurity, with the former being a prerequisite of the latter, both affect all dimensions of antifragility in turn (see Figure 2).

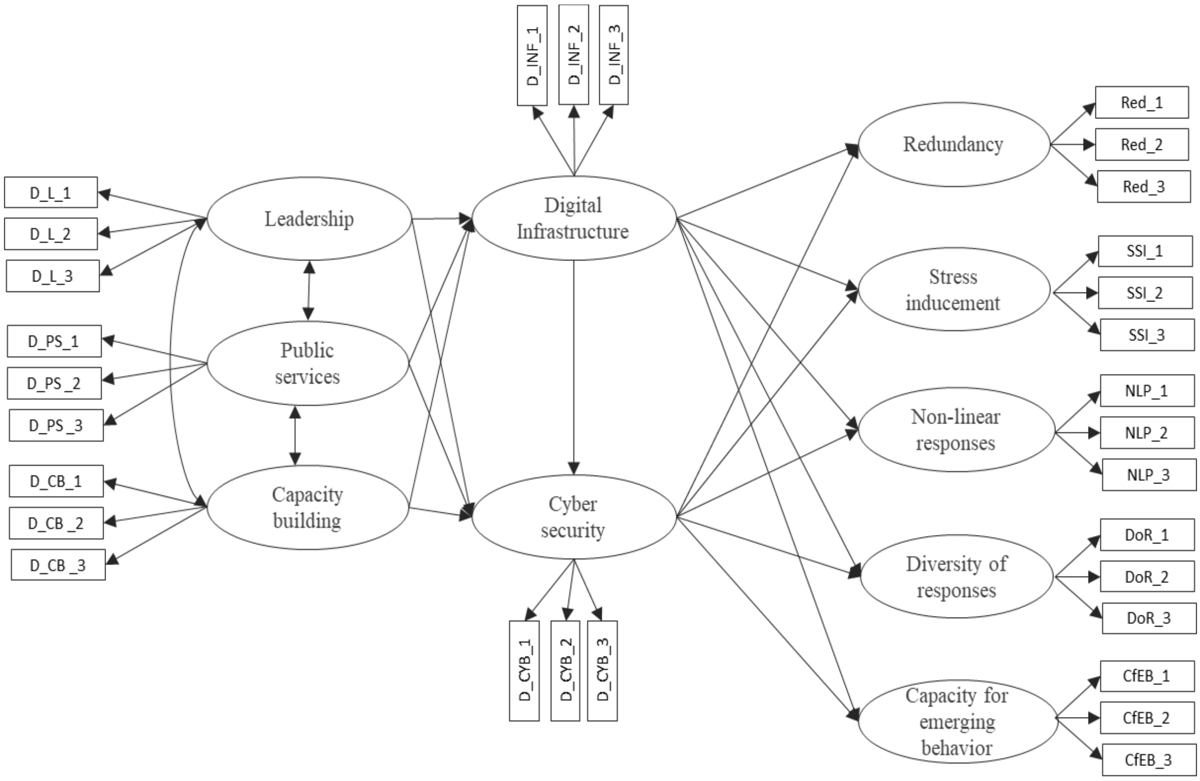

Figure 2. Alternative Model 2

The SEM results of the alternative model are similar to those of the main model: CMIN/DF is 2.476, TLI – 0.925, CFI – 0.933, and RMSEA is below 0.043. The covariance between the intangible components of digital governance, i.e., leadership, public services, and capacity building, is positive and statistically significant (see Appendix 1): each positively affect tangible dimensions of digital governance, i.e., digital infrastructure and cybersecurity. Analyzing standardized regression weights, we can conclude that the effect of digital infrastructure on each antifragility component is significant yet negative. This implies that the more digital infrastructure is developed, the more underdeveloped all of the components of antifragility are. The results of standardized regression weights indicate a positive and significant effect of digital infrastructure on cybersecurity, which in turn positively and significantly affects all five components of antifragility (standardized regression weights provided in Appendix 1).

These results allow us to accept H_{alt}.

4. Discussion and conclusion

This paper aims not only to reveal the dimensional structure of digital governance and organizational antifragility but also to explore the potential of digital governance in catalyzing the development of organizational antifragility. This novel approach was sparked by Chen's (2017) argument that digital transformation is more strongly defined by the "transformation" element than the "digital." Given that organizational antifragility also concerns the capacity to transform, especially in the face of disruption, the concept of investigating the impact of digital governance on the empowerment of an organization's antifragile capability emerged as a compelling and logical path to follow.

Following the arguments of Kitsios et al. (2023) and Gavkalova et al. (2021) regarding the necessity of a holistic approach to digital governance, this study explored this phenomenon from the perspective of five components: leadership, digital public services, capacity building, digital infrastructure, and cybersecurity. The decision to explore digital governance from a broader perspective was also influenced by Lember et al. (2018), who revealed that static organizations with low levels of technological innovation lack the leadership to integrate user feedback directly into their mechanisms. The inverse is also true: public sector organizations with dynamic profiles demonstrate the ability to collect feedback from citizens, integrate it into their internal mechanisms, and update capacity levels in response to needs. Inevitably, such behaviors affect technology levels, as increased digital capacity leads to more sophisticated initiatives that can improve all digital governance aspects within organizations.

The CFA results of this study revealed that all components of digital governance covary positively, and the indicators that measure each component are significant and demonstrate good fit results. These findings are meaningful, as they provide evidence of existing interconnectedness among e-technology measures, such as digital infrastructure and cybersecurity, as well as intangible components, such as leadership, public services, and capacity building. Hence, organizations aiming to sustain their digital governance levels should facilitate a wider spectrum of digital aspects rather than only supporting technological initiatives.

Further examination revealed that the effects of the digital governance components of leadership, digital public services, and capacity building on all antifragility components are insignificant. Furthermore, the results showed that the effect of digital infrastructure on all five antifragility components was significant yet negative. Meanwhile, cybersecurity had a positive and significant effect on all five components of antifragility. While leading to the rejection of our initial hypothesis, these findings are crucial and corroborate the argument of Corvello et al. (2022) that the relationship between digital governance and antifragility is complex and should not be viewed as linear.

Nevertheless, good model fit parameters inspired us to explore alternative interconnections among the factors included in the model; assuming that the effect might not be straightforward, we explored a more complex model design. Influenced by Lember et al. (2018), who argued that organizations' ability to capture and integrate stakeholder feedback relates to higher digital capacity, which in turn leads to the expansion of technological innovation, we initiated an alternative hypothesis. This revised hypothesis postulated that $H_{alt.}$: digital governance consists of endogenously and positively related intangible dimensions, such as leadership, public service, and capacity building, all of which positively affect tangible dimensions of digital governance – i.e., digital infrastructure and cybersecurity. Digital infrastructure and cybersecurity, with the former being a prerequisite of the latter, both in turn affect all dimensions of antifragility. The analysis of the SEM results revealed that digital infrastructure negatively affects all antifragility components. This means that the more digital infrastructure is developed, the lower the levels of organizational antifragility will be observed. These results corroborate the study produced by Lindquist (2022), which uncovered that public sector organizations invest in digital infrastructure eclectically, without strategic prioritization. The procurement of tangible assets such as data analysis programs, data storage platforms, systems, IT support, and IT inventory generates large amounts of data; however, due to a lack of capacity, it is often not efficiently integrated into daily operations. Thus, this process wastes resources that could have been used elsewhere, such as in developing antifragile capabilities.

Nevertheless, these results suggest that the effect of digital infrastructure on the components of antifragility is positive through the mediation of cybersecurity. The study reveals that cybersecurity plays a crucial role in the relationship between the remaining digital governance components and antifragility, acting as a mediator. This finding responds to Dunleavy and Margetts (2023) and Lember's (2018) inducement to better explore the nuances of technological integration to advance public sector innovation and performance. These findings lead to a significant outcome, indicating that cybersecurity works as a total mediator in the relationship between intangible digital governance components that covary with each other, i.e., leadership, digital services, and capacity building, as well as digital infrastructure and organizational antifragility components, i.e., redundancy, stress inducement, non-linear responses, diversity of responses, and capacity for emerging behavior.

The results confirm that the facilitation of digital governance can be considered the enabler of antifragility development within organizations operating in the public sector. However, this effect is not so straightforward. First, organizations must demonstrate strong leadership, a commitment to digital public service development, and capacity building, which will positively affect digital infrastructure and cybersecurity. Only then will digital governance empower the development of antifragile capabilities. In concurrence with the arguments of Corvello et al. (2022), digital infrastructure alone does not bring any value to an organization as it is associated with possessing tangible assets. Instead, it brings value to the institution only if it is fully employed through specific initiatives, such as cybersecurity, which in this study is viewed as the engagement of responsible internal work groups, collaboration with other organizations, and the development of skill-specific training. These implications underline the importance of developing digital governance in line with strategy and skills, which, through investment into technological innovations, will empower the organization's level of antifragile capability.

4.1. Limitations and recommendations for further research

From a scientific point of view, this study provides a novel understanding of the role of digital governance in empowering antifragility in public sector organizations. Complex interconnections revealed the significance of mediating roles identified as essential catalysts for developing antifragile capabilities. From a managerial point of view, this study serves as an essential guideline for public sector managers to help them understand the importance of developing antifragile capabilities and the advantages it brings for organizations, allowing them to reap benefits in times of volatility, uncertainty, complexity, and ambiguity.

Nevertheless, this study is faced by several limitations which might impact the applicability of the results. Although confirmatory factor analysis allowed us to confirm that the suggested structure of both digital governance and antifragility is valid and significant, as well as the indirect variables that were used to explore them, their validity was not tested in different geographical locations. Although Lithuania is a suitable country in which to investigate this case, where transformation within public sector organizations is considered a key priority amongst different levels of stakeholders, this study fails to present the possible outcomes of countries with different dynamics and diversity profiles. Hence, further directions might consider cross-country analysis, which would allow us to compare how different e-profiles of organizations in different countries affect the development of antifragility. Finally, the model proposed in this study is generic for all public sector organizations. Thus, it may be necessary to investigate its suitability for specific sectors such as health, education, and security.

Acknowledgement

This research has received funding from the Research Council of Lithuania (LMTLT), agreement No. S-PD-22-96.

References

Abbas, R., & Munoz, A. (2021). Designing antifragile social-technical information systems in an era of big data. *Information Technology and People*, *34*(6), 1639–1663. https://doi.org/10.1108/ITP-09-2020-0673

Alshourah, S., Altawalbeh, M., Mansour, M., Haraisa, Y. A., & Al-Kharabsheh, A. (2023). Digital strategic orientation and firm's performance: the moderating effect of environmental uncertainty. *Polish Journal of Management Studies*, *28*(2), 7–27. https://doi.org/10.17512/pjms.2023.28.2.01

Androniceanu, A., & Georgescu, I. (2023). Digital competences and human development: a canonical correlation analysis in romania. *Polish Journal of Management Studies*, *28*(1), 43–61. https://doi.org/10.17512/pjms.2023.28.1.03

Aras, A., & Büyüközkan, G. (2023). Digital Transformation Journey Guidance: A Holistic Digital Maturity Model Based on a Systematic Literature Review. *Systems*, *11*(4), Article 4. https://doi.org/10.3390/systems11040213

Autio, E., Mudambi, R., & Yoo, Y. (2021). Digitalization and globalization in a turbulent world: Centrifugal and centripetal forces. *Global Strategy Journal*, *11*(1), 3–16. https://doi.org/10.1002/gsj.1396

Aven, T. (2015). The Concept of Antifragility and its Implications for the Practice of Risk Analysis. *Risk Analysis*, *35*(3), 476–483. https://doi.org/10.1111/risa.12279

Bajaba, A. (2022). *Antifragility: Disorder as the Wind That Energizes the Fire Within Us* [Doctoral dissertation, Louisiana Tech Digital Commons].

Bennich, A. (2024). The digital imperative: Institutional pressures to digitalise. *Technology in Society*, *76*, 102436. https://doi.org/10.1016/j.techsoc.2023.102436

Blečić, I., & Cecchini, A. (2020). Antifragile planning. *Planning Theory*, *19*(2), 172–192. https://doi.org/10.1177/1473095219873365

Botjes, E., Van Den Berg, M., Van Gils, B., & Mulder, H. (2021). Attributes relevant to antifragile organizations. In *2021 IEEE 23rd Conference on Business Informatics (CBI), Bolzano, Italy* (pp. 62–71). IEEE. https://doi.org/10.1109/CBI52690.2021.00017

Bridge, S. (2021). Facing uncertainty: An entrepreneurial view of the future? *Journal of Management & Organization*, *27*(2), 312–323. https://doi.org/10.1017/jmo.2018.65

Butkus, M., Schiuma, G., Bartuševičienė, I., Rakauskiene, O. G., Volodzkiene, L., & Dargenyte-Kacileviciene, L. (2023). The impact of organizational resilience on the quality of public services: Application of structural equation modeling. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, *18*(2), Article 2. https://doi.org/10.24136/eq.2023.014

Butkus, M., Schiuma, G., Bartuseviciene, I., Volodzkiene, L., Rakauskiene, O. G., & Dargenyte-Kacileviciene, L. (2024). Modelling organisational resilience of public sector organisations to navigate complexity: Empirical insights from Lithuania. *Journal of Economic Interaction and Coordination*. https://doi.org/10.1007/s11403-023-00403-x

Cañizares, J. C., Copeland, S. M., & Doorn, N. (2021). Making sense of resilience. *Sustainability (Switzerland)*, *13*(15). https://doi.org/10.3390/su13158538

Chen, Y.-C. (2017). Introduction: The Rise of Digital Governance. In *Managing Digital Governance*. Routledge.

Codara, L., & Sgobbi, F. (2021). Resilience, complexity, and digital transformation: Three case studies in the valves industry. *Journal of Manufacturing Technology Management*, *34*(9), 1–19. https://doi.org/10.1108/JMTM-05-2022-0214

Corvello, V., Felicetti, A., Troise, C., & Tani, M. (2023). Betting on the future: How to build antifragility in innovative start-up companies. *Review of Managerial Science*, *18*, 1101–1127. https://doi.org/10.1007/s11846-023-00636-x

Corvello, V., Verteramo, S., Nocella, I., & Ammirato, S. (2022). Thrive during a crisis: The role of digital technologies in fostering antifragility in small and medium-sized enterprises. *Journal of Ambient Intelligence and Humanized Computing*, *14*, 14681–14693. https://doi.org/10.1007/s12652-022-03816-x

Danielsen, F., Flak, L. S., & Sæbø, Ø. (2022). Understanding Digital Transformation in Government. *Public Administration and Information Technology*, *38*, 151–187. https://doi.org/10.1007/978-3-030-92945-9_7

de Bruijn, H., Groessler, A., & Videira, N. (2020). Antifragility as a design criterion for modelling dynamic systems. *Systems Research and Behavioral Science*, *37*(1), 23–37. https://doi.org/10.1002/sres.2574

Derbyshire, J., & Wright, G. (2014). Preparing for the future: Development of an 'antifragile' methodology that complements scenario planning by omitting causation. *Technological Forecasting and Social Change*, *82*, 215–225. https://doi.org/10.1016/j.techfore.2013.07.001

Dunleavy, P., & Margetts, H. (2023). Data science, artificial intelligence and the third wave of digital era governance. *Public Policy and Administration*, 09520767231198737. https://doi.org/10.1177/09520767231198737

Equihua, M., Aldama, M. E., Gershenson, C., López-Corona, O., Munguía, M., Pérez-Maqueo, O., & Ramírez-Carrillo, E. (2020). Ecosystem antifragility: Beyond integrity and resilience. *PeerJ*, *8*, e8533. https://doi.org/10.7717/peerj.8533

Eugen, P., & Petru, D. (2018). Exploring the New Era of Cybersecurity Governance. *Ovidius University Annals, Economic Sciences Series*, *XVIII*(1), 358–363.

Fan, Y., Chen, J., Shirkey, G., John, R., Wu, S. R., Park, H., & Shao, C. (2016). Applications of structural equation modeling (SEM) in ecological studies: An updated review. *Ecological Processes*, *5*(1), 19. https://doi.org/10.1186/s13717-016-0063-3

Fiorini, R. A. (2017). Would the big government approach increasingly fail to lead to good decision?: A solution proposal. *Kybernetes*, *46*(10), 1735–1752. https://doi.org/10.1108/K-01-2017-0013

Fiorini, R. A. (2019). A Strategic Proposal for the New Society: Surviving and Flourishing from Chaos. In R. Poli & M. Valerio (eds.), *Anticipation Science* (Vol. 4, pp. 149–171). Springer, Cham. https://doi.org/10.1007/978-3-030-03623-2_10

Fulmer, C. A., & Ostroff, C. (2016). Convergence and emergence in organizations: An integrative framework and review. *Journal of Organizational Behavior*, *37*(S1), S122–S145. https://doi.org/10.1002/job.1987

Gavkalova, N., Lola, Y., Malyi, I., Poliakova, H., & Lola, Y. (2021). The institutional transformation of the digital values of ukrainian society. *Intellectual Economics*, *15*(1), 49–63. https://doi.org/10.13165/IE-21-15-1-04

Gershenson, C. (2015). Requisite variety, autopoiesis, and self-organization. *Kybernetes*, *44*(6/7), 866–873. https://doi.org/10.1108/K-01-2015-0001

Ghasemi, A., & Alizadeh, M. (2017). Evaluating organizational antifragility via fuzzy logic. The case of an Iranian company producing banknotes and security paper. *Operations Research and Decisions*, *27*(2), 21–43. https://doi.org/10.5277/ord170202

Guang, L., Nigussie, E., Plosila, J., & Tenhunen, H. (2014). Positioning Antifragility for Clouds on Public Infrastructures. *Procedia Computer Science*, 32, 856–861. http://dx.doi.org/10.1016/j.procs.2014.05.502

Hayes, A. F. (2017). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. Guilford Press.

Hole, K. J. (2022). Tutorial on systems with antifragility to downtime. *Computing*, *104*(1), 73–93. https://doi.org/10.1007/s00607-020-00895-6

Johnson, J., & Gheorghe, A. V. (2013). Antifragility analysis and measurement framework for systems of systems. *International Journal of Disaster Risk Science*, *4*(4), 159–168. https://doi.org/10.1007/s13753-013-0017-7

Kennon, D., Schutte, C. S. L., & Lutters, E. (2015). An alternative view to assessing antifragility in an organisation: A case study in a manufacturing SME. *CIRP Annals*, *64*(1), 177–180. https://doi.org/10.1016/j.cirp.2015.04.024

Lember, V., Kattel, R., & Tõnurist, P. (2018). Technological capacity in the public sector: The case of Estonia. *International Review of Administrative Sciences*, *84*(2), 214–230. https://doi.org/10.1177/0020852317735164

Lindquist, E. A. (2022). The digital era and public sector reforms: Transformation or new tools for competing values? *Canadian Public Administration*, *65*(3), 547–568. https://doi.org/10.1111/capa.12493

Linkov, I., Trump, B. D., Poinsatte-Jones, K., & Florin, M.-V. (2018). Governance Strategies for a Sustainable Digital World. *Sustainability, 10*(2), Article 2. https://doi.org/10.3390/su10020440

Markey-Towler, B. (2018). Antifragility, the Black Swan and psychology: A psychological theory of adaptability in evolutionary economies. *Evolutionary and Institutional Economics Review*, *15*(2), 367–384. https://doi.org/10.1007/s40844-018-0097-6

Munoz, A., Billsberry, J., & Ambrosini, V. (2022). Resilience, robustness, and antifragility: Towards an appreciation of distinct organizational responses to adversity. *International Journal of Management Reviews*, *24*(2), 181–187. https://doi.org/10.1111/ijmr.12289

Munoz, A., Todres, M., & Rook, L. (2021). Empowering Organisations to Gain From Uncertainty: A Conceptualisation of Antifragility Through Leveraging Organisational Routines in Uncertain Environments. *Australasian Accounting, Business and Finance Journal*, *15*(3), 23–42. https://doi.org/10.14453/aabfj.v15i3.3

Nikookar, E., Varsei, M., & Wieland, A. (2021). Gaining from disorder: Making the case for antifragility in purchasing and supply chain management. *Journal of Purchasing and Supply Management*, *27*(3), 100699. http://dx.doi.org/10.1016/j.pursup.2021.100699

Nitzl, C., Roldan, J. L., & Cepeda, G. (2016). Mediation analysis in partial least squares path modeling: Helping researchers discuss more sophisticated models. *Industrial*

Management & Data Systems, *116*(9), 1849–1864. https://doi.org/10.1108/IMDS-07-2015-0302

Nuryadin, R., Sobandi, A., & Santoso, B. (2023). Digital Leadership in the Public Sector-Systematic Literature Review: Systematic literature review. *Jurnal Ilmu Administrasi: Media Pengembangan Ilmu Dan Praktek Administrasi*, *20*(1), Article 1. https://doi.org/10.31113/jia.v20i1.934

O'Reilly, B. (2019). No More Snake Oil: Architecting Agility through Antifragility. *Procedia Computer Science*, *151*, 884–890. https://doi.org/10.1016/j.procs.2019.04.122

Pearse, N. (2011). Deciding on the Scale Granularity of Response Categories of Likert type Scales: The Case of a 21-Point Scale. *Electronic Journal of Business Research Methods*, *9*(2), Article 2.

Ramezani, J., & Camarinha-Matos, L. M. (2019a). A collaborative approach to resilient and antifragile business ecosystems. *Procedia Computer Science*, *162*, 604–613. https://doi.org/10.1016/j.procs.2019.12.029

Ramezani, J., & Camarinha-Matos, L. M. (2019b). Novel Approaches to Handle Disruptions in Business Ecosystems. In L. M. Camarinha-Matos, R. Almeida, & J. Oliveira (Eds.), *Technological Innovation for Industry and Service Systems* (pp. 43–57). Springer International Publishing. https://doi.org/10.1007/978-3-030-17771-3_4

Ramezani, J., & Camarinha-Matos, L. M. (2020). Approaches for resilience and antifragility in collaborative business ecosystems. *Technological Forecasting and Social Change*, *151*, 119846. https://doi.org/10.1016/j.techfore.2019.119846

Russo, D., & Ciancarini, P. (2017). Towards Antifragile Software Architectures. *Procedia Computer Science*, *109*, 929–934. https://doi.org/10.1016/j.procs.2017.05.426

Schwer, K., Hitz, C., Wyss, R., Wirz, D., & Minonne, C. (2018). Digital maturity variables and their impact on the enterprise architecture layers. *Problems and Perspectives in Management*, *16*(4), 141–154. https://doi.org/10.21511/ppm.16(4).2018.13

Signore, F., Pasca, P., Valente, W., Ciavolino, E., & Ingusci, E. (2021). Social resources and emotional exhaustion: the role of communication in professional relationships. *Intellectual Economics*, *15*(2), Article 2. https://ojs.mruni.eu/ojs/intellectual-economics/article/view/6983

Taleb, N. N. (2012). *Antifragile: Things That Gain from Disorder*. United States Random House.

Wu, H., & Leung, S.-O. (2017). Can Likert Scales be Treated as Interval Scales?—A Simulation Study. *Journal of Social Service Research*, *43*(4), 527–532. https://doi.org/10.1080/01488376.2017.1329775

Zhao, N., & Ren, J. (2023). Impact of enterprise digital transformation on capacity utilization: Evidence from China. *PLoS ONE*, *18*(3), e0283249. https://doi.org/10.1371/journal.pone.0283249

Appendix 1. Maximum likelihood estimates of covariances and standardized regression weights

Type of the analysis			**CFA**	**SEM**	**CFA**	**SEM**	**CFA**
			Hypothesized Model No. 1		Alternative Model No. 2		Structure of antifragility
COVARIANCES							
Leadership	<-->	Public_services	4.046***		4.049***		
Leadership	<-->	Infrastructure	3.456***				
Leadership	<-->	Cybersecurity	3.640***				
Public_services	<-->	Infrastructure	4.130***				
Public_services	<-->	Cybersecurity	4.178***				
Infrastructure		Cybersecurity	4.386***				
Capacity_building	<-->	Infrastructure	3.169***				
Capacity_building	<-->	Cybersecurity	3.120***				
Capacity_building	<-->	Leadership	2.925***		2.923***		
Capacity_building	<-->	Public_services	3.322***		3.316***		
Redundancy	<-->	Small_stressor inducement					2.985***
Redundancy	<-->	Non_linear responses					1.680***
Redundancy	<-->	Diversity of responses					1.485***
Capacity for emerging_behaviour	<-->	Redundancy					1.357***
Small_stressor inducement	<-->	Non_linear responses					1.496***
Small_stressor inducement	<-->	Diversity of responses					2.060***
Capacity for emerging_behaviour	<-->	Small_stressor inducement					1.681***
Non_linear responses	<-->	Diversity of responses					1.631***
Capacity for emerging_behaviour	<-->	Non_linear responses					1.505***
Capacity for emerging_behaviour	<-->	Diversity of responses					1.628***
STANDARDIZED REGRESSION WEIGHTS							
Infrastructure	<---	Capacity_building				0.277***	
Infrastructure	<---	Public_services				0.480***	
Infrastructure	<---	Leadership				0.194***	
Cybersecurity	<---	Infrastructure				0.930***	
Cybersecurity	<---	Leadership				0.030**	
Cybersecurity	<---	Capacity_building				0.028**	
Cybersecurity	<---	Public_services				0.025*	
Redundancy	<---	Infrastructure		−6.874***		−5.898***	
Redundancy	<---	Cybersecurity		7.725***		6.153***	
Small_stressor inducement	<---	Infrastructure		−6.145***		−5.224***	
Small_stressor inducement	<---	Cybersecurity		7.046***		5.493***	
Non_linear responses	<---	Infrastructure		−7.764***		−6.886***	

Non_linear responses	<---	Cybersecurity	8.531***	7.167***
Diversity of responses	<---	Infrastructure	−8.616***	−7.643***
Capacity for emerging_behaviour	<---	Infrastructure	−8.466***	−7.656***
Diversity of responses	<---	Cybersecurity	9.561***	7.956***
Emerging_behaviour	<---	Cybersecurity	9.318***	7.957***
Redundancy	<---	Leadership	−0.796	
Small_stressor inducement	<---	Leadership	−0.688	
Non_linear responses	<---	Leadership	0.992	
Diversity of responses	<---	Leadership	−1.068	
Capacity for emerging_behaviour	<---	Leadership	−0.942	
Redundancy	<---	Public_services	−0.101	
Small_stressor inducement	<---	Public_services	−0.251	
Non_linear responses	<---	Public_services	0.006	
Diversity of responses	<---	Public_services	−0.247	
Capacity for emerging_behaviour	<---	Public_services	−0.207	
Redundancy	<---	Capacity_building	0.153	
Small_stressor inducement	<---	Capacity_building	0.161	
Non_linear responses	<---	Capacity_building	0.369	
Diversity of responses	<---	Capacity_building	0.537	
Capacity for emerging_behaviour	<---	Capacity_building	0.469	
Strategy	<---	Leadership	0.927***	0.927***
Project initiatives	<---	Leadership	0.956***	0.956***
Funding	<---	Leadership	0.937***	0.937***
Public service provision	<---	Public_services	0.957***	0.957***
Stakeholder inclusion	<---	Public_services	0.957***	0.957***
Service accessibility	<---	Public_services	0.955***	0.955***
Awareness of competence	<---	Capacity_building	0.937***	0.935***
Competence inventory	<---	Capacity_building	0.945***	0.946***
Training	<---	Capacity_building	0.747***	0.748***
Centralized IT inventory	<---	Infrastructure	0.907***	0.906***
Centralized IT support	<---	Infrastructure	0.895***	0.894***
IT inventory	<---	Infrastructure	0.920***	0.918***
Data analytics integration	<---	Infrastructure	0.880***	0.878***
Management of digital assets	<---	Cyber	0.835***	0.836***
Partnerships	<---	Cyber	0.852***	0.855***
Cyber training	<---	Cyber	0.816***	0.819***
Planning resources	<---	Redundancy	0.853***	0.851***
Stockpiling routines	<---	Redundancy	0.922***	0.923***

ISSN 2071-789X

Critical resource duplication	<---	Redundancy	0.905***	0.906***
Fault injection	<---	Small_stressor inducement	0.956***	0.956***
Risk segmentation	<---	Small_stressor inducement	0.943***	0.943***
Stress training	<---	Small_stressor inducement	0.907***	0.907***
Trial and error	<---	Non_linear responses	0.898***	0.898***
Adaptive learning	<---	Non_linear responses	0.912***	0.913***
Unlearning	<---	Non_linear	0.829***	0.829***
Self-properties	<---	Diversity of responses	0.758***	0.757***
Complexity	<---	Diversity of responses	0.855***	0.856***
Collaborative ecosystems	<---	Diversity of responses	0.844***	0.843***
Tacit knowledge empowerment	<---	Capacity for emerging_behaviour	0.864***	0.865***
Breaking silos	<---	Capacity for emerging_behaviour	0.827***	0.827***
Diversity	<---	Capacity for emerging_behaviour	0.857***	0.856***

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively