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A Key Factor for Success

Resilience, a term that has been used in engineering for over 200 years, migrated after 2000 to unexpected areas. Resilience in mechanics defines the ability of a material to recover after suffering a shock. Then from "materials" it moved to an "entity" and further to a "system". The word ''resilience'' began to be used in psychology, economics, ecology, politics, management, urban planning, the army, organizations. And the ''shock'' can be physical, emotional, economic. It is also emphasized that the recovery time of the system and the changes that occur in the structure of the system are important.

For management, the resilience of organizations is important. In today's world, change is constant and uncertainty is the norm. Organizations face rapid technological advancements, economic shifts, climate challenges, and global disruptions that can strike without warning. In this environment, resilience has become a key determinant of long-term success. It is no longer enough for organizations to be efficient or innovative. They must also be able to adapt, recover, and grow stronger when faced with challenges.

A **resilient organization** is one that does not only survive disruption but learns and evolves from it. Resilience is a combination of preparation, adaptability, and the ability to turn challenges into opportunities. Real-world experience shows resilient organizations excel in three main areas: **leadership, agility, and culture**.

Leadership that adapts and inspires is crucial. Leaders set the tone for how an organization responds to uncertainty. Those who communicate clearly, take decisions in due time, and empower employees create an environment where people feel confident to take action even in difficult situations. For example, during the recent pandemic, crisis organizations with adaptive leadership were able to pivot quickly to remote work, maintain operations, and explore new business models. Pharmaceutical companies rapidly adapted their production lines to meet surging demand for essential medications. Their resilience was built on flexible operations, strong supplier networks, and proactive leadership. Medical IT companies emphasized ethical and adaptive leadership, enabling them to maintain operations and support healthcare systems during global disruptions.

> "*A half of the art of living is resilience.*"
>
> Alain de Botton
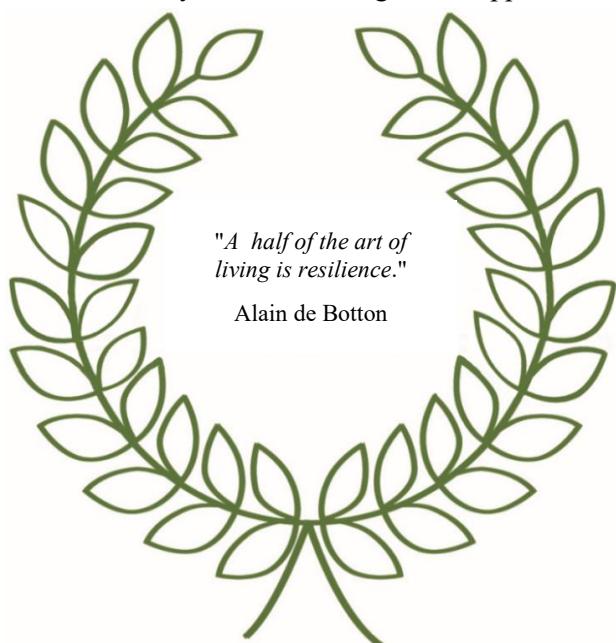
Organizational agility is the second key pillar. Agile organizations can reconfigure themselves quickly to meet changing circumstances. This includes flexible structures, collaborative teams, and the smart use of technology. Companies with agile systems are able to respond to disruptions without being slowed down by rigid processes, making them more competitive in fast-changing markets.

The third pillar is a **culture of learning and trust**. Employees must feel safe to experiment, share ideas, and learn from mistakes. When an organization encourages open communication, collaboration, and continuous learning, it develops the capacity to anticipate risks, innovate, and adapt over time. This culture not only strengthens resilience but also fosters creativity and long-term growth.

Real-world examples demonstrate the power of organizational resilience. During global crises, some companies quickly adjusted production, embraced digital tools, or restructured operations to meet new demands. Others relied on strong leadership and trust-based cultures to maintain employee engagement and stakeholder confidence. These experiences highlight that resilience is not just about surviving a crisis. It is about turning challenges into opportunities for growth.

Resilience is not a one-time achievement; it is a continuous process of learning, adapting, and improving. It requires investment, not just in technology and systems, but in people, leadership, and culture as well. Organizations must anticipate potential disruptions, learn from past experiences, and continuously evolve strategies to remain relevant. Organizations that invest in leadership development, agile structures, and a supportive culture are better prepared to navigate uncertainty and emerge stronger.

Corina - Ionela DUMITRESCU
Guest Editor
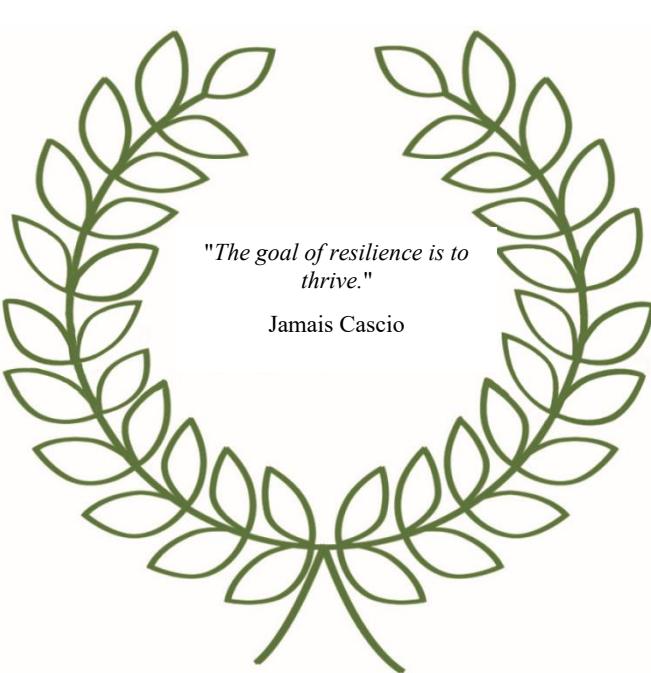
"The goal of resilience is to thrive."

Jamais Cascio

Influence of Taxes on Fiscal Resilience

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Abstract

The study analyzes the relationship between the structure of taxes and economic activity in Romania, from the perspective of strengthening fiscal resilience. Using a multiple linear regression econometric model, it examines the effects of taxes on production and imports (indirect taxes) and taxes on income and wealth (direct taxes) on GDP per capita during the period 2000–2023, based on data from the Eurostat database. The empirical results highlight a significant positive relationship between the level of tax revenues and economic activity, confirming the role of taxation in supporting economic development.

Keywords: taxes, regression, economic activity

Introduction

Fiscal resilience represents the ability of a budgetary system to absorb economic shocks, maintain its essential functions, and quickly return to a sustainable equilibrium without compromising economic growth and macroeconomic stability. It depends not only on the volume of revenues collected but also on the quality of institutions, the efficiency of collection mechanisms, the diversification of revenue sources, and the flexibility of the fiscal framework relative to the dynamics of the economy. In this context, the resilience of tax administrations becomes a fundamental element of economic stability, since the performance of revenue-collecting institutions

"To fly we have to have resistance."
Maya Lin

determines the state's capacity to maintain public revenue continuity, respond quickly to crises, and ensure the sustainability of public finances.

In Romania, the fiscal structure is dominated by indirect taxes, especially value-added tax (VAT) and excise duties, which provide a significant share of budget revenues. These taxes have proven more stable amid economic volatility, displaying high elasticity relative to production and consumption - major components of GDP. By contrast, direct taxes - such as income and wealth taxes - are more sensitive to changes in employment rates, corporate profitability, or fiscal policy decisions, making them more vulnerable during economic instability. Moreover, the effectiveness of these instruments depends on the tax administration's capacity to combat evasion, improve voluntary compliance, and use digital technologies to optimize collection processes.

In academic literature, the relationship between taxation and economic activity is analyzed not only from the perspective of tax levels but also in terms of fiscal governance quality and institutional resilience. In emerging economies, including those of Central and Eastern Europe, indirect taxes are considered the main source of stable revenues that help maintain budgetary balance during uncertainty, whereas excessive reliance on direct taxes can increase the vulnerability of the fiscal system to cyclical fluctuations. Therefore, strengthening fiscal resilience involves not only quantitative adjustments but also structural reforms that ensure the efficiency, transparency, and adaptability of tax administrations.

This paper aims to contribute to existing literature through an econometric analysis of the influence of direct and indirect taxes on economic activity in Romania over the 2000–2023 period. The goal is to assess the extent to which the fiscal structure and the performance of tax administration can support economic resilience and the financial sustainability of the state. Using a multiple linear regression model, the research examines the relationship between tax revenues and GDP per capita, providing an empirical perspective on how fiscal policy can serve not only as a tool for economic stimulation but also as a mechanism for strengthening long-term fiscal resilience.

Literature review

The academic literature emphasizes the importance of taxation as a fundamental instrument of fiscal policy, capable of directly influencing the decisions of economic agents and the stability of the budgetary system. Numerous studies focus on the differences between direct and indirect taxes, outlining varied results depending on institutional context, the level of economic development, and the capacity of tax administrations to respond to external shocks — all of which are central aspects in defining fiscal resilience.

Empirical studies employ diverse methodologies, ranging from classical regressions (OLS, fixed or random effects models) to dynamic techniques. The results are heterogeneous: some research (Kalaš et al., 2018; Hodžić et al., 2020; Gllogjani and Durguti, 2023) shows that indirect taxes can contribute to greater stability in tax revenues, providing a higher degree of resilience under conditions of economic volatility. Other studies (Mutascu and Danuletiu, 2011; Bazgan, 2019) highlight the role of direct taxes, but only when these are supported by efficient institutions and a predictable policy framework.

In emerging and transition economies, the effects of fiscal policy depend not only on the level of taxation but also on the quality of governance and institutions (Tsaurai, 2021). In Central and Eastern Europe, indirect taxes have been identified as the main sources of stable revenues, supporting budgetary resilience during uncertain periods (Gherghina et al., 2024). Conversely, in OECD countries, an excessive level of corporate taxation can weaken economic adaptability, indicating the need for fiscal balance to maintain long-term sustainability (Riadh, 2025).

A substantial branch of the literature focuses on the structure of taxes and the efficiency of their collection. Analyses by Leibfritz et al. (1997) and Perotti (2004) demonstrate that fiscal resilience derives not only from revenue levels but also from the capacity to build positive economic incentives and reduce barriers to investment. Romer and Romer (2010), as well as Afonso and Sousa (2011), use VAR models to show that fiscal policies can generate both stimulative and

restrictive effects, depending on transmission mechanisms and institutional flexibility.

In Romania's case, research (Brasoveanu and Brasoveanu, 2008; Enache, 2009; Muresan et al., 2014; Surugiu and Surugiu, 2018) indicates that high levels of taxation can reduce competitiveness and increase fiscal vulnerability, while a balanced system - based on efficient collection and the reduction of tax evasion - strengthens the resilience of the tax administration. VAT frequently appears as a stable instrument with a direct impact on consumption and production, explaining its central role in ensuring public revenues.

In summary, the literature shows that the influence of taxes on economic activity is closely linked to the tax administration's capacity to ensure resilience. This involves not only the stability of revenues but also the adaptability of policies to changing economic and institutional contexts.

Research methodology

To evaluate the influence of taxes, three main variables were selected. The dependent variable is gross domestic product per capita (GDPCAP), used as a proxy for the average level of economic welfare. The independent variables are represented by taxes on production and imports (indirect taxes), denoted TXPROD, and taxes on income and wealth (direct taxes), denoted TXINC. These variables capture both the role of indirect taxes, which represent a stable source of revenue and reflect consumption and production, and the role of direct taxes, which are closely related to the income and wealth of taxpayers.

The data used were extracted from the Eurostat database and cover the 2000–2023 period, allowing the identification of long-term trends and the potential effects of economic crises on the relationship between variables. Choosing Eurostat as the data source ensures the comparability and statistical accuracy required for econometric analysis.

The econometric model adopted is a multiple linear regression, estimated using the Ordinary Least Squares (OLS) method. This method minimizes the difference between observed and estimated values of the dependent variable, providing coefficients that reflect the direction and intensity of the relationship between variables.

To reduce seasonal variations and linearize the relationships among variables, the data was transformed using natural logarithms. Thus, the estimated model takes the form:

$$LNGDPCAP = \beta_0 + \beta_1 LNTXPROD + \beta_2 LNTXINC + \varepsilon$$

where:
- LNGDPCAP - logarithm of GDP per capita,
- LNTXPROD - logarithm of taxes on production and imports,
- LNTXINC - logarithm of taxes on income and wealth.

The central hypothesis is that both direct and indirect taxes exert a positive influence on the dependent variable, through the revenues collected that support economic activity and the financing of public expenditures.

For the validity of the model, the following basic assumptions of linear regression were verified linearity of relationships between variables, absence of multicollinearity among predictors, homoscedasticity of errors, independence of residuals and absence of autocorrelation and normality of the residuals' distribution. If deviations from these assumptions were detected (e.g., heteroscedasticity or autocorrelation), appropriate adjustments were applied to ensure the robustness of results.

The data analysis was carried out using EViews 10 software, a widely used statistical package in economic research. It offers advanced functionalities for estimating regression models, testing hypotheses, and verifying model validity conditions.

Results and discussion

The evolution of the three variables selected for this research shows a steady economic growth between 2000 and 2023, except for certain crisis periods and some changes in the fiscal structure (Figure 1).
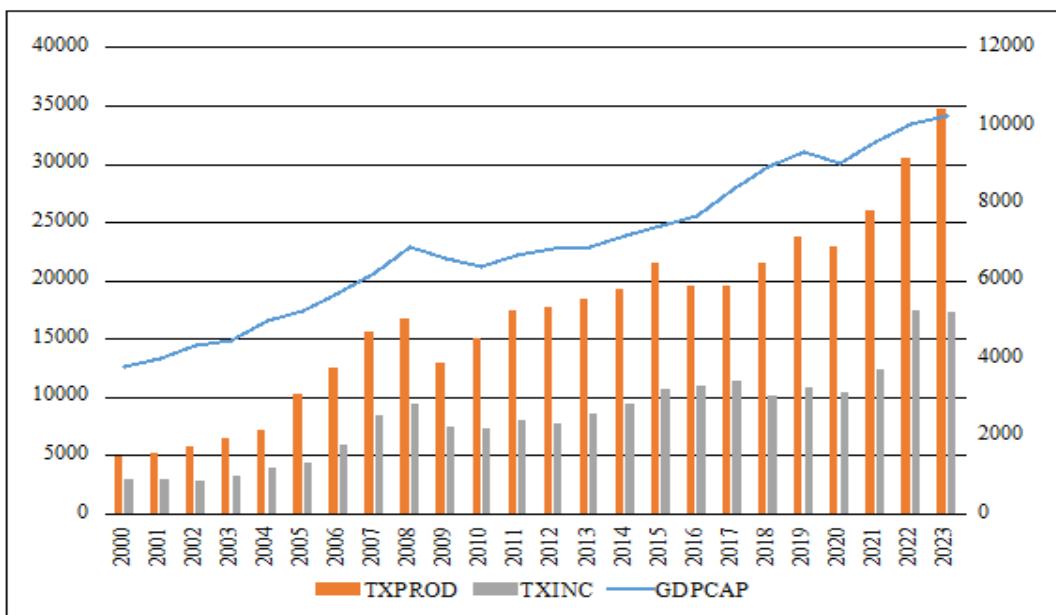
Figure 1 – *Evolution of the selected variables during 2000–2023*

The descriptive statistics of the variables included in the multiple linear regression model, summarized in Table 1, show that the logarithmic transformation of the variables likely helped normalize their distributions.

Table 1 – *The variables included in the multiple linear regression model*

	LNGDPCAP	LNTXPROD	LNTXINC
Mean	8.8053	9.6015	8.9153
Median	8.8291	9.7690	9.0403
Maximum	9.2350	10.4567	9.7674
Minimum	8.2375	8.4847	7.9386
Std. Dev.	0.2925	0.5633	0.5466
Skewness	-0.3656	-0.7262	-0.5505
Kurtosis	2.2001	2.4788	2.2896
Jarque-Bera	1.1747	2.3810	1.7167
Probability	0.5558	0.3041	0.4239
Sum	211.3263	230.4359	213.9682
Sum Sq. Dev.	1.9678	7.2968	6.8724
Obs.	24	24	24

The logarithmic values and the relatively normal distributions suggest approximately linear relationships between predictors and the dependent variable. The Jarque-Bera test confirms that the data do not deviate significantly from normality, which is favorable for statistical inference. The standard deviations do not show extreme values that could excessively influence the coefficients, and the moderate dispersion indicates that the predictors have sufficient variability to explain differences in the dependent variable.

The Variance Inflation Factor (VIF) estimation indicated a value of 5.26, highlighting a moderate risk of multicollinearity.

The correlation between the dependent variable LNGDPCAP and the two independent variables LNTXPROD and LNTXINC is very strong and positive, suggesting a significant link between these components. The relationship between LNGDPCAP and LNTXPROD is characterized by a correlation coefficient of 0.9661, indicating that an increase in taxes on production and imports is associated with a consistent increase in GDP per capita. Similarly, the correlation coefficient between LNGDPCAP and LNTXINC is 0.9727, showing an even stronger positive relationship, suggesting that income and wealth taxes also have a significant connection with economic performance. These high correlation values indicate that both types of taxes contribute positively to explaining variations in GDP per capita.

At this stage of the analysis, we can estimate the parameters of the multiple linear regression model, developed according to the methodology described earlier (Table 2).

Table 2 – *Estimated parameters of the multiple regression model*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.9943	0.2481	16.0983	0.0000
LNTXPROD	0.3514	0.1378	2.5510	0.0186
LNTXINC	0.1612	0.1419	1,1354	0,0269
R-squared	0.9492	Mean dependent var		8,8053
Adjusted R-squared	0.9443	S.D. dependent var		0,2925
S.E. of regression	0.0690	Akaike info criterion		-2,3923
Sum squared resid	0.1001	Schwarz criterion		-2,2450
Log likelihood	31.7075	Hannan-Quinn criter.		-2,3532
F-statistic	196.0258	Durbin-Watson stat		1,2608
Prob(F-statistic)	0.0000			

The linear regression results highlight a significant relationship between GDP per capita (LNGDPCAP) and the independent variables representing taxes on production and imports (LNTXPROD) and taxes on income and wealth (LNTXINC). The coefficient for LNTXPROD is 0.351, suggesting that a 1% increase in taxes on production and imports is associated with a 0.351% increase in GDP per capita. This variable is statistically significant (p = 0.0186). Similarly, the coefficient for LNTXINC is 0.161, indicating a 0.161% increase in GDP per capita for a 1% rise in income and wealth taxes, also statistically significant (p = 0.0269). The model exhibits very high quality, as confirmed by an R² coefficient of 0.949, showing that 94.9% of the variation in GDP per capita is explained by changes in the independent variables. The adjusted R² of 0.944 supports the model's robustness, while the F-statistic (196.03, p < 0.0001) confirms the overall significance of the model.

The next step in the analysis is to verify the descriptive statistics of the residuals to determine whether they meet one of the main assumptions of linear regression — namely, that the meaning of residuals should be equal to or tend toward zero. As shown in Figure 2, the residual values fluctuate around zero throughout the analyzed period. This indicates that the regression model is well-calibrated, without systematic errors that could lead to constant overestimation or underestimation of the dependent variable.
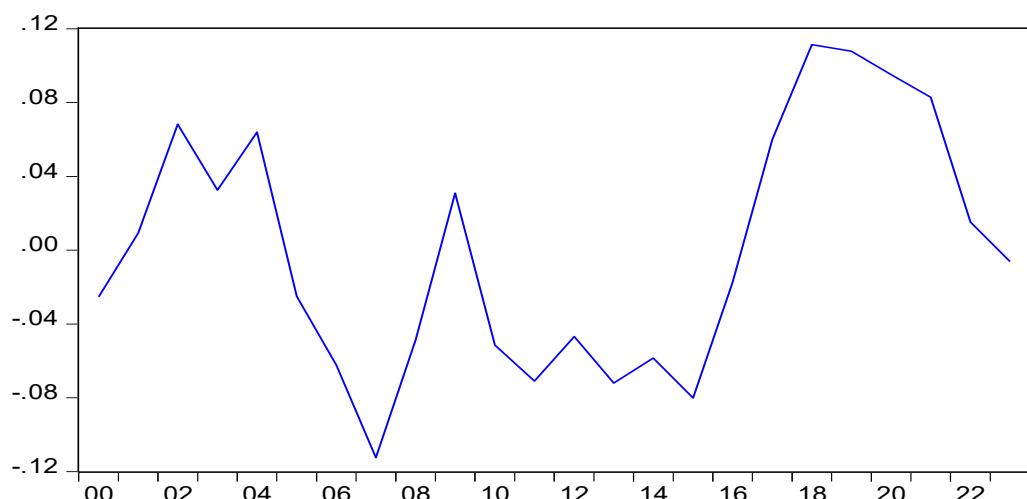
Figure 2 – *Variation of residual values for the regression model*

Several significant fluctuations can be observed in certain time intervals. In the early years of the sample, residuals are relatively unstable, alternating between positive and negative values, suggesting possible under- and overestimation of the dependent variable. Around 2008, a sharp drop in residuals toward negative values appears, likely associated with an economic event or a structural change in the data. After this decline, residuals become more stable between 2010–2017, although minor deviations remain.

Between 2018–2020, residuals rise sharply to high positive values, followed by a sudden decline at the end of the period. These tendencies might indicate model misspecification, the presence of autocorrelation, or the influence of undefined factors not adequately captured by the explanatory variables. Overall, the residual analysis suggests that, while the model performs well in most periods, further checks (such as homoscedasticity and independence of residuals) are necessary for complete validation.

The skewness value (0.2209) indicates a slight positive asymmetry in the residual distribution, but not a significant one. The kurtosis value (1.8468) suggests a flatter-than-normal distribution (platykurtic), implying fewer extreme values. The Jarque-Bera test (1.5251) and the associated probability (0.4665) do not indicate any significant deviation from normality, suggesting that the residuals are normally distributed. The sum of

residuals is extremely close to zero (-3.97E-14), confirming the model's accuracy in maintaining the balance of errors. Overall, these statistics indicate that the residuals conform well to the fundamental assumptions of multiple linear regression used to analyze the impact of taxation on Romania's GDP.

The identification of homoscedasticity or heteroscedasticity was performed using the White test, a statistical method used to verify whether the variance of residuals is constant or depends on the independent variables. The test examines the relationship between the squared residuals and the explanatory variables (or their combinations), providing a clear indication of the presence of heteroscedasticity. For a significance level of 0.05, the critical Chi-square value for 4 degrees of freedom is $Chi^2_{(0,05/4)} = 9.488$.

The White statistic, calculated as $n \times R^2$, equals 5.7345 (where n = 24 and R^2 = 0.3837). Since this value is lower than the critical value (LM < $\chi^2(0.05,4)$), the results indicate that the model does not exhibit heteroscedasticity. To detect autocorrelation in residuals, the Durbin-Watson test was applied. The Durbin-Watson statistic obtained for the estimated regression model is 1.2608, providing indications about possible residual autocorrelation. Ideally, the Durbin-Watson value should be close to 2, which would indicate no autocorrelation. In this case, the value of 1.26 suggests possible positive autocorrelation,

but the result must be compared with critical limits d_L and d_U for a more accurate interpretation. For n=24 observations and k=2 independent variables, the approximate critical limits are d_L=1.21 and d_U=1.57. Because the Durbin-Watson value lies between these limits, the test result is inconclusive (Table 4).

Table 4 - *White Test Results*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.2328	0.2241	-1.0387	0.3127
LNTXPROD^2	-0.0881	0.0733	-1.2011	0.2453
LNTXPROD*LNTXINC	0.1959	0.1450	1.3514	0.1933
LNTXPROD	-0.0468	0.1682	-0.2782	0.7841
LNTXINC^2	-0.1117	0.0725	-1.5405	0.1408
LNTXINC	0.1022	0.1667	0.6133	0.5474
R-squared	0.3837	Mean dependent var		0.0042
Adjusted R-squared	0.2125	S.D. dependent var		0.0040
S.E. of regression	0.0035	Akaike info criterion		-8.2728
Sum squared resid	0.0003	Schwarz criterion		-7.9783
Log likelihood	105.2734	Hannan-Quinn criter.		-8.1947
F-statistic	2.2413	Durbin-Watson stat		1.5041
Prob(F-statistic)	0.0946			

This outcome implies that it cannot be determined with certainty whether the residuals are independent or positively autocorrelated. Possible autocorrelation could affect the estimation of standard errors, which in turn might influence the statistical significance of regression coefficients. Therefore, the results should be interpreted cautiously, considering this uncertainty — though all other diagnostics indicate that the model fits the data very well.

In conclusion, the multiple linear regression model identified to estimate the impact of taxation on Romania's GDP can be expressed as:

LNGDPCAP = 3.9944 + 0.3514*LNTXPROD + 0.1612*LNTXINC

Thus, the multiple regression model describes the relationship between GDP per capita (in logarithmic form, LNGDPCAP) and the two independent variables: the logarithm of taxes on production and imports (LNTXPROD) and the logarithm of taxes on income and wealth (LNTXINC). The intercept of the model (C = 3.9944) indicates the estimated value of LNGDPCAP when the independent variables take the value zero. Although this scenario is unrealistic in practice, the intercept serves to adjust the position of the regression line. The coefficient for LNTXPROD (0.3514) suggests that a 1% increase in taxes on production and imports is associated with approximately a 0.35% increase in GDP per capita, ceteris paribus. Similarly, the coefficient for LNTXINC (0.1612) indicates that a 1% increase in income and wealth taxes corresponds to a 0.16% increase in GDP per capita, assuming constant production-related taxes.

Conclusions

The econometric model reveals a positive association between GDP per capita and the two types of taxes analyzed, suggesting that higher revenues from these sources may support economic development. These results reflect correlation, not causation, but provide a framework for assessing fiscal impact and informing policy.

Production and import taxes exert a stronger influence on GDP per capita than income and wealth taxes. VAT and excise duties directly affect production costs, distribution, and consumer prices, generating immediate effects on economic

activity, whereas income taxes primarily impact individual and corporate revenues. Production taxes also enhance fiscal stability and resilience. Revenues fund public investments in infrastructure, health, and education, producing multiplier effects. Their elasticity links revenue directly to economic activity, reinforcing the budget's capacity to absorb shocks.

Fiscal resilience depends on the efficiency of tax administration. Robust institutions ensure continuous revenue collection, adapt procedures to economic changes, and mitigate losses from evasion or external shocks. In Romania, the broad base for production taxes provides a stable tool for budget planning, strengthening institutional capacity to support policy under uncertainty. A well-designed fiscal strategy combining efficient production taxes, sustainable revenue policies, and resilient administration optimizes collection, stimulates growth, and enhances the state's capacity to withstand shocks, maintain fiscal stability, and finance public investments. Fiscal policy thus serves as a key instrument for both economic growth and institutional resilience.

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"Your success is going to be very dependent on how you adapt."
Jeremy Stoppelman
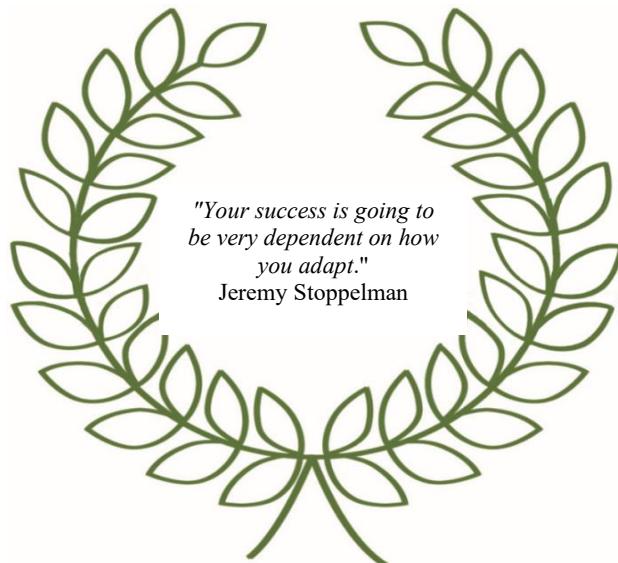
Digital Communication as a Driver of Organizational Resilience

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Abstract

This study explores the impact of digital communication on organisational resilience, innovation, and performance in the service industry, particularly in the context of crisis-driven adaptation. Grounded in the Dynamic Capabilities Framework and Organisational Learning Theory, the research examines how communication maturity enables firms to sense, adapt, and transform in volatile environments. Data were collected through a structured survey of service-sector organisations and analysed using multiple regression techniques. The model reveals that Organisational Resilience is the strongest predictor of performance. These findings confirm that digital communication functions as a dynamic and strategic capability that enhances adaptability, innovation, and organisational performance. The study recommends investing in communication infrastructure and cultivating a digitally fluent workforce to build resilience and sustain competitive advantage in an increasingly digital service economy.

Keywords: digital communication, organisational resilience, service industry

Introduction

The rapid digitalisation of modern economies has transformed how organisations operate and adapt, especially in the service industry, where communication quality determines performance. This transformation creates opportunities for innovation and efficiency but also demands greater adaptability and resilience (Cosa, 2024). Organisational resilience, the ability to anticipate, adapt, and recover has become vital for competitiveness, particularly in service contexts reliant on customer interaction and intangible assets (Hollands et al., 2024). Digital communication enhances resilience by enabling real-time collaboration, informed decision-making, and

"Tough times never last, but tough people do."
Robert H. Schuller

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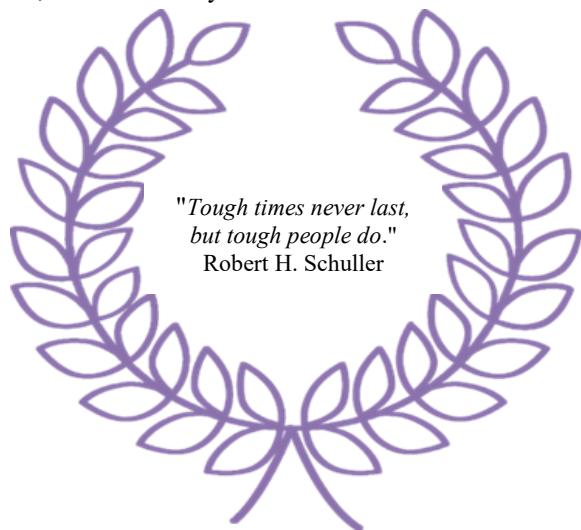
organisational connectedness. Tools such as CRM systems, intranets, and AI-based platforms promote transparency, learning, and adaptability (Putro, 2023).

The aim of this paper is to investigate how digital communication acts as a driver of organisational resilience within the service industry. Specifically, it seeks to explore the mechanisms through which digital tools and platforms contribute to strengthening an organisation's capacity to anticipate, respond to, and recover from challenges.

To address this aim, the research is guided by the following questions:

1. How does digital communication influence organisational resilience in the service industry?

2. What specific digital tools and communication practices support adaptability and continuity during periods of disruption?

3. To what extent can digital communication be considered a strategic resource for building long-term organisational resilience?

By addressing these questions, the paper contributes to a deeper understanding of the interdependence between digital transformation and resilience, providing both theoretical insights and practical implications for organisations operating in the dynamic service environment.

Theoretical Framework

Organisational Resilience. Organizational resilience reflects an organization's capacity to endure disruptions, adapt, and recover while preserving core functions and identity. Initially framed as a reactive ability to "bounce back," it is now seen as a proactive and dynamic capability. Gayed and El Ebrashi (2023) define it as "the ability to rebound from adversity strengthened and more resourceful," emphasizing learning and renewal. Alzate et al. (2024) conceptualize resilience as a dynamic capability integrating flexibility, resource reconfiguration, and foresight, while Marcazzan et al. (2022) describe it as a continuous process of anticipation, coping, and adaptation. These views converge in portraying resilience as an embedded organizational capability rather than a mere outcome.

Four core dimensions underpin resilience: anticipation, adaptation, response, and learning (Mosteanu, 2024). Anticipation enables risk detection, adaptation ensures structural and strategic flexibility, response supports coordinated action, and learning sustains long-term preparedness. In service industries, where customer interaction and intangible outputs dominate, resilience is critical for maintaining quality, trust, and commitment during disruptions (Kaartemo and Helkkula, 2025). Human-centric factors: communication, coordination, and morale, further strengthen resilience, supported by technological readiness and a culture of innovation and learning (Chabane et al., 2023). Overall, organizational resilience integrates structural, cognitive, and behavioural dimensions that enable service organizations to thrive amid uncertainty.

Digital Communication. Digital communication has become integral to modern organisational functioning, redefining how information is produced, shared, and interpreted. It encompasses the use of digital tools and platforms to facilitate interaction among internal and external stakeholders, distinguished by its speed, interactivity, and scalability (Wuersch et al., 2023). Contemporary organizations rely on diverse digital systems, such as Microsoft Teams, Slack, or Workplace by Meta, for collaboration and knowledge exchange, while CRM systems and AI chatbots streamline customer relations and enable data-driven decision-making. Collectively, these tools form an interconnected ecosystem that enhances coordination and operational efficiency.

Beyond tools, digital communication has reshaped organizational culture, fostering decentralised, networked, and participatory forms of interaction (Ahmad et al., 2023). This shift promotes agility and collaboration, key components of organizational resilience. However, it also introduces challenges such as information overload, digital fatigue, and concerns over data privacy (Shams, 2024). Despite these risks, strategically implemented digital communication strengthens learning, adaptability, and responsiveness, core attributes of resilience.

In the service sector, where performance depends on customer experience and employee engagement, digital communication acts both as an operational necessity and a strategic enabler. It supports real-time coordination, innovation, and trust-building, reinforcing organizational capacity to thrive in dynamic and uncertain environments.

The Link Between Digital Communication and Resilience. The link between digital communication and organizational resilience is increasingly viewed as a core element of organizational adaptability and sustainability. Digital communication enhances not only the efficiency of information exchange but also an organization's capacity for rapid and coordinated responses to disruptions. Through digital platforms, teams can share knowledge, align decisions, and act cohesively under uncertainty (Lee et al., 2023).

In times of crisis, real-time digital coordination tools, such as messaging applications, dashboards, and cloud systems facilitate swift information flow, enabling faster decision-making and resource allocation. Equally, consistent and transparent digital communication fosters trust, engagement, and psychological safety, all vital for collective resilience (Jasubhai, 2025). For service industries, maintaining open communication channels also preserves customer confidence and safeguards reputation during disruptions.

The Technology Acceptance Model (TAM) explains how perceived ease of use and usefulness influence employees' adoption of communication tools (Ibrahim and Shiring, 2022). Complementarily, the Dynamic Capabilities Theory views digital communication as a resource that enhances sensing, seizing, and transforming, key processes for adaptation (Sullivan et al., 2023).

Thus, digital communication functions as both a technological and organizational capability, fostering shared understanding, coordinated learning, and proactive innovation. In service contexts, it acts as the connective infrastructure of resilience - linking people, processes, and technologies to ensure agility, trust, and sustained performance in dynamic environments.

Research Methodology

This study adopts a quantitative research approach to examine how digital communication contributes to organisational resilience within the service industry. The research integrates survey-based data collection with descriptive and inferential statistical analyses, including multiple linear regression, to explore the relationships between digital communication practices, organisational learning, resilience capabilities, and performance outcomes.

Guided by the central research question: *How does digital communication enhance organisational resilience and adaptability in the service industry, particularly through its role in information flow, coordination, and learning?*, the following specific objectives were defined:

- Evaluate the extent of digital communication tools adoption and respondents' perceptions of their relevance and effectiveness during disruptive events;
- Identify the most widely used digital communication platforms (e.g., internal messaging systems, social media, CRM systems, and AI tools) and assess areas requiring further development;
- Analyse how digital communication influenced organisational operations, coordination processes, and customer relationship management during periods of disruption;
- Assess communication-based crisis response strategies and their perceived effectiveness;
- Examine the relationship between digital communication intensity, innovation, and organisational resilience;
- Determine the contribution of communication-related and strategic variables to organisational performance using multiple linear regression analysis;
- Explore how post-crisis communication strategies align with resilience-building practices;
- Identify opportunities for strengthening digital communication culture and resilience capabilities in the service sector.

To answer these research questions and objectives, an online questionnaire was developed, inspired by previous studies on digital transformation, resilience, and communication management (He et al., 2023). The questionnaire

was created using Google Forms and distributed via professional social networks (LinkedIn, Facebook) and email to a non-probabilistic convenience sample (Macías Urrego et al., 2024).

The questionnaire consisted of two main sections. The first focused on respondents' demographic and organisational characteristics (gender, age group, sector, position, years of service, and organisational size). The second section addressed perceptions and experiences related to digital communication and organisational resilience. Questions were structured using multiple-choice, 5-point Likert scales, and open-ended formats, covering the following dimensions:

(i) level of adoption of digital communication tools;

(ii) degree of digital competence and organisational digital culture;

(iii) perceived impact of communication technologies on coordination and decision-making;

(iv) communication-based crisis management and response strategies;

(v) post-crisis adaptation and communication improvement practices;

(vi) perceived organisational resilience and adaptability;

(vii) performance indicators, measured through changes in customer satisfaction, operational continuity, and revenue stability.

In this study, organisational resilience is operationalised through survey items reflecting Alhidaifi's et al. (2024) four dimensions: anticipation (strategic foresight and information flow), absorption (ability to sustain communication and operations under stress), recovery (restoration of communication systems and routines), and adaptation (strategic and communicative adjustments post-crisis). These dimensions are captured empirically through indicators such as communication speed, coordination efficiency, information accessibility, and feedback mechanisms.

Within the dynamic capabilities framework (Sullivan et al., 2023), digital communication functions as an enabling capability that supports *sensing*, *seizing*, and *transforming* processes. Effective use of tools such as CRM systems,

internal platforms, and AI chatbots helps organizations detect changes, respond rapidly, and realign communication to evolving needs. From an Organizational Learning perspective (Auqui-Caceres, Furlan, 2023), feedback cycles and communication-driven learning enhance resilience through double-loop learning, integrating lessons from crises into new routines and strengthening preparedness.

Drawing on these frameworks, this study employs associative modeling to analyse how digital communication, innovation, and resilience interact to shape performance. Digital tools foster innovation by enabling collaboration, accelerating knowledge exchange, and supporting cross-boundary integration (Aksoy, 2023). Innovation mediates the relationship between communication and performance, as firms leveraging communication for creative interaction achieve superior adaptability and service quality (Xia et al., 2024).

Empirical findings show that digital communication enhances resilience through real-time decision-making, flexibility, and coordinated crisis response (Issah et al., 2025). Resilient organizations sustain operations, retain clients, and protect employee wellbeing during disruptions (Nosike et al., 2024). A supportive communication culture, rooted in transparency, leadership, and learning, amplifies innovation, agility, and long-term sustainability (Anwar et al., 2025; Kingston, 2023).

Empirical Approach. To empirically test the hypothesised relationships, this study employs a structured quantitative approach. Descriptive statistics (mean, standard deviation, and frequency analyses) were used to evaluate trends in digital communication adoption across the service sector. Pearson correlation analysis was subsequently applied to explore bivariate associations among key variables, such as digital communication and resilience, innovation and performance providing preliminary insights into the direction and strength of these relationships.

Multiple linear regression (MLR) analysis was then used to formally test the following hypotheses:

- H1: Digital communication positively influences innovation.
- H2: Digital communication directly enhances organisational resilience.
- H3: Innovation positively affects organisational performance.
- H4: Organisational resilience contributes positively to performance outcomes.
- H5: Strategic communication responses mediate the relationship between digital communication and performance.
- H6: A strong digital communication culture enhances both innovation and resilience.
- H7: Strategic alignment between communication practices and organisational objectives strengthens performance outcomes.
- H8: Post-crisis communication strategies positively influence organisational adaptability and long-term performance.

Before the main data collection, a pre-test was conducted with 15 respondents to ensure clarity and consistency of the questionnaire (Liu et al., 2024). No major issues were reported. The final questionnaire was made available online between February and June 2025. Following recommendations in the literature (Naseer et al., 2025), periodic reminders were sent to increase participation rates.

All participants held management or supervisory positions and confirmed familiarity with their organisation's communication strategies and resilience planning. A filter question ensured that only respondents with direct experience in digital communication practices could proceed. Participation was voluntary and anonymous, and all respondents provided informed consent prior to completing the survey. The research complied with the ethical principles outlined in the Declaration of Helsinki (2013), ensuring confidentiality, privacy, and data integrity.

A total of 310 valid responses were collected. The sample consisted of 45.8% male and 54.2% female respondents, predominantly aged between 36–55 years (47.4%). Participants represented a wide range of service sectors, including hospitality (26.5%), banking and finance (18.3%), healthcare (17.8%), education (16.9%), and customer support and IT services (20.5%). Most respondents had more than 10 years of professional experience (58.7%), and 62.4% of organisations operated primarily through hybrid service models combining digital and in-person delivery (Table 1).

Table 1 – *The Sample used*

Variable	Category	Frequency (F)	Percentage (%)
Gender	Male	142	45.8
	Female	168	54.2
Age Groups	25–35	58	18.7
	36–45	88	28.4
	46–55	98	31.6
	56–65	66	21.3
Sector (Service Industry)	Hospitality and Tourism	82	26.5
	Banking and Finance	57	18.3
	Healthcare	55	17.8
	Education	52	16.9
	Customer Support and IT Services	64	20.5
Service Time (Years)	1–5 years	78	25.2
	6–10 years	50	16.1
	11–15 years	50	16.1
	>16 years	132	42.6
Business Model	Fully Online	76	24.5
	Hybrid (Online and Offline)	117	37.9
	Primarily Offline	117	37.6
Total Respondents		**310**	**100**

These data indicate that the majority of organisations in the service industry (37.6%) continue to operate primarily through offline or face-to-face models, while a growing proportion (62.4%) integrate online or hybrid business models. This distribution reflects the ongoing digitalisation of service delivery and underscores the sector's increasing reliance on digital communication for coordination, customer engagement, and operational continuity. The significant share of hybrid operations demonstrates that most service organisations are transitioning towards digital integration while maintaining essential human interaction an approach that supports both adaptability and resilience.

The collected data were imported directly from Google Forms into the SPSS 26.0 statistical software for analysis. To ensure internal consistency and measurement reliability, Cronbach's Alpha was calculated for all Likert-scale constructs, yielding a high reliability coefficient ($\alpha = 0.927$). The Kaiser–Meyer–Olkin (KMO) test confirmed sampling adequacy (KMO = 0.841), while Bartlett's Test of Sphericity was statistically significant ($p < 0.001$), validating the suitability of the dataset for multivariate analysis.

This methodological approach provides a statistically robust foundation for examining the interconnections between digital communication, organisational resilience, and performance within the service sector. The results offer valuable, data-driven insights into how communication technologies contribute to organisational adaptability, agility, and long-term sustainability in a post-crisis environment.

Research Results

Respondents perceive that the organisations where they work have a high (41.3%) or moderate (34.2%) level of adoption of digital communication tools (M = 3.52; SD = 0.918). Notably, 38 respondents (12.3%) reported a *very high* level of adoption, suggesting a growing integration of digital platforms in internal and external communication processes. Only 11 respondents (3.5%) and 27 respondents (8.7%) indicated that the level of digital communication adoption is *very low* or *low*, respectively (Table 2).

These results demonstrate that most service organisations are in an advanced stage of digital communication adoption, reflecting a strategic orientation towards digital collaboration, information flow, and customer interaction. The relatively small percentage of respondents reporting low adoption levels may represent traditional service providers that remain dependent on face-to-face communication, highlighting an opportunity for further digital integration to strengthen resilience.

- **Degree of Adoption of Digital Communication Tools and Perceived Impact of Digitalisation on Organisational Resilience**

Table 2 - *Degree of Adoption of Digital Communication Tools and Perceived Impact of Digitalisation on Organisational Resilience*

Variable	Very Low	Low	Moderate	High	Very High	M	SD
Degree of adoption of digital communication tools	11 (3.5%)	27 (8.7%)	106 (34.2%)	128 (41.3%)	38 (12.3%)	3.52	0.918
Perceived impact of digital communication on organisational resilience	18 (5.8%)	32 (10.3%)	114 (36.8%)	102 (32.9%)	44 (14.2%)	3.39	1.014

The findings indicate that respondents generally perceive a positive relationship between digital communication and organisational resilience. Over 47% of participants believe that digital tools have a *high* or *very high* impact on their organisation's ability to adapt and respond during disruptions. This reflects the essential role of communication

technologies in sustaining information flow, decision-making, and stakeholder coordination.

The mean score of 3.39 for perceived impact on resilience suggests that while digital communication has become a core organisational capability, there remains potential for improvement particularly in areas such as crisis communication planning, cross-departmental collaboration, and integration of AI-supported communication platforms.

• Perceived Impact of Digital Communication on Organisational Resilience

The majority of respondents (59.7%) perceive the impact of digital communication on their organisation's resilience as being between "Moderate" (36.8%) and "High" (22.9%) (M = 3.39; SD = 1.014). Additionally, 44 respondents (14.2%) rated the impact as *very high*, indicating that for a considerable proportion of participants, digital communication plays a substantial role in strengthening organisational adaptability and response capabilities.

In the other hand, 32 respondents (10.3%) considered the impact to be *low* and 18 respondents (5.8%) rated it as *very low*. These results suggest that while most service organisations recognise the positive influence of digital communication on resilience, there remains variability in adoption levels and perceived effectiveness, likely depending on technological maturity, organisational culture, and leadership support (Table 3).

Table 3 - *Perceived Impact of Digital Communication on Organisational Resilience*

Impact Level	Frequency (F)	Percentage (%)
Very Low	18	5.8
Low	32	10.3
Moderate	114	36.8
High	71	22.9
Very High	44	14.2
Total	**310**	**100**
Mean (M)		**3.39**
Standard Deviation (SD)		**1.014**

These findings indicate that digital communication exerts a significant positive influence on organisational resilience within the service industry. The majority of respondents rated its impact as moderate to high, underscoring that communication tools and platforms are perceived as vital enablers of information flow, coordination, and operational continuity during disruptions.

The mean score of 3.39 reflects a generally favourable assessment, though the presence of lower ratings suggests that some organisations may still face barriers such as limited digital infrastructure, insufficient training, or fragmented communication strategies.

Overall, these results confirm that the integration of digital communication systems enhances the capacity of service organisations to anticipate, respond to, and recover from challenges, key dimensions of organisational resilience.

• Correlation and Regression Analysis

The correlation results indicate that Organisational Performance (PER) demonstrates a significant and positive relationship with both Digital Communication (DC) *(r = 0.582, p < 0.01)* and Organisational Resilience (OR) *(r = 0.611, p < 0.01)* (Table 4).

Table 4 – *Correlations Analysis*

Variables	(PER)	(DC)	(OR)	(IN)	(LSC)	(TL)	(DCC)	(CSA)
Organisational Performance (PER)	1							
Digital Communication (DC)	0.582 **	1						

Organisational Resilience (OR)	0.611 **	0.703 **	1					
Innovation (IN)	0.494 **	0.667 **	0.456 **	1				
Leadership Support for Communication (LSC)	0.415 **	0.548 **	0.432 **	0.471 **	1			
Training and Learning (TL)	0.381 **	0.418 **	0.405 **	0.463 **	0.387 **	1		
Digital Communication Culture (DCC)	0.364 **	0.589 **	0.481 **	0.534 **	0.625 **	0.474 **	1	
Communication Strategy Alignment (CSA)	0.271 **	0.398 **	0.357 **	0.322 **	0.341 **	0.310 **	0.379 **	1

Note:
.Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

This suggests that enhancements in digital communication capabilities and resilience mechanisms are strongly associated with improved performance within the service industry. Furthermore, Performance shows a moderate positive correlation with Innovation (IN) *(r = 0.494, p < 0.01)* and a weaker but still significant correlation with Communication Strategy Alignment (CSA) *(r = 0.271, p < 0.01)*, indicating that when communication strategies are aligned with broader organisational objectives, performance outcomes tend to improve.

Organisational Resilience (OR) exhibits a very strong positive correlation with Digital Communication (DC) *(r = 0.703, p < 0.01)*, confirming that effective internal and external communication plays a central role in strengthening an organisation's capacity to anticipate, respond, and adapt during disruptions. Resilience also correlates moderately with Innovation (r = 0.456, p < 0.01) and Leadership Support for Communication (LSC) (r = 0.432, p < 0.01), underscoring that leadership engagement in communication initiatives facilitates faster adaptation and learning.

Digital Communication (DC) is strongly correlated with Innovation (IN) *(r = 0.667, p < 0.01)* and Digital Culture (DCC) *(r = 0.589, p < 0.01)*, suggesting that organisations fostering open, technology-driven communication environments are also more innovative and adaptable. The moderate correlation between Digital Communication and Training and Learning (TL) *(r = 0.418, p < 0.01)* highlights that communication-driven knowledge sharing enhances employee adaptability and preparedness.

Innovation (IN) also demonstrates moderate-to-strong relationships with Leadership Support for Communication (r = 0.471, p < 0.01) and Digital Culture (r = 0.534, p < 0.01), suggesting that innovation within service organisations depends on a culture that encourages collaboration, experimentation, and transparent information flow.

Finally, Digital Culture (DCC) and Leadership Support for Communication (LSC) exhibit a strong correlation *(r = 0.625, p < 0.01)*, confirming that leadership engagement and a strong communication culture reinforce one another as key enablers of resilience and long-term competitiveness.

The results underscore the central role of digital communication in fostering both resilience and performance within service organisations. Enhanced communication practices, especially those facilitated by digital tools, strengthen information flow, promote learning, and sustain coordination during crises. Furthermore, the combination of leadership support, organisational learning, and innovation amplifies the impact of communication on performance outcomes.

- **Multiple Linear Regression Analysis**

To evaluate the influence of communication-related and organisational factors on Organisational Performance (PER), a multiple linear regression (MLR) was performed. The analysis included eight

independent variables: Digital Communication (DC), Innovation (IN), Organisational Resilience (OR), Leadership Support for Communication (LSC), Training and Learning (TL), Digital Communication Culture (DCC), Communication Strategy Alignment (CSA), and Customer Relationship Communication (CRC). The dependent variable was Organisational Performance (PER).

The model presents a strong overall correlation coefficient (R = 0.734), indicating a solid linear relationship between the predictors and organisational performance. The regression model was statistically significant, $F_{(8, 311)} = 45.28$, $p < 0.001$, suggesting that the combination of predictors reliably explains variability in performance outcomes. The model produced a coefficient of determination $R^2 = 0.539$, with an adjusted $R^2 = 0.526$, meaning that approximately 53.9% of the variance in performance is accounted for by the predictors included (Table 5).

Table 5 – *Multiple Linear Regression Predicting Organisational Performance*

Predictor	B	SE B	β	t	p	VIF
(Constant)	−0.912	0.203	—	−4.493	<0.001	—
Digital Communication (DC)	0.296	0.061	0.289	4.852	<0.001	2.115
Organisational Resilience (OR)	0.372	0.054	0.365	6.907	<0.001	1.732
Innovation (IN)	0.212	0.058	0.203	3.655	<0.001	1.988
Leadership Support for Communication (LSC)	0.148	0.049	0.139	3.020	0.003	1.603
Training and Learning (TL)	0.127	0.045	0.120	2.822	0.005	1.497
Digital Communication Culture (DCC)	0.115	0.046	0.109	2.500	0.013	1.564
Communication Strategy Alignment (CSA)	0.081	0.041	0.078	1.976	0.049	1.429
Customer Relationship Communication (CRC)	0.053	0.039	0.052	1.359	0.175	1.381

Model Summary: R = 0.734 $R^2 = 0.539$ Adjusted $R^2 = 0.526$ $F_{(8, 311)} = 45.28$, $p < 0.001$

The regression results confirm that digital communication and organisational resilience are the strongest predictors of organisational performance. Both variables show highly significant positive coefficients ($p < 0.001$), indicating that improvements in digital communication effectiveness and resilience practices directly enhance performance outcomes.

Innovation also emerges as a significant contributor ($β = 0.203$, $p < 0.001$), suggesting that organisations that leverage digital communication to drive innovative practices achieve superior adaptability and efficiency.

Leadership support, training, and digital communication culture have moderate but significant positive effects, demonstrating that sustained managerial commitment and learning investment reinforce communication-based performance.

Although customer relationship communication (CRC) and strategy alignment (CSA) have smaller coefficients, they remain relevant, reflecting that consistency in message delivery and client-oriented communication contribute incrementally to resilience and business success.

Overall, the findings highlight that digital communication serves as both a structural and strategic driver of organisational resilience and performance in the service industry. By combining effective communication systems with innovation and leadership support, service organisations can achieve higher adaptability, responsiveness, and long-term sustainability.

Discussion

This study confirms that digital communication is important for fostering organisational resilience and innovation, ensuring continuity and adaptability during crises (Ahmad et al., 2023; Wuersch et al., 2023; Alzate et al., 2024; Gayed and El Ebrashi, 2023). Grounded in Resilience Theory and the

Dynamic Capabilities Framework (Sullivan et al., 2023), resilience emerges as a strategic, communication-driven capability.

Empirical evidence confirms that digital leadership and a supportive communication culture are critical for maintaining efficiency and engagement during crises, reinforcing links between digital competence, sustainability, and competitiveness (Cosa, 2024; Issah et al., 2025; Xia et al., 2024). Digital tools, such as messaging platforms, CRM systems, and collaborative applications, enhance organizational agility and continuity (Putro, 2023; Lee et al., 2023), though rapid adoption without integration risks digital fatigue and fragmentation (Wuersch et al., 2023).

The notion of communicative resilience, encompassing cultural and behavioral adaptability (Chabane et al., 2023; He et al., 2023), underscores that effective communication fosters innovation, collaboration, and learning. Barriers remain, particularly among smaller firms, due to limited infrastructure and skills (Macías Urrego et al., 2024; Liu et al., 2024). Nonetheless, the pandemic catalysed hybrid communication ecosystems supporting flexibility and speed (Kingston, 2023; Gayed and El Ebrashi, 2023).

Findings show that communication maturity - the integration of digital tools within strategy, culture, and learning - correlates with higher agility and performance (Sullivan et al., 2023). Regression results highlight the strongest predictors of performance: Organizational Resilience ($\beta = 0.365$, $p < 0.001$), Digital Communication ($\beta = 0.289$, $p < 0.001$), and Innovation ($\beta = 0.203$, $p < 0.001$). Leadership Support, Training, and Communication Culture amplify these effects.

Aligned with the Dynamic Capabilities and Organizational Learning frameworks (Sullivan et al., 2023; Auqui-Caceres and Furlan, 2023), digital communication emerges as a dynamic capability enabling sensing, coordination, and transformation. Technological tools alone are insufficient—strategic intent, leadership, and collaborative culture determine their effectiveness (Nosike et al., 2024; Ahmad et al., 2023). Ultimately, the service industry's resilience depends on cultivating digitally fluent ecosystems that integrate technology, people, and learning to sustain adaptability and innovation.

Conclusions

Empirical results indicate that organizational resilience and digital communication are the strongest predictors of performance, with innovation mediating their effects. However, technologies alone, without strategic or cultural integration, do not directly improve outcomes; instead, they enable learning, coordination, and informed decision-making.

The model reveals that Organisational Resilience is the strongest predictor of performance ($\beta = 0.365$, $p < 0.001$), followed by Digital Communication ($\beta = 0.289$, $p < 0.001$) and Innovation ($\beta = 0.203$, $p < 0.001$). Additional factors such as Leadership Support ($\beta = 0.139$, $p = 0.003$), Training ($\beta = 0.120$, $p = 0.005$), and Communication Culture ($\beta = 0.109$, $p = 0.013$) also show statistically significant positive effects. By contrast, Communication Strategy Alignment ($\beta = 0.078$, $p = 0.049$) and Customer Relationship Communication ($\beta = 0.052$, $p = 0.175$) demonstrate weaker or non-significant contributions.

The findings highlight that communication maturity, strategic alignment, and learning capacity are central to resilience. Effective communication depends on leadership support and its integration into organizational culture, functioning as both infrastructure and a social process that promotes knowledge sharing and problem-solving. Performance improvements were greatest when digital tools, such as CRM systems, instant messaging, and AI-based platforms, were embedded within broader organizational capabilities. Thus, digital communication acts as a facilitator of resilience and innovation rather than a direct driver of performance.
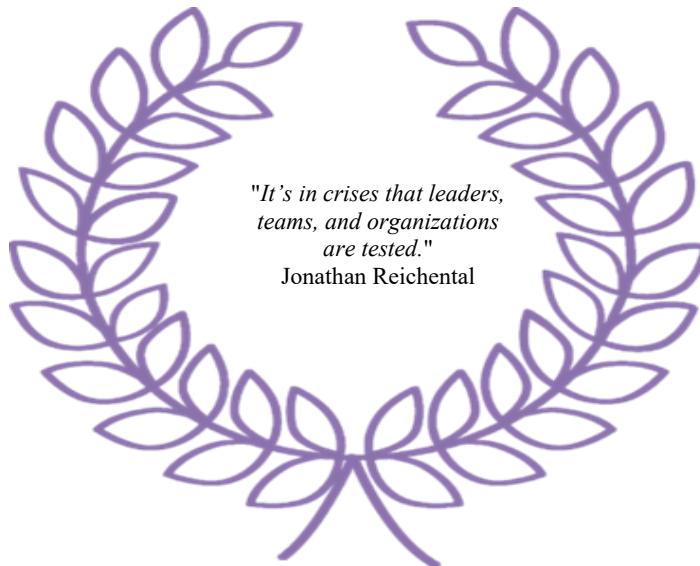
For practitioners, success requires investment in people, leadership, and culture alongside technology. Policymakers should help SMEs strengthen digital competencies and dynamic capabilities. Overall, the study concludes that resilience in the digital era stems not from technology itself but from strategic communication, collective learning, and adaptive leadership.

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"*It's in crises that leaders, teams, and organizations are tested.*"
Jonathan Reichental

The Benefits of the Kaizen Strategy on Employee Well-Being

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Abstract

This study aims to highlight the relationship between the benefits of implementing the Kaizen strategy and employee well-being at the organizational level, with the goal of maximizing performance and fostering a sustainable work environment. The study involved a comprehensive review of specialized literature, through which critical insights were identified for organizations committed to increasing employee motivation, self-esteem, productivity, and overall well-being. The research is supported by statistical data demonstrating a positive relationship between the study's core variables, highlighting from multiple perspectives the direct impact that Kaizen implementation has on improving workplace well-being. The results presented in this study indicate that organizations aiming to be strong in the labor market are not solely focused on economic performance but are particularly invested in cultivating a sense of belonging to a greater purpose.

Keywords: Kaizen strategy, well-being, continuous improvement, employee satisfaction

Introduction

In a globalized society, whose economic environment is often characterized by constant change and high competition, contemporary organizations increasingly seek viable and sustainable solutions to maximize professional performance while maintaining employee well-being. In this context, the organizational world faces multiple challenges that compel managers to refine their work techniques and perspectives through increasingly modern approaches (Rahmanian and Rahmatinejad, 2013).

"Success is walking from failure to failure with no loss of enthusiasm."
Winston Churchill
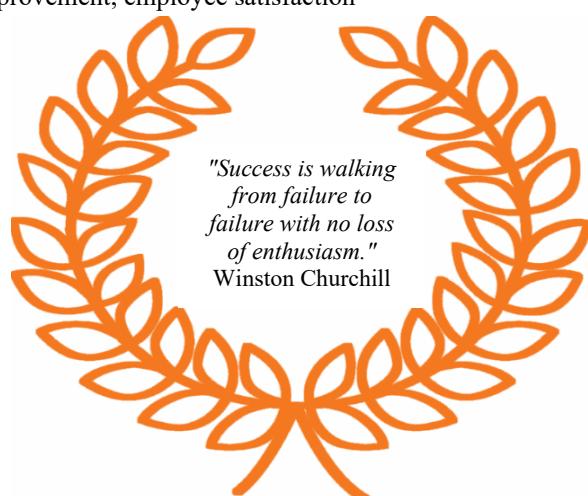
Accordingly, the majority of organizations worldwide achieve success through the implementation of continuous improvement systems that enhance both productivity and the workplace climate. Among the most well-known methods for improving the organizational environment is the Kaizen strategy, defined as a continuous workplace improvement process guided by a „common-sense" vision implemented by senior management (Masaki, 2001).

Building on this foundational concept, the term „Kaizen" has been defined as a multifaceted continuous improvement strategy, as it involves both senior management and ope rational staff in the process. The large-scale application of this model has increased and consolidated labor productivity, with remarkable effects on employee well-being and optimism.

At the opposite end, well-being is regarded as an essential component of mental health, which goes beyond the mere absence of mental disorders and is influenced by biological, environmental, and socio-economic factors. The World Health Organization emphasizes that well-being is an integral part of health, which is defined as a state of physical, mental, and social well-being, and is not limited solely to the absence of disease or infirmity (WHO, 2017).

Overall well-being thus encompasses a variety of human capabilities, the ability to persist in the face of everyday stress, the productivity individuals can achieve in the workplace, and the extent to which they contribute to the well-being of the communities to which they belong. It is therefore vital for living in a „healthy" manner, thinking, feeling, interacting with others, securing one's livelihood, and fostering a sense of satisfaction with life. In this regard, the promotion and protection of well-being constitute an objective in their own right for humanity as a whole.

At the organizational level, well-being has received significant attention, as unfavorable work environments increase the risk of mental health deterioration. It is estimated that in 2019,

approximately 15% of working adults experienced a mental disorder, and globally, around 12 billion workdays are lost due to depression and anxiety, resulting in a dramatic annual productivity loss estimated at approximately 1 trillion USD (ILO, 2022; ILO, 2018; WHO, 2024).

Therefore, its preservation through various preventive and intervention strategies is essential for a sustainable future. Based on this premise, the implementation of the Kaizen strategy, following directions already outlined by the World Health Organization, represents a commitment to the continuous improvement of both life and work quality. This is achieved by engaging employees and managers alike in identifying and eliminating waste, optimizing inefficient work processes, streamlining the organizational environment, and fostering a responsible and supportive workplace.

Research methodology

As previously observed, in a dynamic and demanding professional context, concern for employee well-being becomes increasingly critical for organizational success and stability.

Well-being, understood as a multidimensional concept encompassing: emotional, social, spiritual, physical, economic, ecological, and organizational dimensions, operates under the principle of overall balance, enabling individuals to function optimally, feel satisfied, and actively contribute to the society to which they belong. Numerous studies over time have demonstrated a direct relationship between well-being and high motivation, professional performance, healthy interpersonal relationships, organizational climate, effective communication, and other psycho-organizational variables (Mubeen, Ashraf and Ikhlaq, 2022; Tesi, Aiello and Giannetti, 2019; Radic et al., 2020; Hill and Turiano, 2014; Kim, Kubzansky and Smith, 2015; Howell et al., 2016; Kahneman and Deaton, 2010; Korpela et al., 2014; Keyes, 1998; Dass Ghiya, 2019; Andarsari and Ningtyas, 2019; Diener, 2000; Susanto et al., 2022; Iqbal and Mansell, 2021; Fedorov, Ilaltdinova and Frolova, 2020; Sironi, 2019).

Consequently, organizations increasingly focus on adopting management techniques, strategies, and methods aimed at fostering the psycho-social and professional development of employees, pursuing not only efficiency but also the creation of a conducive work environment. Among these methods is the Kaizen strategy, which seamlessly integrates the continuous need for organizational progress with the promotion of healthy principles for enhancing workplace well-being.

The Kaizen strategy seeks, through small, incremental efforts, to improve the work environment and enhance well-being at both the individual level (through the professional activity of each employee) and the organizational level. The Japanese mindset emphasizes that continuous improvement is an action that should never cease (Sinisi, 2020).

The ingenuity of this method stems from its seemingly simple operational principle, as it does not rely on massive investments (which entail high costs) but requires consistent effort, discipline, stability, deeply rooted commitment, customer-oriented leadership, loyalty, a satisfied workforce, high income, and minimized costs. This comprehensive „formula" ensures long-term success and unequivocally contributes to profit growth. The Kaizen strategy provides a systematic vision for achieving objectives by reminding senior management that processes require consistency to achieve progress.

The term „Kaizen", derived from two Japanese words: „Kai" meaning „change" and „Zen" meaning „good" or „toward better" operates based on four main characteristics: it is continuous and inexhaustible; regular and gradual; economical (with minor adjustments); and requires full participation from the entire organization (Rahmanian and Rahmatinejad, 2013).

Kaizen is, in fact, a philosophy in itself within Japanese culture, as it refers to a lifestyle to be fully embraced in family life, the workplace, and society at large, with the overarching goal of continuous improvement. In Japanese society, this philosophy is so deeply ingrained that most people apply it almost unconsciously, representing a natural way of „being" (Masaki, 2001).

The utility and superiority of this Japanese strategy, compared with other European or American strategies, stem from its „small-step" approach, which emphasizes organizational employees who are motivated to participate consciously and responsibly in achieving objectives, emotionally anchored and committed to the concrete application of the strategy. In this regard, Kaizen minimizes, and in some cases eliminates, social issues such as lifetime employment concerns, wage levels relative to work quality, unions, bonuses, promotions, incentives, and access to higher professional levels (Sinisi, 2020).

The Kaizen strategy functions as an „umbrella" concept encompassing most methods specific to Japanese management: customer orientation; long-term and system-oriented thinking; workforce and equipment management; full participation of all organizational members; process emphasis over results; total quality control; suggestion systems; Kaizen teams focused on quality improvement; automation; work rules and norms; efficient repair systems; labor productivity; error elimination; cooperation; productivity of new work processes, among others (Figure 1).

Support for these methods is also provided by specialized literature investigating the direct relationship between this strategy and its tangible outcomes on employees, revealing a positive association with employee well-being. Through engagement, employees become increasingly involved in the work process, quickly identifying areas requiring attention and various improvements, ultimately leading to the implementation of the action plan (Cheser, 1998; García et al., 2014; Ulhassan et al., 2015).

KAIZEN

- Customer orientation;
- Long-term thinking and system orientation;
- Workforce and work equipment;
- Full participation from all members of the organization;
- Focus on process rather than focus on results;
- Total quality control;
- Suggestion system;
- Kaizen teams focused on quality improvement;

- Automation;
- Work rules and standards;
- Efficient repair system;
- Labor productivity;
- Error elimination;
- Cooperation;
- Productivity of new work processes.

Figure 1 - *Kaizen Umbrella*

(Source: Imai, 1991)

Furthermore, a study conducted in 2010 reinforces previous findings, demonstrating that management utilizing the Kaizen strategy leads to reduced risk-taking, improved workplace safety, and increased productivity. In addition, from a psychosocial perspective, it enhances the protection and promotion of overall employee health. Other studies have also shown that the Kaizen strategy positively affects work capacity, employees' self-assessment, psychosocial interventions, and the familiarization of workers with their tools and work processes (Ikuma et al., 2010; von Thiele Schwarz et al., 2015; Smith, 2002).

Kaizen's impact on stress should not be neglected, as a study conducted in 2010 showed that its implementation and use at the organizational level significantly reduced employee stress, making them considerably more autonomous. In addition, the emphasis on small changes (which the Kaizen strategy promotes) has demonstrated a significant alleviation of professional burnout through the simplification of work processes and increased control over work tasks (Suárez-Barraza and Ramis-Pujol, 2010). Another benefit of its use is that the strategy functions as a genuine system for communicating ideas across the entire organizational chain, encouraging people to seek out and capitalize on new opportunities while removing barriers to information flow.

The beneficial effects of Kaizen implementation were also observed in a study conducted with two distinct groups in Denmark and Sweden. Researchers highlighted that the strategy cultivates initiative among employees, motivating them to actively participate in organizational processes and changes, thereby enhancing both efficiency and effectiveness. Its principles help individuals become more aware of what occurs during work processes, achieve greater satisfaction and balance, and operate within an optimal zone of mental health (Schwarz et al., 2017).

Mendez and colleagues (Mendez et al., 2018) demonstrated through a 2018 case study that adopting the Kaizen strategy facilitates the formation of new habits, beliefs, and attitudes, enabling a three-dimensional learning process designed to develop human potential and enhance employee well-being. From a quantitative impact perspective, Howell (2011) asserts that organizations can obtain the following benefits through Kaizen adoption (Table 1).

Table 1 - *Impact of implementing the Kaizen strategy in organizations*

Inventory reduction	*30–70 %*
Operating space	*approximately 50 %*
Process time reduction	*40–80 %*
Productivity improvement	*20–60 %*
Delivery times reduction	*70–90 %*
Walking distance reduction	*40–90 %*

Garza (2005) also explains that the benefits of implementing the Kaizen strategy are reflected in terms of efficiency and effectiveness, highlighting the main reasons why organizations choose to implement it (Figure 2).
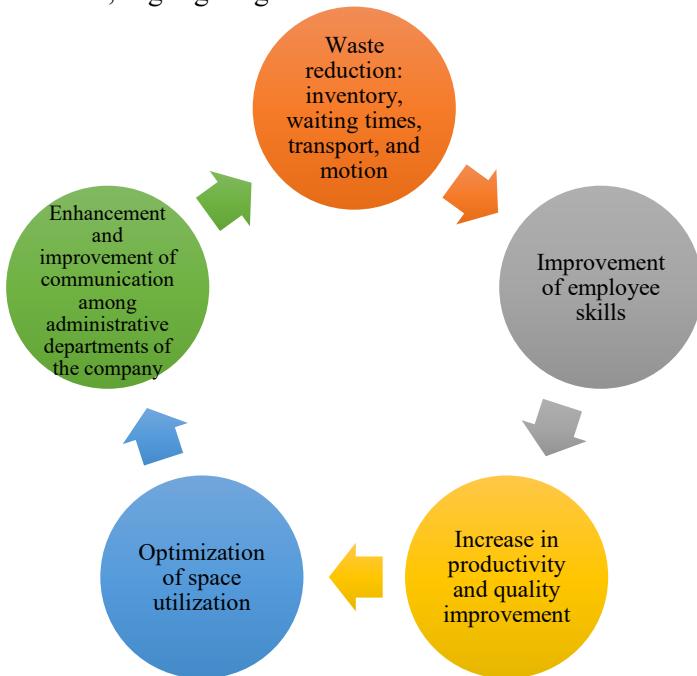
Figure 2 - *The benefits of the Kaizen strategy*

The specialized literature documents a series of remarkable global results achieved by large companies following the implementation of the Kaizen strategy. The following outcomes serve as evidence in this regard.

In 2007, Lincoln Industries saved over USD 630.000, and the following year over USD 1.630.000, representing an increase of one million dollars compared to the previous year. Similarly, Barnes Aerospace, an international manufacturer of metal aircraft components, managed in 2012 to improve employee productivity by 24% and reduce delivery lead times by 61%, making the company significantly more competitive and sustainable in the labor market (Suárez-Barraza and Miguel-Dávila, 2014).

From a human resource management perspective, the Kaizen strategy contributes to: increased self-esteem, higher motivation, reduced client loss, decreased employee turnover, improved work attitudes, development of personal and professional skills, enhanced job satisfaction, reduction of health problems caused by ergonomic conditions, improved interpersonal communication, participation, collaboration, and even the maintenance of focus and attention on professional activities (Garza, 2005; García et al., 2014; Dwivedula, Bredillet, 2010; Vieira et al., 2012; Doolen et al., 2008; Magnier-Watanabe, 2011; Dhurup et al., 2016; Koide et al., 2007; Glover et al., 2014). A review of the literature further highlights, in percentage terms, how the Kaizen strategy has improved various organizational variables, as follows (Figure 3).

Productivity
37%
(Gasper & Mwenda, 2023)

Job satisfaction
11, 4%
(Nahmens, Ikuma & Khot, 2012)

Employee engagement
28%
Kareska, 2024

Figure 3 - *The implementation of the Kaizen strategy. Benefits*

Results and Discussion

The analysis of empirical studies and the secondary data made available reveals two major categories of outcomes: measurable operational and organizational benefits derived from the use of the Kaizen strategy or similar continuous improvement programs, and psychosocial effects on employees'

well-being, including variables such as job satisfaction, engagement, perceived autonomy, and stress reduction.

From the perspective of operational and organizational benefits, the application of Kaizen principles contributes to increased productivity, defect reduction, shortened process times, and optimization of the entire workflow. As

demonstrated by a recent practical study in the manufacturing sector, the application of the Kaizen strategy combined with a type of preventive-oriented maintenance led to a 1% reduction in waste and significantly increased overall process efficiency (Medina et al., 2024).

In this regard, the Kaizen philosophy has evolved from a tool intended to streamline production into a complex strategic framework encompassing sustainability, digitalization, and organizational culture. Its principles contribute to the reduction and even elimination of non-value-adding activities, thereby optimizing the overall performance of the organization (Sahmi and El Abbadi, 2024; Irfan, Rafiquzzaman and Manik, 2025).

Regarding psychosocial benefits for employee well-being, the results suggest that the high overall efficiency imposed by the organizational application of the Kaizen strategy produces not only technical effects but also psychological ones. Employee involvement in continuous improvement processes at the workplace provides opportunities to access, give, and receive constant feedback, key factors of another work-oriented model, the Job Demands-Resources framework, which correlates these processes with higher participation levels and lower burnout rates among employees. In this context, the gains translate into organizational efficiency and act as genuine mediators of workplace well-being (Bakker and Demerouti, 2017).

An equally important aspect of the Kaizen strategy and its effectiveness is influenced by the organizational culture in which it is applied, the technological/digital development of the company, and the organization's overall vision regarding sustainability. Consequently, the Japanese philosophy almost always requires significant adaptations when implemented in Western contexts or certain industries where work processes may be more flexible and less standardized.

This analysis provides a hyper-complex perspective on the benefits of implementing the Kaizen strategy, showing that it is more than a tool aimed at improving work processes; it is a philosophy of individual and professional life, centered on people and their continuous development.

By its very principles, Kaizen lays the foundation for a culture of continuous learning and participation, where each employee plays the „primary role" in the change process, rather than merely executing assigned tasks.

The findings of academic literature demonstrate that strategy implementation brings both economic and psychosocial benefits. While organizations thrive and achieve superior efficiency, individuals directly involved in the process experience improved workplace well-being, enjoy an optimal professional climate, exercise greater control over their work, and exhibit a higher openness to new initiatives.

The Kaizen strategy fosters creativity and organizational learning, employs a leadership style based on trust and support, and, most importantly, genuinely addresses the physical, mental, and emotional health of employees. It thus becomes a „bridge" between the economic and human dimensions in a deeply digitalized environment operating at „maximum speed", where psychological pressure and heightened competitiveness are particularly pronounced.

Employee well-being is therefore not a secondary outcome of the performance ensured by continuous improvement but a prerequisite for it. The strategy establishes the framework through which these variables mutually reinforce one another: a conducive and balanced work environment leads to performance, and performance, in turn, strengthens affective-motivational elements such as self-esteem, satisfaction, independence, joy, initiative, willpower, perseverance, and others.

Essentially, the Kaizen strategy serves as a „pillar of resilience" for modern organizational cultures, and its integration into environmental, social, and governance policies, as well as sustainable development goals, is both natural and necessary. Its potential is enormous, extending beyond merely „doing things better" to creating better workplaces where the quality of both personal and professional life becomes a priority.

Conclusions

The analysis conducted within the research study „*The benefits of the Kaizen strategy on employee well-being*" confirms that the Kaizen strategy has a clear and significant positive impact on employee well-being. By adopting and implementing Kaizen principles, the organizational environment flourishes, becoming healthier, more responsive to the needs of others, collaborative, supportive, and psycho-socially balanced.

The reviewed specialized literature fully supports these conclusions, highlighting that the implementation of the Kaizen strategy contributes to the reduction of occupational stress, increased job satisfaction, strengthened employee motivation, and the maximization of overall performance.

It is no coincidence that the available data indicate a positively altered sense of well-being and a significantly higher level of active participation when organizations apply principles of continuous improvement. Moreover, the Kaizen strategy aligns perfectly with the World Health Organization's recommendations for supporting and maintaining mental health and well-being in the workplace, emphasizing the importance of preventing psychosocial risks, promoting positive mood, supporting employees with mental health disorders, and creating an organizational environment focused on positive change.

Therefore, the implementation of the Kaizen strategy not only optimizes work processes themselves but also generates tangible benefits for employee well-being, reinforcing organizational culture and the overall performance of the company. Evidence from the academic literature suggests that such interventions are intended to reduce staff turnover and absenteeism, increase productivity, and establish a work environment that is genuinely enjoyable, where health and safety are protected, and work quality is rewarded appropriately.

Consequently, when management employs „people-friendly" strategies, such as the Kaizen approach, employees' self-esteem increases, they feel part of something greater than themselves, adapt more easily to emerging challenges, and perceive that their suggestions not only matter but make a real difference.

In conclusion, the Kaizen strategy can be regarded not only as a model of organizational efficiency and effectiveness but also as a key strategic factor in maintaining and promoting workplace well-being, as it creates a perfect balance between the work environment and the individual.

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"*You don't need to be a genius to be successful. You just need a framework and a dream*"
Michael Dell

The Impact of Strategic Autonomy within European Policy

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Abstract

In the current volatile geopolitical context, Europe faces the challenge of maintaining equilibrium between instability, rapid technological change, and growing economic interdependence. Global trade disruptions - intensified by armed conflicts, public health crises, and repeated energy shocks - have prompted the European Union to reassess the relationship between economic governance and security planning. This research identifies the convergence between Defence economics and European trade policy as the core of an emerging governance model termed the Economic Security Policy. Drawing on Romania's practical experience in integrating military logistics with civilian systems, the paper illustrates how coordinated economic and Defence planning can simultaneously enhance competitiveness and foster coherent, autonomous action within a fragmented international environment.

Keywords: defence economics, strategic autonomy, EU trade policy, military logistics, economic security policy

"Resilience is knowing that you are the only one that has the power to pick yourself up."
Mary Holloway

Introduction

The global order today is marked by heightened geopolitical tensions, disrupted supply chains, and the fast-paced transformation of international trade structures. These developments have compelled the European Union (EU) to reconsider how it preserves economic strength and strategic
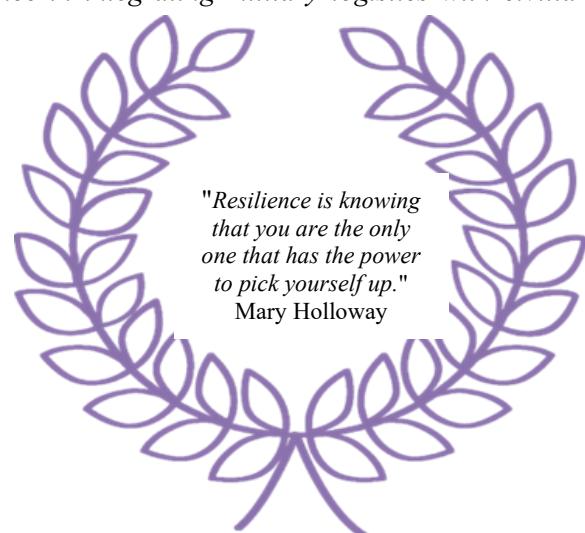
sovereignty through frameworks that promote resilience and autonomy.

In this evolving environment, European strategic autonomy has moved from being a distant policy ambition to becoming a central objective of the Union's agenda. It reflects Europe's determination to reduce excessive dependencies on external partners and to reinforce its industrial and technological base.

The Common Commercial Policy (CCP), initially designed as a trade regulation mechanism, has gradually assumed a strategic dimension. Initiatives such as the Global Gateway and the Strategic Compass illustrate how the EU integrates its trade, investment, and innovation policies into a coherent approach that sustains both competitiveness and collective security.

This transformation highlights the growing interdependence between Europe's economic and Defence spheres — where trade functions not only as an engine of growth but also as a stabilizing factor in the face of global uncertainty.

The present paper explores this intersection between Defence economics and EU trade policy as the foundation for a new Economic Security Policy. Using Romania's experience with civil–military logistics cooperation as an applied example, the analysis demonstrates how economic mechanisms can enhance strategic autonomy and operational effectiveness. Ultimately, it proposes a governance model in which economic policy serves as a catalyst for innovation, stability, and sustainable security, empowering Europe to respond decisively to global challenges.

Literature Review

Over the past decade, scholars have increasingly explored the interconnections between Defence economics and trade policy, reflecting the European Union's growing determination to strengthen both its strategic autonomy and industrial foundations.

Classical approaches to Defence economics, such as those proposed by Hartley and Sandler, conceptualize the field as the efficient allocation of national resources to sustain deterrence, security, and operational readiness. Later contributions, including the works of Dunne & Tian (2013) and Braddon (2019), expand this definition by linking Defence expenditure with innovation, technological progress, and participation in global trade networks. These studies underline that Defence investments can stimulate long-term productivity and competitiveness when aligned with economic and research policies.

Within the European framework, initiatives like the Strategic Compass (2022) and Global Gateway (2021) signal a shift from a narrow economic approach toward an integrated geo-economic perspective. According to Biscop (2022) and Fiott (2023), Europe's economic interdependence generates both opportunities and risks - fostering growth and global influence while simultaneously increasing exposure to vulnerabilities in areas such as energy, critical technologies, and logistics.

Complementary literature on military logistics (Blanchard, 2001; Mason, 2012) highlights the strategic relevance of dual-use systems and civil–military interoperability. Such models show that efficiency and resilience can coexist, provided that Defence and trade mechanisms are developed in a coordinated manner.

Reports from institutions like the European Defence Agency (2023) and NATO (2022) further reinforce the call for an integrated governance model that unites industrial policy, security planning, and trade regulation.

Taken together, the academic discourse illustrates a paradigm shift: Defence is no longer perceived solely as a budgetary cost, but as a strategic catalyst for technological innovation, industrial cooperation, and sustainable competitiveness across the European economy.

The conceptual foundation of this study lies at the crossroads of Defence economics, international trade theory, and strategic autonomy frameworks.

As outlined by Sandler and Hartley (1995), Defence economics analyses how nations allocate limited resources to ensure deterrence, collective security, and operational readiness.

From this standpoint, Defence spending should not be viewed as a static budgetary cost, but as a strategic investment that fuels stability, technological innovation, and long-term competitiveness. Within the European context, this approach aligns closely with the dual-use paradigm, according to which military research and logistics capabilities can generate tangible benefits for the civilian economy through spillover effects in sectors such as transport, manufacturing, and information technology.

From the perspective of international trade theory, the Common Commercial Policy (CCP) of the European Union has gradually evolved from a liberal trade framework into a strategic governance tool. Geo-economic models (Luttwak, 1990) argue that trade policy serves not only to enhance economic welfare, but also to safeguard strategic interests and mitigate dependencies on non-EU powers. In this sense, trade is redefined as an instrument of security—complementary, not competitive, to Defence objectives.

The theoretical foundation of this research lies at the intersection of Defence economics, international trade theory, and strategic autonomy frameworks. Defence economics, as formulated by Sandler and Hartley (1995), examines how limited national resources are allocated to maintain collective security, deterrence, and operational capability. From this perspective, Defence expenditure is not a sunk cost but an investment in stability, innovation, and technological competitiveness. In the European context, this rationale aligns with the dual-use paradigm—the idea that military research and logistics can generate civilian economic benefits through spillover effects in transport, manufacturing, and information technology.

The emerging theory of economic security, integrated into EU policy discourse (EC, 2023),

proposes a holistic link between economic resilience, supply chain reliability, and the protection of critical infrastructure. Strategic autonomy, in this framework, is no longer measured solely by military strength, but also by control over essential technologies, resources, and industrial capacity.

Finally, systems theory, applied to logistics (Blanchard, 2001), reinforces the idea that interconnectivity between civilian and military supply chains enhances both efficiency and redundancy. This systemic logic supports the development of an Economic Security Policy, where Defence, trade, and innovation interact as interdependent pillars of Europe's strategic resilience and sustainable autonomy.

Analytical Perspective

To gain a deeper understanding of how Defence economics and trade policy interact within a strategic framework, several analytical models offer relevant interpretative tools. One of the most comprehensive is the Total Logistics Cost Model, which encompasses the full spectrum of costs associated with procurement, transport, warehousing, personnel, downtime, and exposure to risk. When technologies such as artificial intelligence, predictive analytics, or military–civil interoperability systems are introduced into this model, inefficiencies can be dramatically reduced, leading to significant improvements in both economic performance and operational readiness.

Another valuable analytical foundation is the Input–Output Model, traditionally used in macroeconomic analysis to trace how resources (inputs) are transformed into tangible economic outcomes (outputs). In the context of Defence logistics, this model allows policymakers to evaluate the ripple effects of investments in infrastructure, automation, or dual-use technologies—illustrating how such expenditures stimulate employment, innovation, and industrial growth across the broader economy.

From the viewpoint of production economics, the Cobb–Douglas function provides a mathematical perspective on how capital, labour, and technology interact to shape productivity. It demonstrates that technological investment, particularly in digitalization and automation, generates exponential returns through efficiency gains and optimal resource allocation.

The Return on Investment (ROI) approach to critical infrastructure reinforces this logic, showing that despite high initial modernization costs, long-term benefits—such as reduced waste, faster response times, and greater resilience—far exceed the expenditure

Finally, Resilience Theory conceptually unifies these models, emphasizing that adaptive and digitally integrated logistics systems contribute simultaneously to economic competitiveness and strategic stability. When trade instruments and Defence mechanisms operate in harmony, the European Union achieves a coherent form of strategic autonomy, rooted in efficiency, innovation, and preparedness.

Discussion

The intersection between Defence economics and EU trade policy reveals a complex mix of opportunities and structural limitations in the pursuit of European strategic autonomy. Evidence suggests that the EU's economic instruments - initially designed to promote liberal market integration - can be effectively reoriented to reinforce the Defence - industrial base and increase logistical resilience. Yet, the shift from theoretical alignment to operational implementation remains uneven among Member States, reflecting variations in institutional capacity, political will, and economic resources.

The introduction of artificial intelligence and digital technologies into military logistics - particularly in strategic warehousing - has already demonstrated measurable economic benefits, while simultaneously raising new strategic challenges that demand coordinated governance.

From an economic perspective, Romania's experience in adapting military infrastructure for

civilian purposes offers a concrete model of dual-use efficiency. Leveraging Defence assets for public transport, emergency logistics, or supply chain continuity can deliver cost optimization and reinforce national resilience. However, such an approach requires predictable funding mechanisms, coherent legislation, and close cooperation between Defence and economic institutions. In their absence, interoperability gains risk being offset by bureaucratic inertia and fragmented priorities.

At the EU level, frameworks such as Global Gateway and the Strategic Compass provide a solid foundation for linking economic policy with security objectives. Nonetheless, policy fragmentation persists, especially in the coordination of industrial, trade, and Defence agendas. True resilience should therefore be understood not as mere redundancy or resource accumulation, but as adaptive capacity - the ability to reorganize production, supply chains, and logistics flows swiftly in the face of disruption.

Ultimately, the success of a coherent Economic Security Policy will depend on integrated governance - aligning technological, economic, and Defence dimensions under a shared strategic vision. A unified European framework, supported by transparent procurement systems, interoperable digital platforms, and data-based decision-making, could redefine the EU as a proactive, security-oriented actor capable of sustaining autonomy through intelligent interdependence.

Conclusions

The study demonstrates that integrating Defence economics with the European Union's trade and industrial policy can act as a true catalyst for both strategic autonomy and sustainable growth. When economic mechanisms are designed with security objectives in mind, they transform from neutral financial instruments into strategic tools that enhance the EU's ability to act independently amid global uncertainty. The

concept of an Economic Security Policy, as proposed in this research, represents a paradigm shift toward a comprehensive governance model that unites Defence, trade, and technological innovation under a single strategic vision.

Empirical insights from Romania confirm that adapting military logistics to civilian needs can yield measurable improvements in efficiency, infrastructure use, and resilience. Nonetheless, such progress depends on stronger coordination - both institutionally and financially - at national and European levels. Persistent gaps in standardization, interoperability, and long-term funding continue to limit the potential of dual-use initiatives and hinder their scalability across Member States.

In essence, achieving economic security requires more than fiscal stability: it demands institutional coherence, technological adaptability, and a shared European vision of autonomy and resilience. Further research should explore the economic impact of dual-use logistics, develop quantitative resilience indicators, and propose governance frameworks that reconcile open trade with collective Defence imperatives.

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"When we tackle obstacles, we find resilience we did not know we had." Abdul Kalam
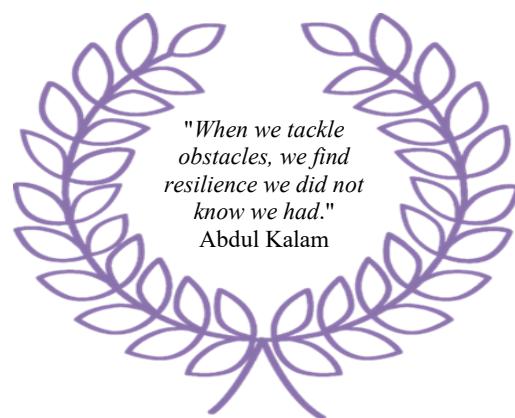
Implications of Organizational Culture for Resilience

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Abstract

This paper presents a conceptual model exploring the relationship between organizational culture, employee productivity, and their combined impact on organizational resilience. The proposed model identifies key cultural elements – such as shared values, leadership approaches, communication practices, and adaptability – that influence employee engagement and productivity. These, in turn, serve as foundational drivers of resilience by enhancing an organization's ability to respond to and recover from disruptions. The study highlights the strategic importance of aligning culture and productivity initiatives to build resilient organizations capable of thriving in dynamic environments. His research provides practical implications for managers and organizational leaders seeking to align culture and productivity strategies with resilience-building efforts.

Keywords: organizational culture, employee performance, resilience, dynamic environments.

Introduction

Employee performance is a rating system used in many organizations to evaluate the ability and efficiency of employees. Every employee is required to make a positive contribution through good performance, considering that organizational performance depends on the performance of its employees. Performance results from a particular job function and within a certain period. The work results are the results of the abilities, skills, and desires achieved. Various factors can affect employee performance, and these factors are essential to improve a particular series of activities to achieve predetermined organizational goals (Nugroho et al., 2021).
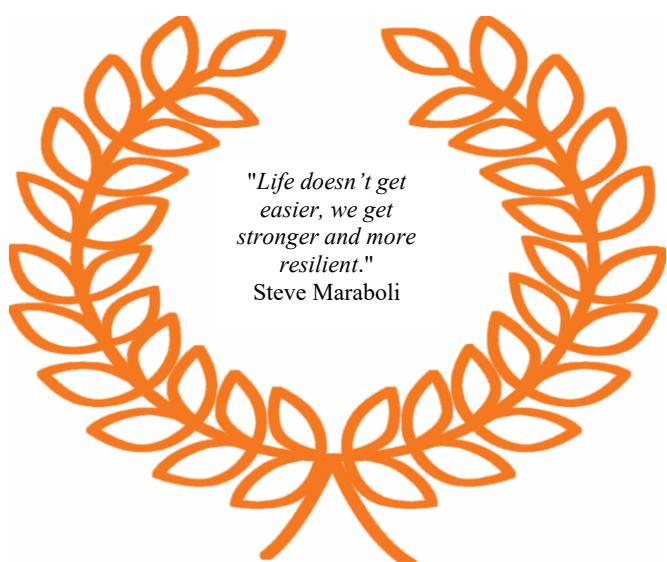
"*Life doesn't get easier, we get stronger and more resilient.*"
Steve Maraboli

One of the most important resources for an organization in supporting the achievement of its goals is human resources. Human resources are now seen as assets that were previously only seen as factors of production such as land, buildings, money, and other factors of production. For this reason, human resources have become part of strategic activities and even become central in organizational activities. The basic values and beliefs initiated by the leader will give birth to practices and policies that are socialized to each member as a guide for behavior. If these basic values and beliefs can answer organizational problems, they will automatically be embedded in the consciousness of each member. The basic values and beliefs that are embedded in the consciousness of each member are known as organizational culture. The more organizational culture becomes a solution, the stronger its influence on the behavior of organizational members. The strength of organizational culture is a guide to behavior making it one of the determining factors for employee performance (Kenedi et al., 2022). As a result of a study conducted in 2023, Ariani believes that organizational culture is a value shared by all members of the organization. Shared values will encourage employees to identify with the organization so that they feel comfortable in the organization, feel an attachment to the organization, being able to innovate and be creative, and improve their performance and organizational performance.

A strong organizational culture will show a clear direction for employees to carry out their duties. A weak organizational culture tends to result in employees not mastering a clear orientation. A strong culture can help organizational performance. Due to this it creates an extraordinary personality in employees. Some experts argue that organizational culture should be developed to support continuous improvement of employee performance (Kawiana et al., 2018). One of the most important goals in every organization is to improve the level of productivity. The work environment which encompasses several factors impacts on the way the employees perform their work. A comfortable and conducive workplace environment will boost the employees' performance, hence boosting the organizational performance. The success of any organization is closely tied to the job performance of its employees. The quality of the employees' workplace environment impacts on their motivation level and hence performance (Nwachukwu et al., 2019).

The success of a firm is greatly dependent on the productivity of the employees as well as the underlying organizational culture. Organizational culture can be perceived as a set of values, beliefs, assumptions, and ways of interaction within an organization, which emerges with time aid in the creation of a specific functional psychological and social environment that supports the firm's offerings. However, organizational management can shape the organizational culture as desired to bolster organizational performance (Nzuva and Kimanzi, 2022).

The research conducted by Akpa et al., (2021) showed that organizations where culture determines how things are done, where employees had a clear spelt out work ethics, were like-minded employees hold similar beliefs and values, guided by values of consistency, adaptability and effective communication system, gives employees a sense of identity which increased their commitment to work. It was noted that in organizations with strong cultural values, employees practice acceptable personal habits, which are guided by the organization's overall strategic plan, in carrying out and completing work assigned to employees with regards to the desired standards, and committing maximum efforts to the work leading to improved performance.

The existence of an organization in the age of globalization should be regarded as living beings who want to grow and develop in accordance with the demands of a changing environment. To develop an organization that has the competitive advantage of value-based, then the management needs to pay attention to its organizational culture, because the organizational culture is a set of values, beliefs, and attitudes among members of the organization imposed (Ratnasari et al., 2020).

Several writers argue that a strong organizational culture is good for business because

it serves three important functions. First, corporate culture is a deeply embedded form of social control that influences employee decisions and behavior. Second, corporate culture is the social glue that bonds people together and makes them feel part of the organizational experience. This social glue is increasingly important to attract new staff and retain top performers. Finally, corporate culture assists the sense-making process i.e., it helps employees understand organizational events enabling them to communicate more efficiently and effectively, thereby reaching higher levels of cooperation with each other because they share common mental models of realities. The literature on organizational culture and performance revealed that companies that know how to develop their cultures in an effective way most probably have the benefit of advancement in productivity and the quality of work life among the employees (Akpa et al., 2021). Organizational culture has the potential to enhance organizational performance, employee job satisfaction, and the sense of certainty about problem solving (Kotter, 2012).

Literature review

In today's dynamic and unpredictable business environment, organizations try to achieve rapid growth, continuous improvement, profitability and top position in their activities in the global spectrum. In the *age of change*, for achieving performance excellence, organizations are forced to use new managerial approaches, taking in account that traditional management methods are becoming inadequate. Therefore, to achieve high performance of the organization, it is essential to identify and leverage key performance drivers such as organizational culture (Nikpour, 2017).

The concept of organizational culture was first introduced by Pettigrew (1979) and received attention in the late 1980s and early 1990s when management scholars sought to understand performance disparities between American and Japanese companies. The concept of a national culture was not a sufficient explanation to this phenomenon, and a model was needed that allowed

for differentiation between organizations within a culture (Akpa et al., 2021).

Organizational culture is part of an organization, rooted in its founder philosophy, being briefly defined as the basic assumptions about the world and the values that guide life in organizations (Schneider et al., 2013). It is a system of shared values, beliefs, perceptions, and behavioral norms that influence employees' attitudes and guide organizational behavior in achieving organizational goals (Ratnasari et al., 2020).

According to Robbins and Judge (2011), organizational culture is a value or characteristic that influences the performance of members of an organization. A good organizational culture maintains variation and develops organization's employees' performance by motivating employees toward a shared objective and goal and lastly shapes and channels employees' behavior to this specific focus which must be preferred for functional and operational plan.

Empirical evidence consistently indicates that organizational culture significantly and positively influences employee performance (Syahruddin et al., 2020; Nurasniar, 2022; Manggis et al., 2018; Farhani, 2019; Tianingrum, 2022), either in the form of technical ability, conceptual ability, responsibility, initiative, and interpersonal skills.

According to Mafrudoh (2023), the key characteristics of organizational culture are as follows:

(a) for organizational members, culture is a genuine way of life that subtly yet profoundly shapes behavior, often being visible when compared with other organizations or during period of change;

(b) involving basic assumptions, shared values, and collective beliefs, organizational culture tends to remain relatively stable over time, ensuring continuity despite personal turnover;

(c) cultural content can include internal and external organizational factors: internally, it can foster innovation, risk-taking, or information management, while externally, it may support "Customer First" slogans or competitors' unethical behavior;

(d) organizational culture can have a significant influence on overall performance and employee satisfaction. A positive culture creates a supportive work environment that influence employee performance and ensures innovation, creativity, dynamism, and long-term organizational productivity (Nwachukwu et al., 2019; Nzuva and Kimanzi, 2022). Therefore, culture plays an important role so that the stronger the values instilled in employees as the motor of a company, the better their work quality; conversely, a weak organizational culture diminishes employee performance (Nasution et al., 2018).

Numerous studies have demonstrated that organizational culture plays a decisive role in shaping employee performance, productivity and overall organization success. Stewart (2007) opined that to ensure profitability is the goal of any organization, and one of the best places to start improvements is with an examination of the organization's work culture. A strong culture aligns individual attitudes and behaviors with corporate objectives, fostering commitment and collaborative efforts (Akpa et al., 2021).

As organizations face rapid technological change and development of knowledge, their ability to adapt to environmental changes depends on empowering existing Human Resources (HR) with relevant abilities and skills so that they can work efficiently and effectively, positively contributing to achieving organizational goals. The achievement of productivity is inseparable from the habits, commitments and rules set in the organization and must be carried out by employees (Rohim, 2022).

Employee performance is the key that determines the success or failure of a company in achieving its targets and objectives and a good organizational culture and work environment have a direct positive and significant effect on it. Consequently, companies must learn to pay attention to the organizational culture applied in the company and the conditions of the work environment around the employees (Nurcahyo and Indradewa, 2022).

Employee performance is a reasonable outcome resulting from the internal alignment of HR practices that harmoniously enhance employee abilities, motivation, and opportunities (AMO). It also serves as a key proximal outcome in HR - performance linkage. HR research has examined the influence of HR systems on organizational outcomes e.g., productivity, quality, and service (Jiang et al., 2012).

In the modern workplace, where employee loyalty can no longer be assumed, the extent of organizational identification of employees has become a key predictor of positive organizational outcomes. Fostering a sense of oneness is therefore essential (Kumar and Jauhari, 2016).

A well-built organizational culture serves as a powerful tool to promote innovative ideas, to shape employee's behaviors, to increase performance, and to enhance performance by aligning individual's values with organizational practices. The more employees perceive continuous learning, open dialogue, and effective leadership, the more committed they will be to the organizational goals (Isa et al., 2021).

Employee performance refers to the quality and quantity of work achieved by someone in carrying out its duties assigned to them based on their skills, experience, seriousness, and time (Kawiana et al., 2018). It reflects both quantitative and qualitative outcomes, such measurable output (such as the amount of work of employees in the unit every day, the amount of weight of goods that can be lifted by employees) and qualitative aspects, such work quality goal achievement (Ratnasari et al., 2020). Closely related, employee productivity (sometimes referred to as workforce productivity) assesses the efficiency of a worker or group of workers in producing output in a specific period, making it a key determinant of any organization success (Massoudi and Hamdi, 2017).

Over the decades, various scholars have examined the influence of organizational culture on performance and productivity, though its effect on specific productivity indicators remains unexplored. Workforce productivity is a function of the employees' commitment, motivation, and effective leadership - all of which are shaped by organizational culture, determining the overall

organization performance. The organizational culture encourages employees to be more innovative and creative, which in turn makes them perform optimally for the benefit of the organization (Nzuva and Kimanzi, 2022).

Employee performance is the result of work achieved by employees in carrying out the tasks assigned to them based on expertise, experience, and timeliness and it serves, for some organizations, as a benchmark of organizational success (Nurcahyo and Indradewa, 2022).

To achieve organizational goals and maintain competitive advantages the companies are thriving to recruit highly performing individuals, while providing a supportive organizational culture that help them reach individual objectives. Therefore, an organization is a consciously coordinated system where characteristics of individuals, groups and organization interact with each other and effective interaction among them highly depends on organizational culture that shapes the individual performance (Uddin, et al., 2013).

Employee performance reflects the extent of workers' contribution to the company, through output quantity, quality, workplace attendance and cooperation. As a very important organizational asset, human resources must be effectively managed to ensure good coordination between each work unit and department. Performance quality indicates the overall quality of human resources and is influenced by several factors, including locus of authority (Annisa and Ginarti, 2023).

Recent studies emphasize the growing importance of management practices in enhancing employee performance and productivity, which are critical to organization growth. Most studies indicate that organizations must apply effective managerial styles that prioritize employee welfare and engagement, those being the key to maintain high productivity, as organizational performance greatly dependent on the management style adopted (Kalogiannidis et al., 2021).

Previous studies have indicated a strong link between organizational culture and its performance, as culture is deeply embedded in organizational practices. A strong organizational culture should be at the top of operational and functional strategies taking in account that it enhances adaptability, motivates employees toward shared goals and objectives, and shapes employees' behavior to that specific direction (Uddin et al., 2013).

Organizational culture greatly affects how an organization operates and how the workforce interacts to carry out daily activities, functioning as a dynamic social system that must be adjusted to match different contexts over time as it affects the overall outcomes of the various operations and processes. Various scholars state that a strong culture shapes operations and productivity, guides behaviors toward desired outcomes and aligns work practices with the organization's strategic intent and values. Both employees and management play vital roles in creating a productive work environment (Nzuva and Kimanzi, 2022; Padhi, 2017).

Empirical evidence demonstrates that the attributes of organizational culture positively influence over employee performance, emphasizing the need for managers to focus on the factors that have a significant effect on employee job performance, if they want to enhance their businesses (Wambugu, 2014).

The conceptual model

The model illustrates the relationship between organizational culture and employee productivity, highlighting how the key cultural dimensions influence individual performance outcomes. It posits that a well-defined and shared organizational culture - characterized by clear values, open communication, supportive leadership, employee involvement, and adaptability - positively impacts employee motivation, engagement, and, ultimately, productivity. In dynamic work environments, the model (Figure 1) suggests that a strong organizational culture enhances organizational resilience, helping employees maintain high levels of performance even under uncertainty or change.
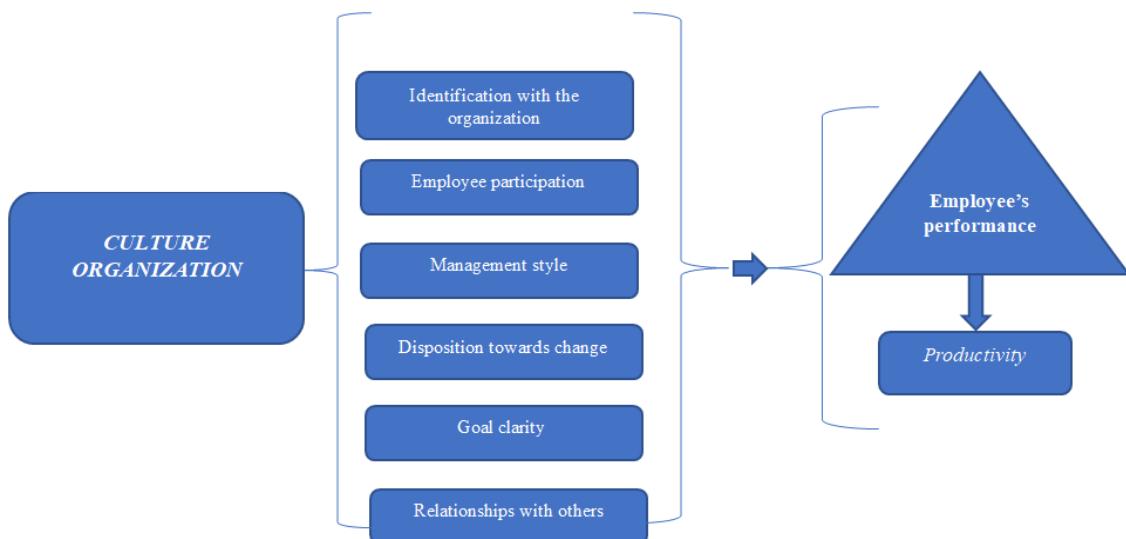
Figure 1 – *The conceptual model of organizational culture and employee's performance*

Research methodology

Research Design. This study is based on a quantitative, cross-sectional design, which aims to investigate the relationship between organizational culture and employee productivity, as well as its implications for organizational resilience in dynamic contexts. The proposed model was tested through empirical research based on the analysis of data obtained from standardized questionnaires.

Participants and Sampling. The sample consisted of 200 respondents, employed in various organizations, selected based on a simple random sample. The participants had different functions and seniority, thus ensuring a relevant diversity for the analysis of the relationships between the variables.

Data Collection. Data was collected through a self-administered questionnaire, distributed online. The questionnaire consisted of three main sections:

1. Demographic data (age, gender, position, professional experience, etc.)

2. Items on organizational culture - based on validated instruments (e.g. Denison Organizational Culture Model, Hofstede, etc.)

3. Items on perceived employee productivity - measured on a Likert scale from 1 to 5

Data Analysis. Data was analyzed using SPSS. Analyses performed included:

- Descriptive statistics (means, standard deviations)
- Pearson correlation coefficient to determine the relationship between variables

Working hypotheses

H1. The more clearly employees perceive and understand the organizational culture of the company/institution, the higher their level of productivity at work will be.

The organizational culture is clearly perceived and understood within the company/institution where you work.	Pearson Correlation	1	.277**
	Sig. (2-tailed)		.005
	N	100	100
How do you evaluate your level of productivity at work?	Pearson Correlation	.277**	1
	Sig. (2-tailed)	.005	
	N	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

The Pearson correlation coefficient (r = 0.277) shows that there is a statistically significant correlation between the two variables, which means that a clear perception of organizational culture can have a positive impact on employee performance. Although the intensity of the relationship is weak to moderate, it is relevant and significant, indicating that the way culture is communicated and assumed in the organization can have a positive impact on individual performance. This finding highlights the importance of managers ensuring transparency and consistency in communicating organizational values and norms, in order to stimulate employee involvement and efficiency.

H2. The more employees identify with the values and mission of the company/institution, the higher their level of productivity at work will be.

To what extent do you identify with the values and mission of your company/institution?	Pearson Correlation	1	.365**
	Sig. (2-tailed)		.000
	N	100	100
How do you rate your level of productivity at work?	Pearson Correlation	.365**	1
	Sig. (2-tailed)	.000	
	N	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

The Pearson correlation coefficient (r = 0.365) shows that there is a statistically significant correlation between the two variables, meaning that employees who identify with the company's values and mission tend to be more productive at work. The moderate correlation signals a significant link between the alignment of personal and organizational values and the perception of one's own effectiveness at work. This relationship highlights the importance of a coherent and well-communicated organizational culture that allows employees to identify with the company's mission and values, which can contribute to increased productivity and motivation.

H3. The more the employees feel proud to be part of their company/institution, the higher their level of productivity at work will be.

Do you feel proud to be part of your company/institution?	Pearson Correlation	1	.364**
	Sig. (2-tailed)		.000
	N	100	100
How do you rate your level of productivity at work?	Pearson Correlation	.364**	1
	Sig. (2-tailed)	.000	
	N	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

The Pearson correlation coefficient (r = 0.364) shows that there is a statistically significant correlation between the two variables, which means that employees who feel a strong sense of belonging and loyalty to the company tend to be more efficient and perform better in their professional activity. This relationship emphasizes the role of organizational culture and of the internal image of the company in stimulating individual involvement and performance. The measures to strengthen organizational identity and employee value can indirectly contribute to increasing productivity.

H4. The more support employees perceive from the company/institution in the process of adapting to changes, the higher their level of productivity at work will be.

The company/institution you work for supports you in adapting to changes.	Pearson Correlation	1	.266**
	Sig. (2-tailed)		.008
	N	100	100
How do you evaluate your level of productivity at work?	Pearson Correlation	.266**	1
	Sig. (2-tailed)	.008	
	N	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

The Pearson correlation coefficient (r = 0.266) shows that there is a statistically significant correlation between the two variables, which means that employees who feel they receive support from the organization to adapt to changes (technological, structural, cultural, etc.) will have a higher level of productivity. Although the relationship is not a very strong one, it is significant and indicates that organizational support during transition periods plays a role in maintaining or improving individual performance. This relationship highlights the importance of effective management changes, which provide employees with resources, information and psychological support to cope with organizational transitions without loss of efficiency.

H5. The more often employees' ideas and suggestions are taken into account within the company/institution, the higher their level of productivity at work will be.

To what extent are your ideas and suggestions taken into account within the company/institution where you work?	Pearson Correlation	1	.356**
	Sig. (2-tailed)		.000
	N	100	100
How do you evaluate your level of productivity at work?	Pearson Correlation	.356**	1
	Sig. (2-tailed)	.000	
	N	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

The Pearson correlation coefficient (r = 0.356) indicates that there is a positive and statistically significant relationship between the degree to which employees feel that they are listened to (by having their ideas and suggestions considered) and their productivity at work. In other words, employees who feel valued, listened to, and involved in the decision-making process tend to be more effective and productive at work. This relationship highlights the importance of a participative organizational climate, in which open communication and employee feedback are encouraged and applied. Furthermore, it shows that recognizing employees' ideas not only increases satisfaction but can also contribute to perceived performance.

H6. The more employees perceive that the management style contributes to a positive work environment, the higher their level of productivity at work will be.

The management style within your company/institution contributes to a positive work environment.	Pearson Correlation	1	.350**
	Sig. (2-tailed)		.000
	N	100	100
How do you evaluate your level of productivity at work?	Pearson Correlation	.350**	1
	Sig. (2-tailed)	.000	
	N	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

The Pearson correlation coefficient (r = 0.350) shows that there is a statistically significant correlation between the two variables, which means that employees' perception of management style as a factor contributing to a positive work environment is associated with higher productivity. In other words, when managers adopt an open and people-oriented leadership style, employees tend to feel more effective and motivated at work. This relationship highlights the importance of leadership quality in creating an environment conducive to performance. A positive organizational climate, supported by an appropriate management style, can be a key factor in increasing employee productivity and engagement.

H7. The better employees communicate and collaborate with their colleagues and superiors, the higher their level of productivity at work will be.

How well do you communicate and collaborate with your colleagues and superiors?	Pearson Correlation	1	.357**
	Sig. (2-tailed)		.000
	N	100	100
How do you evaluate your level of productivity at work?	Pearson Correlation	.357**	1
	Sig. (2-tailed)	.000	
	N	100	100

**. Correlation is significant at the 0.01 level (2-tailed).

The Pearson correlation coefficient (r = 0.357) shows that there is a statistically significant correlation between the two variables, which means that effective communication and collaboration within the team - both with colleagues and superiors - is associated with higher productivity. In other words, employees who feel connected, listened to, and supported in their work relationships tend to be more effective and perform better in their work. This relationship highlights the crucial role of interpersonal relationships and organizational communication in supporting individual performance. Promoting an open, collaborative, and trust-based work climate can significantly contribute to increasing productivity.

Results and discussion

The proposed model underscores organizational culture as a central determinant of employee performance and resilience. Within dynamic and evolving environments, this integrated framework offers a systematic approach to building and sustaining a long-term competitive advantage.

Although this study provides valuable insights into the relationship between organizational culture and employee productivity, there are several limitations that need to be considered:

- Sample size and representativeness - the sample used was limited to a specific number of respondents, coming from a specific sector or geographical region. This may limit the generalizability of the results to other industries or organizational cultures.
- Data collection methods - the data were collected through self-reported questionnaires, which may introduce a certain degree of subjectivity or the desire to provide socially acceptable answers.
- Complexity of organizational culture - organizational culture is a complex and multidimensional construct. The model used only captured certain aspects of it, which may omit important influences from other cultural dimensions.
- Uncontrolled external factors - the results may be influenced by external or contextual factors (e.g. economic, technological, social changes) that were not included in the analysis, but which may affect employee productivity and perceptions.

Conclusions

This study highlighted the essential role of organizational culture in influencing employee

productivity, highlighting how it can contribute to organizational resilience in dynamic and changing environments. Empirical results indicate that shared values, a clear mission, and a sense of belonging reinforced by a strong organizational culture lead to higher levels of employee engagement and productivity.

Furthermore, the proposed model shows that organizations that invest in building and maintaining a positive and adaptable culture develop an increased capacity to face challenges from the external environment, demonstrating resilience and agility. This resilience is reflected in maintaining or increasing productivity even in conditions of uncertainty and rapid change.

Active employee involvement, stimulated by a healthy organizational culture, not only optimizes individual performance, but also creates a framework conducive to innovation and collaboration, key elements for long-term success. Therefore, managers and organizational leaders must pay special attention to the development of internal culture as a strategic strategy for increasing organizational productivity and adaptability.

In conclusion, the proposed model confirms that a solid organizational culture, well aligned with employee values, is a determining factor not only for productivity, but also for organizational resilience in face of the challenges of dynamic environments.

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"*Resilience is accepting
your new reality.*"
Elizabeth Edwards

Critical Factors of Organizational Resilience

Irina COICIU

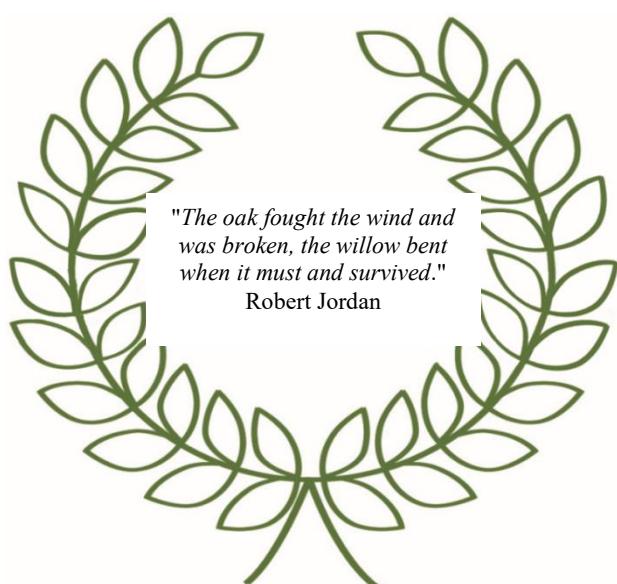Rethink BCM, 75P Cooperativei, Bucharest, Romania

Abstract

In an era of volatility and systemic disruption, organizational resilience has become a core capability for ensuring continuity and sustainable performance. This paper compares key theoretical models of organizational resilience with international standards and excellence frameworks. Using a comparative analytical approach, the study identifies strong convergence around three critical factors - leadership, organizational culture and learning -that enable resilient performance. Theoretical perspectives emphasize resilience as a dynamic capability enabling anticipation, adaptation, and renewal, while standards translate these into governance structures, stakeholder engagement, and continual improvement systems. The paper proposes an integrative view of resilience built on three interdependent layers: structural (governance and resources), behavioral (leadership and culture), and dynamic (learning and innovation).

Keywords: organizational resilience; business continuity; organizational culture

Introduction

The concept of organizational resilience has gained increasing attention in recent years, driven by escalating global uncertainty and systemic interdependence. Crises such as the COVID-19 pandemic, geopolitical conflicts, cyberattacks, and supply-chain disruptions have exposed the vulnerability of organizational systems and the limits of conventional risk management and business continuity approaches. In this context, resilience has evolved from a reactive notion of recovery to a proactive and strategic capability, which is essential for survival and sustainable performance (Duchek, 2020; Denyer, 2017).

"The oak fought the wind and was broken, the willow bent when it must and survived."
Robert Jordan

Academic literature defines organizational resilience as the ability of an organization to prepare for, respond to, and adapt to change and disruption while maintaining its essential functions and strategic objectives (Hollnagel, 2011; ISO 22316:2017). However, despite broad interest, there is still no unified understanding of its determinants. Scholars approach resilience from diverse disciplinary perspectives - psychology, systems engineering, and strategic management - while international bodies such as the International Organization for Standardization (ISO) and the British Standards Institution (BSI) have translated it into operational frameworks (ISO 22316:2017; BS 65000:2014).

This diversity of perspectives results in conceptual fragmentation and limited comparability between theoretical and normative approaches. Academic models emphasize adaptive capabilities - anticipation, learning, and renewal (Hollnagel, 2006; Duchek, 2020) - whereas international standards focus on structured governance and process assurance (ISO 22301:2019). Bridging these perspectives is crucial for developing a holistic understanding of organizational resilience that integrates both capability and system dimensions.

Under this presented context, this study aims to analyze and compare the critical factors of organizational resilience as reflected in important theoretical models and international standards. This research seeks to identify areas of convergence and divergence and to conceptualize a dynamic balance between standardization and adaptability. The goal is to propose a coherent conceptual foundation that can support the future development of resilience maturity assessment models applicable across sectors.

Research methodology

Research design. This study adopts a qualitative and comparative research design grounded in an extensive review of academic literature and international standards related to organizational resilience. The design is exploratory and conceptual in nature, seeking to integrate theoretical and normative perspectives into a coherent analytical framework.

The research has three main correlated objectives:

- To identify the key factors and dimensions that define organizational resilience within leading theoretical models developed in academic literature;

- To analyze and compare how these factors are operationalized within international standards and excellence frameworks, particularly ISO 22316:2017, ISO 22301:2019, BS 65000:2014, and the EFQM Model (2020);

- To synthesize the convergences and divergences between conceptual and normative approaches, to propose an integrated perspective of resilience as a *learning-based and systemic capability*.

There is used a comparative analytical approach, as it is particularly suitable for the above-mentioned objectives. It enables examination of how different knowledge systems - academic and standard-based - conceptualize and institutionalize resilience. By contrasting capability-oriented theories (e.g., Duchek, 2020; Lengnick-Hall et al., 2011) with process- and governance-oriented frameworks (e.g., ISO 22316, ISO 22301), the study reveals both complementarities and potential integration opportunities.

The design thus combines conceptual synthesis (identifying recurring dimensions and constructs) with normative mapping (analyzing how standards translate these dimensions into operational requirements). The resulting comparative framework provides a structured foundation for future empirical validation and supports the development of resilience maturity assessment models applicable across organizational contexts (Denyer, 2017; Duchek, 2020).

Data Sources and Selection Criteria. The analysis included two main categories of data sources: theoretical models and academic literature on organizational resilience, and international standards and excellence frameworks. These sources were selected according to their scientific relevance, conceptual contribution, and cross-sector applicability (Table 1). The selection criteria

of the data sources ensured that each of these explicitly addressed the principles, attributes, or capabilities of resilience at the organizational level.

Table 1 - *Categories of Data Sources Used in the Comparative Analysis*

Category	Selection Criteria	Representative Sources	Purpose / Contribution
Theoretical models and academic literature	High citation relevance; conceptual contribution to resilience theory; focus on organizational (not individual) level	Mallak (1998); Coutu (2002); Hollnagel (2006, 2011); Lengnick-Hall et al. (2011); Denyer (2017); Duchek (2020)	Identify conceptual dimensions of resilience such as leadership, culture, learning, adaptability, and dynamic capabilities
International standards and excellence frameworks	International recognition; cross-sector applicability; inclusion of resilience-related principles or attributes	ISO 22316:2017 (Organizational Resilience – Principles and Attributes); ISO 22301:2019 (Business Continuity Management Systems – Requirements); BS 65000:2014 (Guidance on Organizational Resilience); EFQM Model (2020) (European Foundation for Quality Management Excellence Model)	Examine how resilience is operationalized through governance structures, processes, and continual improvement mechanisms

The comparative analytical framework was designed to ensure systematic identification, classification, and synthesis of resilience-related constructs across academic and normative sources. The process consisted of three main stages, summarized in Table 2.

Table 2 – *Stages of the Comparative Analytical Framework*

Stage	Description	Analytical Purpose	Representative Sources
1. Conceptual synthesis	Extraction of definitions, principles, dimensions, and attributes of resilience from theoretical and standard-based sources.	To identify how resilience is defined and structured within academic and normative literature.	Mallak (1998); Hollnagel (2006, 2011); ISO 22316:2017; BS 65000:2014
2. Categorization and mapping	Grouping identified elements under recurring dimensions (leadership, culture, learning, governance, adaptability, resource management).	To organize and compare resilience attributes across sources according to thematic and functional similarities.	Denyer (2017); Duchek (2020); ISO 22301:2019; EFQM (2020)
3. Cross-comparison and integration	Identifying overlaps, complementarities, and conceptual gaps between academic and standard-based approaches.	To outline a unified set of critical factors and propose an integrative conceptual model of organizational resilience.	Lengnick-Hall et al. (2011); Duchek (2020); ISO 22316:2017

Validity and Limitation. The methodological rigor of this study is supported by using multiple credible sources (peer-reviewed literature and official standards, as further presented) and by transparent criteria for inclusion and comparison. However, there are certain limitations of the study, as presented further-on. The analysis is conceptual rather than empirical, relying on secondary sources; therefore, it cannot directly measure organizational resilience in practice. Additionally, the selection of frameworks - although comprehensive - focuses on widely recognized models and may not capture sector-specific or emerging perspectives (e.g., digital or ESG-related

resilience). Despite these limitations, the chosen design offers a strong foundation for theoretical integration and for subsequent empirical research aimed at developing resilience maturity assessment models.

Results and discussion

The comparative analysis of theoretical models and international standards reveals that organizational resilience is a multidimensional concept, grounded in both human capabilities and systemic structures. The findings, as detailed in the following sections, demonstrate a progressive convergence between academic conceptualizations and international frameworks, as well as persistent divergences that underscore the need for integrative approaches.

Identified critical factors of organizational resilience. Across all reviewed sources, the study identifies a consistent set of critical factors that enable resilient performance. These factors synthesize both behavioral and structural dimensions of resilience and are summarized in Table 3.

Table 3 – *Critical factors of organizational resilience*

Critical factor	Definition and organizational role	Representative sources
Leadership and governance	Provide strategic direction, support decision-making under uncertainty, and institutionalize resilience practices within governance structures.	Denyer (2017); ISO 22316:2017
Organizational culture	Foster trust, collaboration, open communication, and a shared commitment to learning and adaptation.	Mallak (1998); Coutu (2002); ISO 22316:2017
Learning and adaptation	Represent the core mechanisms of renewal, allowing organizations to transform experience into capability and sustain continuous improvement.	Hollnagel (2006); Duchek (2020); EFQM (2020)
Preparedness and continuity planning	Ensure operational stability, readiness, and rapid recovery capacity during crises through structured planning and testing.	ISO 22301:2019; BS 65000:2014
Resource management and stakeholder engagement	Secure critical resources, promote flexibility, and strengthen relational resilience through effective stakeholder collaboration.	Lengnick-Hall et al. (2011); ISO 22316:2017

Convergences between theoretical and standard-based perspectives. Both domains - academic and normative - increasingly emphasize capability-building and learning orientation as foundations of resilience. Theoretical models conceptualize these as dynamic processes that foster anticipation, coping, and adaptation (Duchek, 2020; Hollnagel, 2011), while standards translate them into formalized systems of governance and continual improvement (ISO 22301:2019; EFQM, 2020).

This convergence indicates that resilience has evolved from risk management and initial stages of business continuity towards a strategic important capability that supports sustained organizational performance. The integration of leadership, culture, and learning across both conceptual and normative frameworks demonstrates a shared understanding of resilience as a learning-based and systemic capability.

Divergences and complementarities. Despite convergence, there are notable differences to be taken into consideration. Academic models describe resilience in behavioral and processual terms - emphasizing human adaptability, collective sensemaking, and learning cycles (Mallak, 1998; Duchek, 2020). On the other hand, international standards operationalize resilience through formalized processes, roles, and evidence

requirements, emphasizing measurability and auditability (ISO 22301:2019).

While standards provide procedural assurance, they may risk over-formalization if not supported by an organizational culture of adaptation. Conversely, purely theoretical models lack prescriptive mechanisms for implementation and monitoring. This complementarity reinforces the necessity of balancing structure and flexibility — a dynamic balance between standardization and adaptability that allows organizations to institutionalize resilience without constraining innovation. Such balance ensures that resilience systems remain rigorous enough to meet compliance and assurance requirements, yet flexible enough to encourage creativity, learning, and transformation.

Integrative Conceptual Framework. Synthesizing these findings, organizational resilience can be viewed as comprising three interdependent layers, as presented in Table 4.

Table 4 - *Organizational resilience comprising three interdependent layers*

Layer	Core Components	Representative Sources
Structural resilience	Governance, resource allocation, continuity planning	ISO 22301:2019; ISO 22316:2017; BS 65000:2014
Behavioral resilience	Leadership, culture, empowerment, communication	Mallak (1998); Coutu (2002); Denyer (2017)
Dynamic resilience	Learning, adaptability, innovation, renewal	Hollnagel (2006); Duchek (2020); EFQM (2020)

This layered view reflects the dual nature of organizational resilience: it is both structural, ensuring continuity and control, and dynamic, enabling adaptation and transformation. Organizations that succeed in aligning these dimensions are more likely to sustain high performance under complex and uncertain conditions, as in any VUCA context.

Implications for Research and Practice. From a research perspective, the results provide a conceptual foundation for developing resilience maturity assessment models that integrate qualitative (capability-based) and quantitative (standard-based) indicators. Such models can support empirical validation of resilience as a measurable construct.

From a managerial perspective, the findings highlight that compliance with standards such as ISO 22301 or ISO 22316 is not sufficient in isolation. True resilience emerges when standardized processes are supported by a learning culture, empowered leadership, and adaptive governance. In practice, this requires cultivating an organizational mindset where standardization enables, rather than constraints, adaptability - a core principle of resilient organizations in the modern era.

Conclusions

This study examined the critical factors of organizational resilience by comparing major theoretical models and international standards. The analysis revealed that resilience is best understood as a learning-based and systemic capability that enables organizations to anticipate, respond, and adapt effectively to disruption.

The results show a strong convergence between conceptual and normative approaches around three recurring dimensions: leadership and governance, organizational culture, and learning and adaptation. While academic models emphasize the behavioral and capability-building aspects of resilience, standards such as ISO 22316 and ISO 22301 formalize these principles into governance structures, resource systems, and continual improvement mechanisms.

At the same time, divergences exist and were identified. Theoretical frameworks focus on flexibility, sensemaking, and transformation, whereas standards prioritize structure,

accountability, and evidence. The study highlights the need to maintain a dynamic balance between standardization and adaptability - ensuring that resilience systems remain rigorous enough for assurance, yet flexible enough for innovation and renewal.

The main contribution of this paper lies in bridging the gap between theory and practice, offering a conceptual foundation for future empirical research. Further studies should develop and validate resilience maturity assessment models that integrate qualitative (capability-based) and quantitative (standard-based) indicators, enabling organizations to evaluate and strengthen resilience in a measurable and sustainable way.

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"*I can be changed by what happens to me. But I refuse to be reduced by it.*"
Maya Angelou
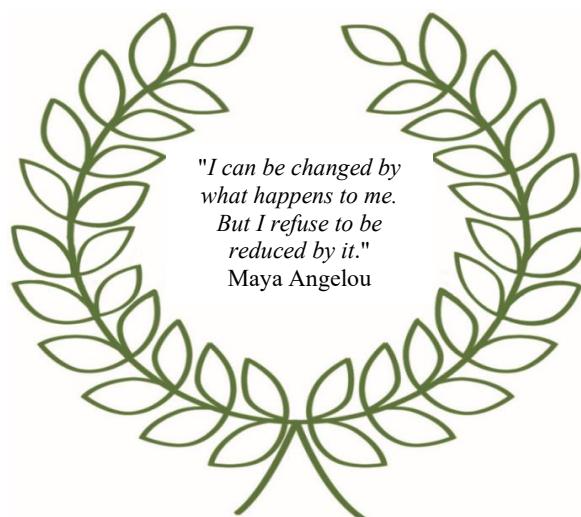
An Analysis of Corporate Governance in Central and Eastern Europe

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Abstract

This study explores the evolving relationship between corporate governance and sustainability in Central and Eastern European (CEE) economies. Although these countries follow distinct institutional trajectories, they share the overarching goal of aligning governance frameworks with European Union (EU) sustainability standards. A mixed comparative approach, that combines doctrinal legal analysis with secondary empirical data, the research applies agency, stakeholder and reflexive governance theories was applied to evaluate how governance structures influence sustainability practices and ESG (Environmental, Social and Governance) disclosures. Findings reveal that, while CEE states have strengthened their governance systems, the degree of sustainability integration remains uneven due to regulatory fragmentation, institutional limitations and enforcement disparities.

Keywords: corporate governance, sustainability, Central and Eastern Europe

Introduction

Over the past three decades, Central and Eastern Europe (CEE) has undergone a profound transformation from centrally planned systems to market-oriented economies. This transition brought a reconfiguration of legal, institutional and corporate frameworks, creating the conditions for both the development of modern corporate governance and the gradual embedding of sustainability principles into business practices. In the early 1990s, governance reforms were primarily aimed at privatization and capital market establishment; today, they are increasingly tied to sustainability imperatives and ESG disclosure obligations under EU law.

Corporate governance, as defined by the OECD (2015), refers to the set of relationships between a

"The greatest glory is not in never falling, but in rising every time we fall."
Confucius

company's management, its board, its shareholders and other stakeholders. Its essence lies in ensuring accountability and transparency in corporate

decision-making. Sustainability, in turn, extends this accountability beyond shareholders to encompass social and environmental responsibilities, reflecting the broader goals of sustainable development (Velte, 2021; Clarke, 2020).

The integration of governance and sustainability has been accelerated by the EU's Green Deal and accompanying legislative architecture, notably the Non-Financial Reporting Directive (NFRD) (Directive 2014/95/EU) and its successor, the Corporate Sustainability Reporting Directive (CSRD) (Directive EU 2022/2464). These directives have redefined disclosure obligations and embedded sustainability within the fabric of corporate governance across Member States. As Albu et al. (2024) observe, the CEE region has experienced an "institutional learning curve", where sustainability principles are increasingly codified into governance practices, although with varying depth and quality.

The rationale for this study emerges from the ongoing disparities between policy intent and practical implementation. While all CEE states have adopted formal corporate governance codes based on OECD and EU best practices, actual compliance and enforcement vary widely. Poland and the Czech Republic have earlier developed robust oversight mechanisms through stock exchanges and financial supervisory authorities, whereas Romania, Hungary and Croatia are coming from behind with improved monitoring and assurance frameworks (Wolf, 2021; EY, 2024).

The main objective of the research lies in understanding how governance structures either enable or hinder sustainability adoption in transitional markets. Unlike Western Europe, where corporate governance systems evolved alongside mature capital markets, CEE markets have faced dual challenges: building governance institutions while simultaneously incorporating sustainability into them.

The secondary objectives of this study are:

1. Analyze the evolution and current state of corporate governance frameworks in five CEE countries.

2. Evaluate the integration of sustainability principles within these frameworks, with an emphasis on ESG reporting and stakeholder engagement.

3. Assess the policy implications of recent EU-level reforms, particularly the 2025 Omnibus adjustments, for proportionality and regional convergence.

The importance of this research lies in its regional specificity. While global sustainability literature often aggregates Europe as a single policy space, the CEE region presents unique historical legacies, ownership structures and regulatory capacities that shape ESG governance outcomes. Understanding these contextual dynamics is crucial for developing tailored strategies that balance compliance with competitiveness.

Literature review

The literature on corporate governance and sustainability in CEE sits at the intersection of comparative institutional analysis, regulatory theory and sustainability accounting. This section synthesizes key strands of research relevant to the study: (a) corporate governance development in transition economies, (b) sustainability reporting evolution, and (c) EU regulatory convergence and proportionality.

Corporate Governance in Transition Economies. Early CEE corporate governance focused on the challenges of privatization and ownership restructuring. Post-socialist economies faced weak investor protection, limited capital markets and a lack of managerial accountability mechanisms (Mallin, 2019). Over time, as these economies integrated into the EU, they adopted legal frameworks reflecting both Anglo-Saxon and continental governance models (Tricker, 2019). The OECD (2019; 2024) emphasizes that governance reform in CEE was not merely about formal rule adoption but about institutional capacity to enforce those rules. In many cases, initial reforms were externally driven, pushed by EU accession conditions and international financial institutions (EBRD, 2024), rather than endogenous corporate culture. As a result, "compliance formalism" (Fota and Albu, 2024) emerged: companies often disclosed compliance statements without substantive behavioral change.

Recent studies have documented gradual maturation. Horvath et al. (2017) and Blach et al. (2025) find that governance quality, board independence and audit structures correlate positively with firm performance in Poland and Hungary. Similarly, the World Bank (WB, 2024) identifies improvements in shareholder rights and risk disclosure across the region. However, enforcement gaps remain, particularly in markets where self-regulation dominates.

From Governance to Sustainability. A growing body of research explores the link between governance mechanisms and sustainability outcomes. Agency theory, which views governance to align managerial and shareholder interests, has been expanded to incorporate stakeholder and legitimacy perspectives (Jensen and Meckling, 1976; Suchman, 1995). In this context, sustainability reporting becomes a governance tool that bridges information asymmetry between firms and stakeholders (Ioannou and Serafeim, 2015; Velte, 2024).

In CEE, the transition to sustainability-oriented governance has been shaped by both market incentives and regulatory pressure. Studies show that listed companies respond more rapidly to sustainability obligations due to investor demand, whereas small and medium-sized enterprises (SMEs) rely on regulatory compulsion (Kuchynska and Lehky, 2024). The adoption of the "comply or explain" principle across CEE stock exchanges represents a hybrid governance approach that balances flexibility with transparency.

The European context reinforces this trajectory. The CSRD and the upcoming Corporate Sustainability Due Diligence Directive (CSDDD) create a legal environment where governance and sustainability are inseparable. As Voss (2006) explains through reflexive law theory, modern regulation functions less by imposing prescriptive rules and more by establishing procedural frameworks that encourage self-regulation within set boundaries, a model particularly visible in EU sustainability law.

Sustainability Reporting Evolution in CEE. Before 2017, sustainability reporting in CEE was largely voluntary, driven by multinational subsidiaries and reputation-sensitive sectors. The transposition of the NFRD marked the first wave of mandatory non-financial disclosure. However, implementation was inconsistent: Romania, Hungary and Croatia transposed it relatively late (2017–2019), while Poland moved earlier under pressure from domestic institutional investors (Wolf, 2021).

The shift to the CSRD significantly raised both expectations and complexity. It expanded the scope of companies required to report, introduced double materiality and mandated alignment with European Sustainability Reporting Standards (ESRS). As noted by PwC (2024), this has placed new demands on national authorities to develop supervisory and assurance capacities.

CEE stock exchanges (Albu et al., 2024; Mititean, 2021) indicate that sustainability reporting quality is improving but remains fragmented. The main challenges include limited expertise, absence of standardized indicators and insufficient integration between financial and non-financial disclosures. The introduction of the 2025 Omnibus Package, which temporarily relaxes scope and timing, must therefore be understood not as deregulation but as a recalibration intended to enhance long-term compliance feasibility (EC, 2025).

The European Union's regulatory philosophy emphasizes proportionality, subsidiarity and coherence (Scott, 2010). Within sustainability governance, these principles ensure that reporting obligations remain balanced across firm sizes and sectors. The Omnibus I Package represents the EU's response to stakeholder feedback about excessive administrative burdens associated with CSRD compliance.

In the CEE context, proportionality is essential. Many regional companies are mid-sized and family-owned, lacking the administrative infrastructure of Western European corporations. The "Stop-the-Clock" Directive (EU 2025/794) postpones reporting deadlines for later waves, allowing regulators to build capacity and firms to develop internal ESG systems. However, as AE (2025) warns, prolonged deferrals may risk "two-speed compliance," where advanced markets move ahead while smaller economies lag. This dynamic makes governance reform even more critical: strong

governance structures help companies internalize sustainability norms independently of legal enforcement.

Research methodology

This research uses a multi-theoretical framework combining Agency, Stakeholder (Freeman, 1984), and Reflexive Governance (Voss et al., 2006) theories to conceptualize sustainability as an extension of good governance, where transparency and adaptability foster legitimacy. It follows an interpretivist, comparative qualitative design grounded in the social-constructivist paradigm, recognizing governance and sustainability as socially embedded constructs shaped by national institutions and market cultures.

Focusing on five EU Member States (Romania, Hungary, Croatia, the Czech Republic and Poland), the study uses a mixed-methods approach integrating qualitative document analysis and secondary quantitative data (e.g. compliance, disclosure, enforcement). Secondary sources include EU legislation, governance codes, institutional reports (OECD, EBRD, PwC, EY, World Bank), academic studies and stock exchange monitoring data.

The analysis followed four stages: documentary coding, comparative synthesis, pattern identification and theoretical integration. Credibility was ensured through triangulation of legal and empirical data. Despite limitations of uneven data, interpretive subjectivity and emerging Omnibus impacts, the study highlights transitional governance maturity and institutional convergence across CEE.

Results and discussion

Corporate governance in CEE exhibits notable convergence towards EU standards but remains diverse in practice. Each of the five selected countries has adopted a corporate governance code inspired by the G20/OECD Principles of Corporate Governance (2015). However, the degree of institutionalization and enforcement varies.

Romania. Romania's governance evolution has accelerated in the past decade, particularly after the 2015 revision of the Bucharest Stock Exchange (BVB) Corporate Governance Code. The 2024 update introduced stronger sustainability and issuers' monitoring elements aligned with the CSRD and ESG reporting standards. The code requires listed companies to publish an annual "comply or explain" statement addressing board composition, internal control and stakeholder engagement (BVB, 2024).

Romania's Financial Supervisory Authority (ASF) oversees enforcement for listed issuers, while the Ministry of Finance supervises sustainability reporting under the CSRD transposition (Order No. 1421/2025). This order aligned national accounting legislation with EU Directive (EU) 2025/794 ("Stop-the-Clock"), deferring reporting for wave-two and wave-three companies until fiscal years starting in 2027.

Despite this progress, compliance quality remains uneven. Studies show that many firms still provide formalistic, boilerplate disclosures rather than substantive ESG integration (Fota and Albu, 2024). Nonetheless, Romania's institutional architecture, combining ASF oversight and BVB self-regulation, has established a foundation for further convergence.

Hungary. Hungary's corporate governance landscape is shaped by the Budapest Stock Exchange (BSE) Corporate Governance Recommendations (2020) and the Hungarian Accounting Act, which now incorporates sustainability obligations following CSRD transposition in 2024. The recommendations emphasize board accountability, risk management and shareholder communication.

Hungary stands out for early experimentation with sustainability, with the BSE Green market segment, designed to attract responsible investors. However, governance enforcement relies primarily on voluntary self-declaration, with limited sanctions for non-compliance (Kuchynska and Lehky, 2024).

The Hungarian National Bank (MNB) has taken a proactive stance, issuing ESG guidelines for listed companies and financial institutions. These initiatives position Hungary among the more advanced CEE jurisdictions in ESG governance,

although a gap persists between financial-sector leadership and industrial adoption.

Croatia. Croatia's governance framework reflects a more recent convergence path. The Zagreb Stock Exchange (ZSE), in cooperation with the Croatian Financial Services Supervisory Agency (HANFA), issued an updated version of the Corporate Governance Code in 2024. It formally incorporates ESG reporting expectations and diversity objectives.

Croatian companies are generally smaller, and many remain family-owned, which limits the diffusion of advanced governance practices (OECD, 2024). Compliance culture is still developing: while most listed firms submit "comply or explain" statements, the quality of explanations varies. Even though HANFA's oversight is qualitative, public reporting on non-compliance remains sporadic.

Nonetheless, Croatia has taken important steps toward institutionalizing sustainability. The integration of the CSRD into national law (July 2024) represents a turning point, as it extends non-financial reporting to large private companies for the first time. Government support through the National Recovery and Resilience Plan also links governance reforms with access to EU funds, creating new incentives for compliance.

Czech Republic. The Czech Republic operates under the Prague Stock Exchange (PSE) Corporate Governance Code (2018), developed in line with OECD and EU principles. The Ministry of Finance leads transposition of the CSRD and the 2025 Omnibus adjustments. The Czech code is characterized by a high degree of flexibility and transparency; however, sustainability integration has been relatively slow.

A 2024 EBRD report (European Bank for Reconstruction and Developement) found that while over 80% of listed firms comply with board independence and audit committee requirements, fewer than half disclose detailed sustainability policies. The Czech Republic completed transposition of the Stop-the-Clock Directive in September 2025, aligning deadlines for waves two and three.

Interestingly, the Czech context reveals a dual governance structure: strong corporate governance among large, listed entities contrasts with weaker ESG adoption among private SMEs. Policymakers have been exploring digital tools for ESG reporting, including via the Czech Business Register Portal, signaling an incremental but positive trend.

Poland. Poland has long been a regional frontrunner in corporate governance. The Warsaw Stock Exchange (GPW) introduced the Best Practice for GPW Listed Companies (2021), which integrates sustainability disclosure and diversity requirements. Poland's Financial Supervision Authority (KNF) and the Ministry of Finance actively monitor implementation, providing a robust enforcement mechanism.

Poland was also among the first in CEE to transpose both the CSRD and the Stop-the-Clock Directive (July 2025). This proactive approach reflects strong administrative capacity and capital market maturity. Empirical evidence suggests Polish listed firms demonstrate higher ESG disclosure quality compared with regional peers (Blach et al., 2025). This is partly attributed to investor demand: Poland hosts a growing number of ESG funds and sustainable indices, reinforcing the governance-sustainability linkage. However, smaller firms face challenges in adapting to CSRD's double materiality concept, leading policymakers to advocate for proportionality, an idea later institutionalized through the 2025 Omnibus Package (European Commission, 2025).

Sustainability Integration in Corporate Governance. Sustainability integration in corporate governance across CEE has advanced over the past five years but varies by institutional maturity and market development. Across Romania, Hungary, Croatia, the Czech Republic and Poland, it is embedded mainly through board oversight, risk management and non-financial reporting, with the "comply or explain" model balancing flexibility and accountability (Albu et al., 2024).

Romania promotes ESG disclosure via the BVB Code's "responsible business" principle, though under 40% of firms report measurable indicators (ASF, 2024). Hungary benefits from financial-sector leadership and the National Bank's Green Program but remains uneven beyond listed companies (Kuchynska and Lehky, 2024). Croatia progresses slowly, mainly driven by EU funding

conditions (OECD, 2024). The Czech Republic shows growth in export-oriented sectors but limited board engagement. Poland leads with mandatory ESG disclosure and sustainability indices (GPW, 2021). Overall, strong governance supports sustainability, but institutional capacity, assurance systems and expertise are essential for lasting integration.

The Omnibus Directive (2025): Simplification and Proportionality. The 2025 Omnibus I Package and accompanying Stop-the-Clock Directive (EU 2025/794) mark the EU's recalibration of sustainability regulation, aiming to balance ambition with administrative feasibility (EC, 2025).

Key measures include: limiting CSRD scope to firms with over 1,000 employees, introducing a voluntary VSME standard (Voluntary Sustainability Reporting Standard for SMEs), capping value-chain data and delaying reporting deadlines by two years for later compliance waves.

These proportionality measures are crucial for CEE economies, where most firms are small or mid-sized (Table 1). The delay enables governments to strengthen ESG infrastructure, develop data portals and train professionals. Yet, critics warn that it could deepen the East-West compliance gap, as advanced Member States progress faster (AE, 2025).

Table 1- *CEE Transposition Dynamics*

Country	Status	Key Legislative Act	Entry into Force	Main Effect
Romania	Transposed	Order 1421/2025	22 Aug 2025	2-year delay for wave 2 & 3 entities
Poland	Transposed	Act 9 Jul 2025	12 Aug 2025	Aligns CSRD & CSDDD deadlines
Czech Republic	Transposed	Amendment Aug 2025	Sept 2025	Full 2-year deferral; paused CS3D
Hungary	Transposed	Accounting Act update	2025	Delay embedded within 2024 CSRD law
Croatia	In Progress	Accounting Act – Official Gazette 85/24 (CSRD transposition, effective 27 Jul 2024); planned amendments to the Accounting Act and the Capital Market Act to implement Directive (EU) 2025/794	27 Jul 2024 (CSRD). Stop-the-Clock: not yet in force; government announced alignment by end-2025 (EU transposition deadline: 31 Dec 2025)	Once adopted, Stop-the-Clock will defer CSRD reporting for wave-2 by 2 years (to FYs starting 2027) and listed-SME wave-3 to FYs starting 2028;

Romania, Poland and the Czech Republic implemented the Omnibus proactively, integrating it with digital ESG systems, while Croatia and Hungary adopted basic compliance. The reform offers CEE firms a vital window to build governance capacity and prepare for full ESRS implementation.

Institutional Convergence and Divergence in CEE. Institutional convergence reflects the harmonization of governance structures and regulatory practices across EU Member States. In CEE, alignment with EU norms is a major post-accession achievement, yet substantive convergence, where formal rules drive behavioral change, remains uneven.

Regulatory convergence is advanced: all five countries have adopted governance codes and supervisory bodies aligned with EU directives. However, enforcement and monitoring vary from country to country. Cultural convergence is slower; many firms still view sustainability as external compliance rather than value creation (Albu et al., 2024; Fota, 2024), leaving ESG initiatives peripheral.

Sustained progress requires stronger institutional capacity, assurance systems and stakeholder engagement. Successful stories of other countries show that effective governance demands consistent monitoring and incentives for excellence.

Through agency, stakeholder and reflexive governance lenses, CEE's governance evolution reflects a shift from compliance formality to adaptive learning, with sustainability reporting fostering accountability and legitimacy.

Conclusion

This study explores the relationship between corporate governance and sustainability in five CEE countries (Romania, Hungary, Croatia, the Czech Republic and Poland) within the EU's framework of regulatory convergence. Governance systems have evolved from post-socialist formalism to accountable and transparent structures, yet sustainability integration remains uneven due to capacity, data and enforcement gaps.
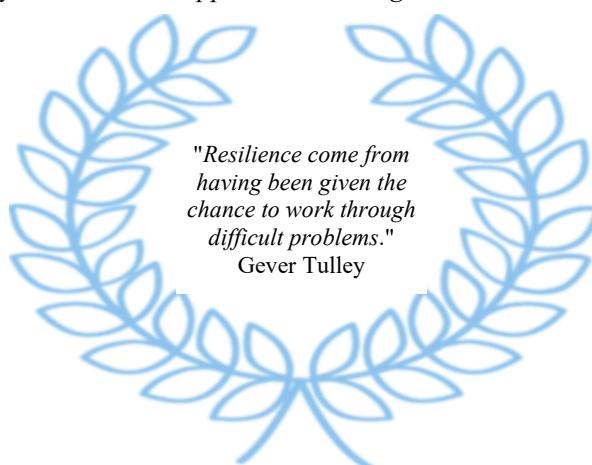
The Omnibus I Package (2025) represents a key policy shift, introducing proportionality and simplification. While it allows CEE economies to build administrative and digital capacity, it also risks widening disparities between advanced and lagging markets without targeted support.

Findings show that the "comply or explain" model remains essential but needs stronger enforcement, stock exchanges act as sustainability mediators and institutional convergence advances faster in regulation than behavior. Effective governance, anchored in agency, stakeholder and reflexive governance theories, forms the foundation for ESG integration. Continued progress depends on stronger supervision, regional cooperation and digitalized ESG systems.

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"Resilience come from having been given the chance to work through difficult problems."
Gever Tulley

The Effect of Digitalization on the Resilience of Public Transport Organizations

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Abstract

This paper examines the enhancement of organizational resilience in Romanian public institutions responsible for the transport sector, highlighting the pivotal influence of digitalization and artificial intelligence (AI) in strengthening adaptive capacity, decision-making, and process efficiency. The study employs a conceptual and analytical framework to investigate the impact of integrating digital technologies and AI-driven tools on enhancing institutional agility, data-driven management, and proactive risk mitigation. It also finds important factors that help or hurt digital transformation in the Romanian public transport administration and suggests a framework for using technology-driven management practices to make the system more resilient. This paper can be a useful instrument for both management and technical specialists from the public transport authorities, illustrating some directions for future appliable ideas.

Keywords: organizational resilience, artificial intelligence, public institutions, transport sector

Introduction

Organizational resilience has become a critical capability for public and private institutions operating in complex and unpredictable socio-economic environments. It refers to an organization's capacity to anticipate, prepare for, respond to, and adapt to incremental changes and sudden disruptions, thereby ensuring operational continuity and long-term sustainability (ISO, 2017). Resilience is not a static attribute; rather, it is a dynamic capability that develops through processes of learning, adaptation, and innovation.

Duchek (2020) defines organizational resilience as a capability-based process composed of three stages: anticipation, coping, and adaptation. This

"Resilience it's a variety of skills and coping mechanisms."
Jean Chatzky
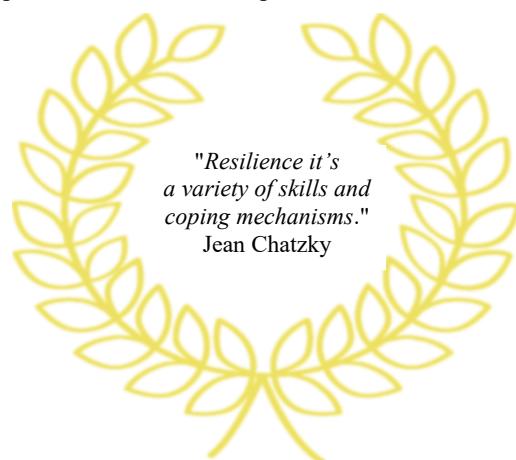
approach underlines that resilient organizations do not merely recover from crises, they use them as opportunities to improve and innovate. Similarly, (Beck et al. 2011) emphasize that resilience depends

on how effectively an organization integrates strategic learning and human resource development to enhance adaptability. From this perspective, resilience combines operational stability with strategic flexibility.

Resilience within open administration presents specific challenges due to unmoving bureaucratic structures, hierarchical decision making, and limited flexibility during crises. Burnard and Bhamra (2011) note that open institutions often lack the agility required for speedy response to shocks, chiefly as a result of broken governance and outdated processes. The accelerated adoption of digital technologies now offers opportunities to enhance resilience through technology integration, data driven management, and intelligent decision support systems. Based on this abstract foundation, the present paper investigates the role of digitalization and synthetic intelligence (AI) as strategical enablers of organizational resilience in Romania's open institutions operating under the Ministry of Transport. In this context, digital transformation represents not only a scientific upgrade but also a managerial shift toward agility, prognostic decision making, and continuous improvement.

The purpose of this research is to identify how AI tools, digital platforms, and data governance mechanisms can strengthen the adaptive capacity of public institutions responsible for critical transport infrastructure. The study aims to provide both a theoretical understanding and practical insights that can guide decision-makers in modernizing institutional processes and promoting sustainable, resilient governance.

Theoretical framework

Digitalization represents a method for redefining organizational processes, communication structures, and value creation mechanisms in both private and public sectors. According to Vial (2019), digital transformation reshapes operational models through the integration of emerging technologies such as cloud computing, big data analytics, and automation, thereby enhancing efficiency and capacity of making decisions. Within public administration, digitalization contributes to resilience by improving transparency, information flows, and service continuity during crises (Mergel et al. 2019).

Artificial intelligence (AI) amplifies these effects by introducing predictive analytics, intelligent automation, and data-driven decision-making. AI tools enable public institutions to anticipate risks, simulate crisis scenarios, and optimize resource allocation in real time. The Organization for Economic Cooperation and Development (OECD, 2025) emphasizes that AI applications in areas such as infrastructure maintenance, mobility management, and emergency response can substantially increase both operational stability and institutional adaptability.

Together, digitalization and AI act as strategic enablers of organizational resilience, fostering institutions capable of learning, adapting, and evolving under uncertainty. They promote what Beck and Lengnick-Hall (2011) describe as strategic flexibility - a capability combining technological infrastructure with human adaptability. In public governance, this synergy supports rapid response, informed policymaking, and long-term institutional sustainability (Figure 1).

However, Burnard and Bhamra (2011) note that public institutions frequently encounter obstacles in leveraging these technologies due to rigid bureaucratic frameworks and fragmented decision-making processes. Therefore, the integration of digital solutions requires not only technical investments but also transformations in governance, leadership agility, and cross-sector collaboration.
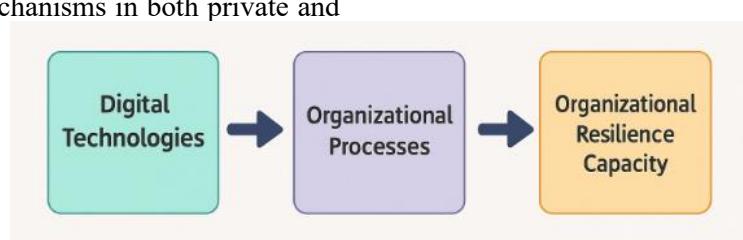

Figure 1 – *Conceptual relationship between digital technologies and organizational resilience*

The Romanian Transport Sector Context

The Romanian transport sector offers a relevant case for analyzing how digitalization and AI can strengthen institutional resilience. Public organizations such as the National Company for Road Infrastructure Administration (CNAIR), Romanian Railways (CFR SA), the Romanian Auto Registry (RAR), and the Romanian Air Traffic Services Administration (ROMATSA) are critical to the nation's infrastructure ecosystem. Their capacity to sustain operations during crises such as natural disasters or cyberattacks, directly impacts economic stability and public safety.

Despite recent modernization efforts, many of these institutions continue to rely on legacy IT infrastructures, isolated data systems, and non-interoperable digital platforms, all of which restrict agility and inhibit data-driven decision-making. These technological limitations slow response times and constrain proactive crisis management.

Nevertheless, initiatives under the National Recovery and Resilience Plan (PNRR) and the Digital Europe Programme have accelerated digitalization within the sector. Examples include digital licensing systems, e-document management, and integrated mobility data platforms. These projects align Romania's transport administration with broader European strategies for digital governance and resilient public services (EC, 2023).

Building resilience in this context demands more than technological upgrades; it requires a digital organizational culture grounded in transparency, interoperability, and continuous learning. The Ministry of Transport and Infrastructure's organizational structure can be seen at a high level at Figure 2.
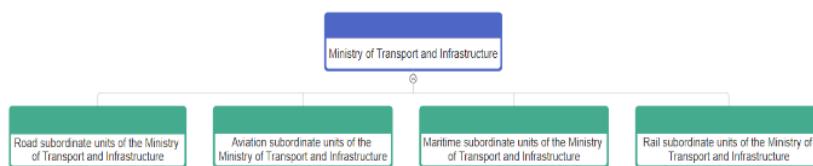
Figure 2 – *Organizational Structure of the Ministry of Transport and Infrastructure of Romania*

Romanian Government considered that transport sector must be divided in four types of units: road, rail, aviation and maritime. The Ministry of Transport and Infrastructure in Romania contains also some medical units, but this study does not focus on those elements. By connecting digital innovation, artificial intelligence, and institutional reform, Romanian transport institutions can transition from reactive management to proactive governance, achieving greater operational stability, efficiency, and strategic resilience.

Figure 3 – *Road and Rail subordinate units of the Ministry of Transport and Infrastructure*

Figure 3 shows Road and Rail subordinate units of the Ministry of Transport and Infrastructure of Romania. It is easy to observe that there are different entities that solve the majority of context that can appear regarding rail and road transport realities.

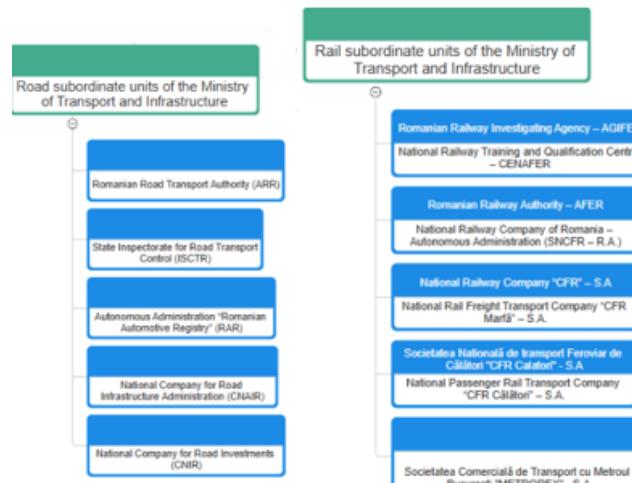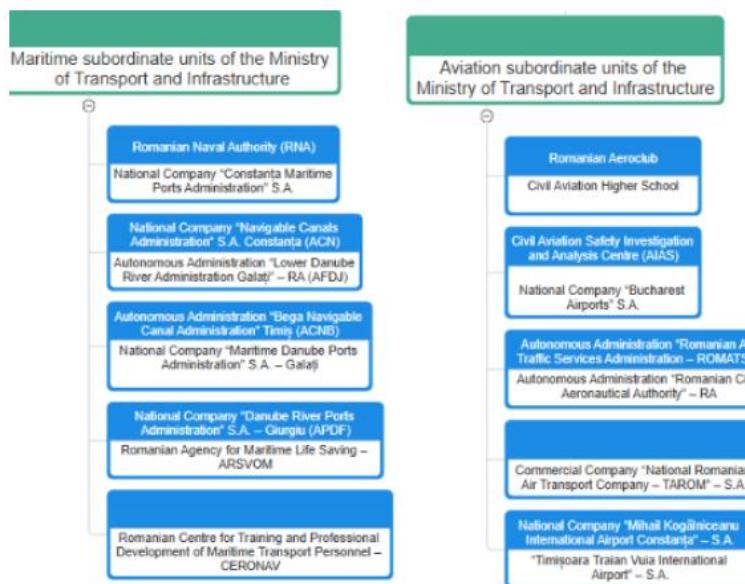**Figure 4** – *Maritime and Aviation subordinate units of Ministry of Transport and Infrastructure*
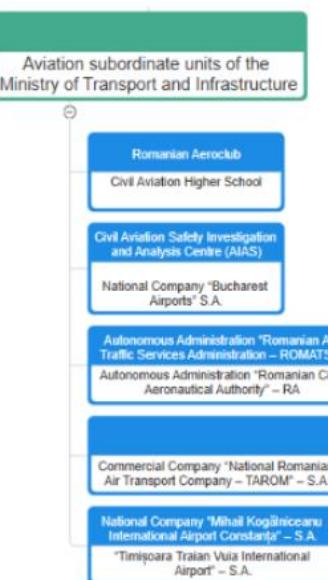
Figure 4 shows Maritime and Aviation subordinate units of the Ministry of Transport and Infrastructure of Romania.

Research methodology

This study employs a conceptual and analytical research design to explore the role of digitalization and artificial intelligence (AI) in enhancing organizational resilience within Romania's public transport sector. Given the complexity of public institutions and the novelty of AI integration in governance processes, a qualitative, comparative approach was considered most appropriate to identify patterns, challenges, and opportunities. The methodology combines three main components:

Literature Review. A comprehensive literature review was conducted to establish the theoretical foundations of organizational resilience, digital transformation, and AI application in public sector organizations. Key sources included academic journals, policy reports, and international best practice frameworks from the OECD, European Commission, and governmental bodies of leading countries (United States, United Kingdom, European Union). This review provided the basis for identifying critical success factors, risks, and implementation strategies relevant to the Romanian context.

Comparative Case Analysis. The study examines digital resilience practices in selected international public transport systems, including the United States, European Union member states, and the United Kingdom. This comparative analysis allows for the identification of transferable lessons and best practices that can inform strategies in Romania. Indicators such as digital maturity, AI adoption, interoperability, and crisis response capability were used to assess institutional performance and innovation potential.

Contextual Analysis of Romanian Institutions. The research analyzes the current state of digital transformation and AI integration within Romanian public institutions responsible for transport, including National Company for Road Infrastructure Administration (CNAIR), Romanian Railways (CFR SA), Romanian Auto Registry (RAR), and Romanian Air Traffic Services

Administration (ROMATSA). Data was collected from official institutional reports and public documents; national and european funding program evaluations such as National Recovery and Resilience Plan (PNRR); academic studies and industry analyses of usefull technology adoption in public administration.

This component focuses on defining the level of the technological infrastructure, human capital capabilities, process efficiency, and organizational readiness. The analysis highlights both strengths and gaps that may impact resilience-building initiatives the key factors that may influence the advantages or gaps of the resilience strengthening.

Analytical Framework. The study integrates findings from the literature review, comparative analysis, and contextual examination to develop a conceptual framework for digital organizational resilience. This framework identifies the interaction between:
- Leadership and Governance: strategic commitment and policy alignment,
- Digital Infrastructure: interoperable platforms, cybersecurity, and data systems,
- Human Capital: digital literacy, training programs, and AI competencies,
- Data-Driven Decision Making: predictive analytics and evidence-based management.
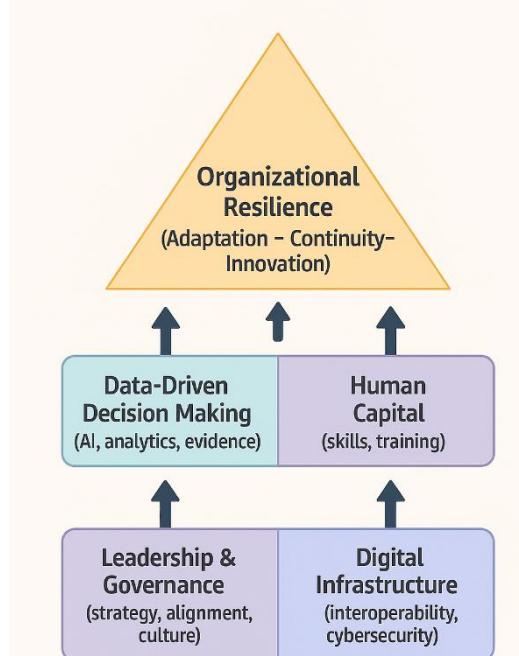
Figure 5 – *Conceptual framework for digital organizational resilience*

The methodology (Figure 5) realizes a holistic way of approaching the subject, combining theoretical aspects with empirical observations and comparative lessons to create recommendations for policymakers, managers and technical specialists.

Results and Discussion

Romania's transport institutions operate within complex and evolving environments, requiring both operational continuity and adaptability. Key institutions under the Ministry of Transport and Infrastructure include the National Company for Road Infrastructure Administration (CNAIR), Romanian Railways (CFR SA), Romanian Air Traffic Services Administration (ROMATSA), Romanian Auto Registry (RAR), TAROM, and the National Company for Maritime Ports Administration (CN-APM). These organizations face challenges related to legacy IT systems, fragmented data infrastructures, and limited interoperability, which can hinder efficient decision-making and resilience during disruptions (OECD, 2023).

Digital skills among personnel remain a critical constraint. Only 27.7% of the Romanian population possesses basic digital competencies, considerably below the EU average of 55.6% (European Commission, 2024). Limited digital literacy affects the capacity of transport institutions to adopt advanced AI and digital solutions.

Potential Applications of Artificial Intelligence. Artificial intelligence has the potential to transform operational processes and strengthen institutional resilience. For example, AI could be applied in predictive maintenance for road and rail networks, automated air traffic management, digital licensing, and intelligent mobility planning. While some initiatives, such as GIS-based monitoring in CNAIR or digital licensing platforms in RAR, are underway, much of the potential remains unexplored. These approaches could enhance predictive capacity, reduce operational risks, and improve resource allocation (McKinsey and Company, 2025; Androniceanu, 2023).

Current Initiatives and Realized Projects. Several initiatives illustrate progress in digitalization:

- CNAIR: Implementation of GIS-based infrastructure monitoring platforms.
- ROMATSA: Use of automation for air traffic control processes.
- RAR: Digital services for vehicle registration and licensing.
- CFR SA**:** Pilots for predictive maintenance on rail networks.

Additional institutions under the Ministry, such as TAROM and CN-APM, are exploring digital solutions for operational optimization and customer service improvements. EU funding programs, particularly the National Recovery and Resilience Plan (PNRR) and Digital Europe, provide opportunities for scaling these initiatives (European Commission, 2023).

Comparative Overview: Romania, USA, UK, and EU. The Table 1 shows a comparison between Romania, USA, UK and EU capabilities regarding some important indicators of technology adoption and development.

Table 1 - *Comparative Overview*

Indicator	Romania	USA	UK	EU (average)
Digital Skills	Low/Medium (European Commission, 2024)	Advanced	High	High
Interoperability	Limited	High	Advanced	High
AI Adoption	Limited	Advanced	Advanced	Advanced

In order to see a graphic representation of the information from the table, we will assume the next corresponding Low, Limited -1, High –2 and Advanced-3. Another representation that facilitates the understanding of the comparison between the states is depicted in the Figure 6.

Recommendations for Enhancing Organizational Resilience. To strengthen digital resilience, Romanian transport institutions should:

- Invest in continuous digital skills development and AI competence training.
- Implement interoperable IT platforms across all institutions under the Ministry.
- Promote public-private partnerships to foster innovative digital solutions.

- Ensure robust cybersecurity measures to protect critical transport infrastructure.
- Pilot AI-driven predictive maintenance and intelligent mobility systems were feasible

By focusing on these areas, Romanian transport institutions can enhance their adaptive capacity, operational efficiency, and long-term resilience.

Conclusions

This paper examined the potential of digitalization and artificial intelligence (AI) to enhance organizational resilience within Romania's public transport institutions . By analyzing both global practices and the special context of

Romanian agencies under the Ministry of Transport and Infrastructure , it became clear that digital transformation can serve as a important lever for improving adaptive capacity, functional efficiency, and service quality. Romania's transport institutions, including CNAIR, CFR SA, ROMATSA , RAR , TAROM , and CN-APM, face general challenges: legacy IT systems, fragmented data infrastructures, limited interoperability, and lean digital skills . These factors constrain their ability to respond to disruptions efficaciously and to harness AI's full potential.
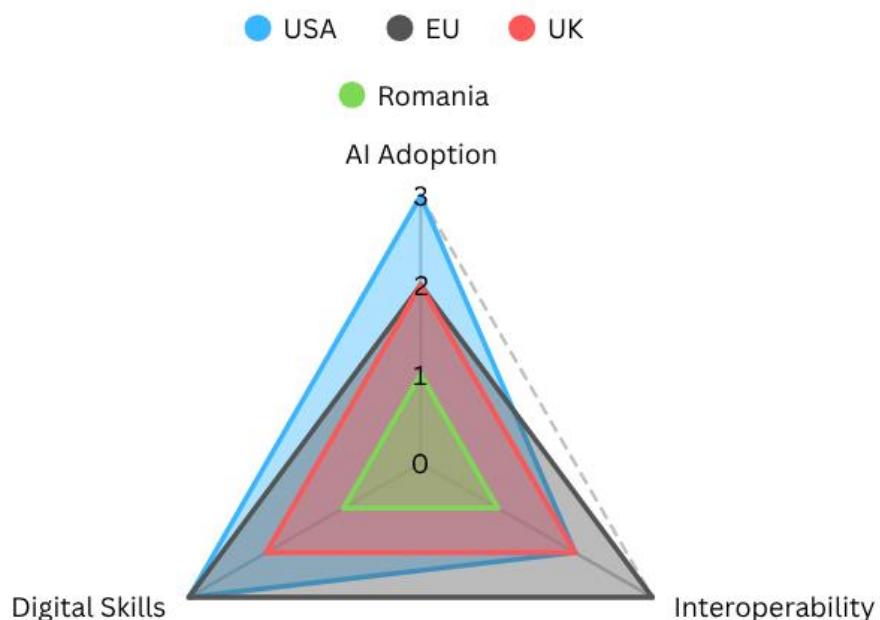
Figure 6 – *Comparative Overview – Global Approaches to Digital Resilience*

The relative analysis with the United States, United Kingdom, and European Union highlights serious lessons: interoperable platforms, staff digital and AI competence, AI adoption, and public private collaboration are central to building resilient institutions. Romania can leverage these lessons to design an adhesive national strategy linking technology, governance, and human capital development.

To strengthen resilience and functional performance, Romanian transport institutions should develop a national digital resilience strategy, invest in continuous expert development focused on AI and digital skills, implement interoperable digital platforms, establish AI competence hubs and innovation centers, ensure unrefined cybersecurity frameworks, and promote adaptive leadership and organizational cultures that encourage innovation and proactive risk management. Romania already invested time and money and successfully created academic centers for AI technologies research. By pursuing these directions, Romania's transport institutions can transform challenges into opportunities, enhance resilience against critical changes, and achieve sustainable modernization. Future research should empirically evaluate the impact of these interventions, refine resilience indicators, and explore socio- technical aspects of AI integration in public administration to guide evidence based policy development.

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"*When one door of happiness closes, another opens.*"

Sheryl Sandberg

The Role of Lean Six Sigma in Enhancing Organizational Resilience

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Abstract

In today's volatile global environment, resilience has become a strategic risk-mitigator for organizations facing uncertainty. Lean Six Sigma (LSS), integrating Lean's efficiency with Six Sigma's precision, offers a structured approach to enhance adaptability through waste reduction, variation control, and data-powered decision-making. This research article is based on a bibliometric analysis using VOSviewer to analyze research trends linking LSS methodology and organizational resilience. Findings reveal a transition from efficiency-focused workflows to resilience-oriented frameworks, increasingly aligned with Industry 4.0 and real-time analytics. Citation patterns show limited activity until 2020, followed by a marked surge in 2021 and a peak in 2022, suggesting the COVID-19 pandemic accelerated the dynamism of scholarly activity. Mechanisms identified include DMAIC procedures, workflow structuring, and digital augmentation, reframing resilience as a measurable operational capability.

Keywords: continuous improvement, Lean Six Sigma, organizational resilience

Introduction

In a constant dynamic and complex global framework, organizations are faced with the need to anticipate, absorb, adapt a resilient mindset to recover from different types of vulnerabilities. As the pre-Socratic Greek philosopher Heraclitus mentioned 'you cannot step into the same river twice' (Freeman, 1949), the only universal constant is change, and continuous adaptability and improvement are fundamental. In this context, to increase organizational resilience, a new strategic methodology which integrates Lean's efficiency focus with Six Sigma's precision, has emerged: Lean Six Sigma. By merging continuous

"Remember an arrow can only be shot by pulling it backwards."
Joseph Campbell
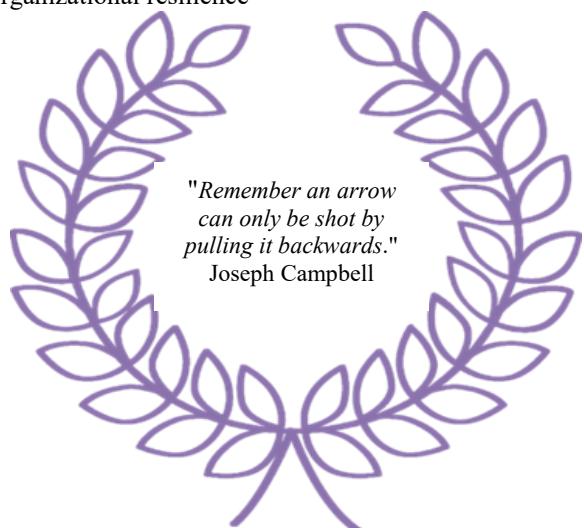
development, data-based decision-making process, and cross-functional communication, collaboration, Lean Six Sigma approach enhance organizational capacity to efficiently respond to change, uncertainty and sustain operational integrity.

Based on this, it can be mentioned that multiple research studies support and reiterate this approach. For instance, Kumarasamy et al. (2025) explain how Lean Six Sigma (LSS), when correctly implemented with Industry 4.0 technologies, generates resilient manufacturing systems through top management dedication and real-time analytics. Moreover, Sakib et al. (2025) also demonstrated that Lean six Sigma methodology supports organizational adaptability and performance among multiple departments through a bibliometric analysis based on VOSviewer's generated data. This academic discourse has also been developed by different scholars and academic institutions. More concretely, MIT's OpenCourseWare provides a complex and exhaustive introduction to Lean Six Sigma methodology, underlying its extensive scope in multiple domains such as aerospace, healthcare, and automotive area as a main productivity and resilience vector (Murman et al., 2012).

Also, Harvard Business School explores the LSS approach in strategic change and crisis management, accentuating its role in operating uncertainty (HBS , 2023). Considering this, it can be mentioned that Oxford University's Saïd Business School has also investigated LSS from the sustainable operations and resilience in global supply chains perspective (OSBS, 2024). Finally, and of equal importance, Stanford University's Center for Work, Technology & Organization has analyzed the LSS principles impact on organizational learning process and adaptive capacity (SC-WTO, 2023). Furthermore, these practices contribute to operational performance enhancement and strategic sustainability by mitigating process variation and waste, as illustrated by the case of General Electric (GE) which successfully applied Lean Six Sigma methodology in the aircraft engine manufacturing processes. More exactly, the organization encountered different challenges, including an increased defect rate and extended cycle times, which affected costs

and customer satisfaction. Through the implementation of the DMAIC (Define, Measure, Analyze, Improve, Control) framework, General Electric structured and standardized the current workflows, adopted visual management techniques, and excluded non-value-added steps through Kaizen events. These incremental changes generated a 68% decrease in defects, a 30% reduction in production per cycle time, and financial performance through annual savings exceeding $10 million (Novark Services, 2025).

This research article extends prior foundational findings by conducting a bibliometric analysis using VOSviewer software to compress the intellectual framework of current research at the intersection of Lean Six Sigma and organizational resilience. By analyzing academic discourse trends, co-authorship networks, and ideological clusters, the article aims to discover how LSS supports resilience-foundation and identify further research directions. In this direction, it acts as a bridge between operational excellence and strategic adaptability: a complex synthesis for surviving in a tech-dominated world of constant change. The aim of this research article is supported by the main research question: ***How Lean Six Sigma methodology impacts organizational resilience?***

Literature review

Lean Six Sigma: The Dynamic Framework Switching Complexity into Clarity. The Lean Six Sigma (LSS) methodology represents a performance-improvement approach which focuses on the Lean's waste reduction and process integration with Six Sigma's statistical emphasis on decreasing process deviation and deficiency, to increase operational efficiency and customer value through a methodical, systematic, data-based strategy. As mentioned by APMG International, Lean 'drives out waste' through mechanisms as Kaizen, Workplace Organization, Visual Controls, and Value Stream Mapping (APMG International, 2025). On the other hand, Six Sigma 'emphasizes variation reduction' through statistical analysis, experimental design, and statistical process monitoring. In this context, this bilateral approach

allows organizations to optimize their current workflows, enhance quality, and implement a continuous improvement strategy across different segments (APMG International, n.d.). Traditionally, Lean has its' roots in the Toyota Production System (1950s) and Six Sigma in Motorola (1980s). The fusion into LSS indicates the increasing acknowledgment that sustainable effectiveness and efficiency enhancement conventionally demands both flow quickening and variation control (APMG International, n.d.).

The Lean Six Sigma project execution is based on the problem-solving cycle process: DMAIC (Figure 1) (Define – Measure – Analyze – Improve – Control). More exactly, initially, organizations typically start with Lean diagnostics and flow enhancements (for example: mapping and eliminating non value added steps), subsequently implementing the Six Sigma's statistical framework if process problems continue, aligning improvement efforts with customer defined value and quantifiable outcomes (APMG International, n.d.). For instance, in order to decrease the average emergency department, wait time, Harvard's multi faced case on Academic Medical Hospital operationalizes DMAIC. It demonstrates how through meticulous and consequent measurement, analysis, countermeasure piloting, and control strategy, programming can generate statistically significant performance improvements in rigorous clinical settings (HBP, 2008a; 2008b).
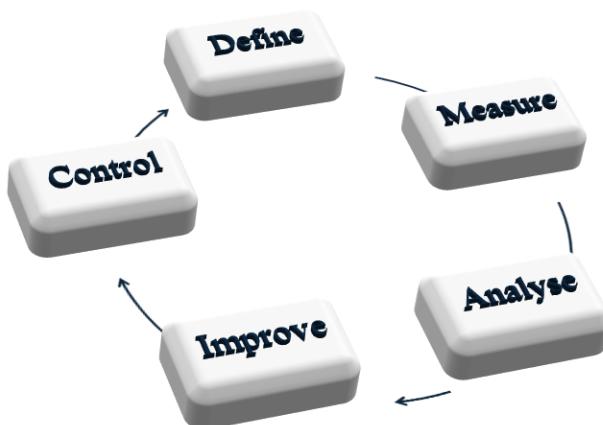
Figure 1 – *DMAIC process*
(Source: adapted from Shankar, 2009)

In terms of certification pathways and professionalization, APMG International asses the methodology implementer through belt-based certifications in concordance with LSSA skills (Figure 2), such as: White Belt (possess a general Lean Six Sigma understanding), Yellow Belt (team participation), Green Belt (project leadership and analytics), Black Belt (enterprise deployment, advanced methods) and Master Black Belt (expert in process improvement, strategic leadership, mentors other belts, drives organizational change). These certifications ensure the context of an organizational Lean culture (APMG International, 2025).

Moreover, it can be mentioned that the efficiency and effectiveness of Lean Six Sigma methodology can be evidenced across different sectors, such as: healthcare, professional services (legal), energy, aerospace and manufacturing and public sector. In the legal are, Harvard Law School's demonstrates this through SeyfarthLean case which relies on how Lean Six Sigma changed legal service delivery over a 10 years' timeframe. It optimized workflows using visual management, and standardized the current processes to increase client value (HLSCS, 2015).

Figure 2 - *Lean Six Sigma - Belt-Based Certification Model*

In the energy sector, an MIT doctoral study of DTE Energy extended on 12 years, revealed that Lean Six Sigma supported leadership, program design, and learning cycles performance enhancement (Quinn, 2011). Also, in the aerospace and manufacturing or services areas, MIT and Harvard studies demonstrated how Lean Six Sigma's cross-sector applicabi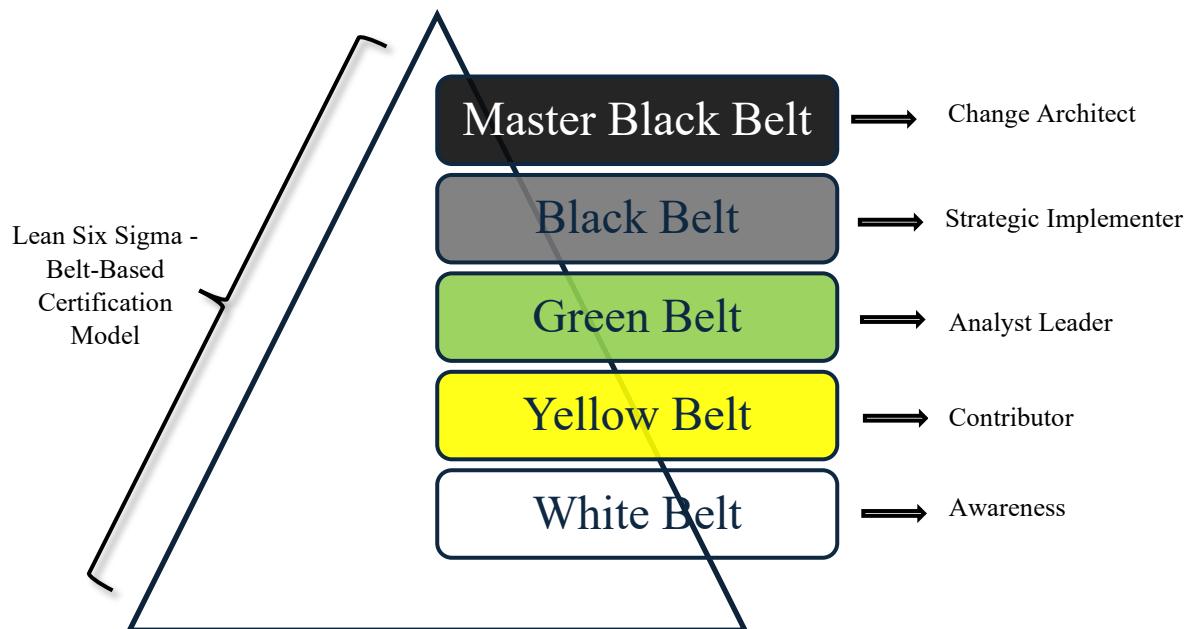lity can impact the cycle time by reducing it (in aerospace and clinics) and enhance customer experience in hospitality (Neuhaus and Guarraia, 2007). Moreover, the applicability of Lean Six Sigma methodology can be found in the public sector as well as per Harvard's Results Washington case study which relates how this approach and performance management enhanced government operations enabling scalability through transparency, assessment, and continuous improvement (HKSAC, 2017).

Based on this, the Lean Six Sigma framework is generally linked to cycle-time, defects, errors and cost optimizations when correlated with strong metrics, leadership, and belt-based assessments. Despite current progress has been made in the implementation of Lean Six Sigma methodologies, significant gaps persist in areas such as: organizational resilience, long-term sustainability, cultural integration, and strategic implementation. These unaddressed topics, suggest that future research efforts should be distributed into this (APMG International, 2024; Neuhaus and Guarraia, 2007; MIT-SSM, 2011).

Organizational Resilience: Turning Change into a Bridge to Performance. On one hand, as defined by the American Psychological Association, resilience represents *'the process of adapting well in the face of adversity, trauma, tragedy, threats and even significant sources of stress, such as family and relationship problems, serious health problems, or workplace and financial stresses'* (Waldman and Jackson, 2017). On the other hand, the organizational resilience can be generally defined as an entity's capacity to adapt to crises or critical perturbations while maintaining its key capabilities and sustainable performance (ISO, 2017). More concretely, *'organizational resilience is the ability of an organization to anticipate potential threats, cope effectively with adverse events, and adapt to changing conditions in ways that allow it to maintain essential functions and thrive in the long term'* (Hillmann and Guenther, 2021, p. 10).

The efficiency of organizational agility can be illustrated through a significant case study from MIT Sloan on Nissan Motor Company's resurgence after the natural disasters from 2011: Great Tōhoku earthquake and tsunami. Despite critical supply chain challenges, Nissan adopted a prompt response approach, flexible supply distribution system, and improved transparency across its operations. These initiatives sustained Nissan to reinstate its operations ahead than industry's counterparts and even expand market share during in times of industry instability through crisis (Simchi-Levi and Schmidt, 2013). This concrete example underlines that organizational resilience serves more than a risk-mitigation mechanism but a tactical competence that can increase competitive advantage. Also, Harvard academic research further reiterates this perspective, demonstrating that companies manifesting resilient behaviors (such as: knowledge sharing, emergent innovation, and agile decision-making based processes) had lower risks of insolvency during the COVID-19 pandemic crisis, validating that resilience can be a determinant factor of sustained financial stability (Suarez and Montes, 2020).

In order to categorize the organizational resilience, it can be mentioned the effort submitted after the Darfield earthquake (4 September 2010), through a survey which was conducted to evaluate organizational resilience among affected institutions, companies. The survey was focused on organizational leaders to obtain an early impact perspective, risk reduction measures, and post-crisis barriers, incorporating the Organizational Resilience Measurement Tool approach developed by the Resilient Organizations Research Programme (McManus, 2008; Lee et al., 2013). As described in Table 1, this effort resulted into a resilience illustration through 13 indicators (Ran Bhamra, 2015).

Table 1 - *Indicators of Organizational Resilience*

INDICATOR	DESCRIPTION
Leadership	Solid leadership during instability.
Information and Knowledge	Role replacement if key staff unavailable.
Recovery Priorities	Transparent and well-defined priorities for crisis and reinstatement.
Decision Making	Organizational fast decision-making process during crisis.
External Resources	Sustains relations with partner organizations.
Situation Monitoring	Observes industry activity for early warning signs.
Planning Strategies	Adaptive planning for unexpected events.
Proactive Posture	Focused on readiness for emergent and unexpected conditions.
Participation in Exercises	Emergency plans are evaluated and practiced.
Minimization of Silos	Facilitates cross-functional communication and collaboration.
Internal Resources	Resources managed for minor unexpected changes.
Staff Involvement	Employees included into to problem-solving process.
Innovation and Creativity	Team members leverage expertise innovatively.

(Source: adapted from Ran Bhamra, 2015).

From Capex to Opex: Integrating Lean Six Sigma into Organizational Resilience.

Organizational resilience is based on continuous operational improvement enabling a systematic Lean Six Sigma (LSS) approach, with its structured, data-powered framework, implementing resilience into current operations. The Table 2 demonstrates exactly how Lean Six Sigma methodology supports organizational resiliency (mapping key indicators with concrete process description and real-word examples) through the reduction of variability, elimination of waste, and cross-functional collaboration.

Table 2 - *Lean Six Sigma's Impact on Resilience*

INDICATOR	HOW LEAN SIX SIGMA STRENGTHENS THIS RESILIENCE CAPABILITY	EXAMPLE
Leadership	Create visible sponsorship and accountability through Champions/Belts assessment. Leadership uses DMAIC governance framework, dashboards, and tollgates to steer through instability.	Toyota implemented LSS within its lean culture, with leadership backing DMAIC-driven improvements that enhanced efficiency and reduced variability: sustaining performance in a competitive context (Invensis Learning, 2025).
Information and Knowledge	Enables standardized processes, control plans, and knowledge capture. Training (Yellow/Green/Black Belts) institutionalizes problem-solving when key employees are absent.	Motorola invested in company-wide Six Sigma training and standardized methods, decreasing defects >90% and ensuring process know-how was not employee-dependent (Invensis Learning, 2025).
Recovery Priorities	The Define phase of DMAIC framework establishes CTQs and customer's voice to set transparent priorities for stabilization and rehabilitation after a crisis.	Amazon used Six Sigma to identify critical processes (order fulfillment, inventory, shipping) and prioritize fixes that shrank processing times and errors by accelerating service recovery (Invensis Learning, 2025).
Decision Making	Transposes crisis decisions from intuition to data-powered options: measurement systems, baselines, hypothesis tests, and cost-of-poor-quality quantify tradeoffs quickly.	Toyota used data to assess waste and variation, leveraging faster, evidence-based decision-making processes during improvement cycles (Invensis Learning, 2025).
External Resources	Enables LSS approach also to suppliers or partners via supplier quality, shared CTQs (Critical to Quality), and cross-company SPC (Statistical Process Control): keeping ecosystem performance steady under stress.	Ford applied Six Sigma across manufacturing and supply chain areas, decreasing defects and costs: enhancing collaboration with upstream/downstream partners (Invensis Learning, 2025).
Situation Monitoring	SPC or control charts and leading indicators generate early warning of change before it becomes a crisis. Dashboards reveal potential risks.	Amazon tracked order accuracy and delivery metrics to detect bottlenecks early and act before customer impact scaled (Invensis Learning, 2025).
Planning Strategies	FMEA (Failure Mode and Effect Analysis), DOE (Design of Experiments), and control planning generate adaptive plans and pre-approved policies; DMADV (Define—Measure—Analyze—Design—Verify) builds resilient processes by design.	Ford implemented DMAIC and controls to assure quality gains (fewer warranty claims) and plan for sustained performance under variable demand (Invensis Learning, 2025).
Proactive Posture	Kaizen scheduling and continuous improvement phases keep teams 'crisis-ready': identifying and fixing weak signals before they escalate.	Toyota reinforced a Kaizen culture together with Six Sigma methodology, continually focusing on improvement opportunities that reduced latent risk (Invensis Learning, 2025).
Participation in Exercises	Tollgates, pilots, and controlled trials serve like readiness exercises for emergency playbooks: teams practice detection, response, and control.	Amazon enhanced and then controlled new process states (for example: optimized routes) through sustained monitoring: operational 'drills' that kept results resilient (Invensis Learning, 2025).
Minimization of Silos	Cross-functional DMAIC teams (for example: ops, supply chain, quality, IT) utilize general tools or language, allowing fast, lateral communication during crisis.	Ford trained the employees across different departments to work collaboratively on quality issues, eliminating defects and accelerating challenge resolution (Invensis Learning, 2025).

Internal Resources	Waste elimination (Lean) and variability reduction (Six Sigma) free capacity (time, materials, cash), providing buffers for minor shocks.	Motorola's defect reduction and efficiency results translated into major cost savings (~$16B over 10 years), generating resource slack for resilience (Invensis Learning, 2025).
Staff Involvement	Belt structure implementation, Gemba, and root-cause facilitation coach employees into problem solvers, improving engagement under pressure.	Ford empowered employees via Six Sigma training and cross-functional teams to proactively identify and solve problems on the spot (Invensis Learning, 2025).
Innovation and Creativity	Tools like DOE, TRIZ (often paired), and DMADV allow a strategy-based experimentation approach: innovating under constraints with measurable risk control.	Toyota's continuous improvement and Six Sigma yielded continuous innovations in manufacturing methods while maintaining quality steady (Invensis Learning, 2025).

(Source: adapted from Invensis Learning, 2025

The Table 2 illustrates the manner of how Lean Six Sigma methodology improves multiple dimensions of organizational resilience, including: leadership, decision-making process, and resource effectiveness through optimization. These dimensions are aligned with different tools and frameworks which enable Lean Six Sigma's efficiency, such as: DMAIC, Kaizen, SPC, and belt-based training. Also, it describes the cross-sector practical applications of this methodology, reiterating its role in improving adaptability and continuous improvement in a dynamic and volatile context.

Research methodology

To build a solid response to the main research question, mentioned in the introduction part of this research article, the authors conducted a bibliometric analysis using data retrieved from the Web of Science Core Collection. The search query, key words implied was represented by: Lean Six Sigma and Organizational resilience. As illustrated in Figure 3, the time span was set from 2004 to 2025 and a total of 52 publications were retained for analysis. To examine the intellectual and structural characteristics of the field, we employed VOS Viewer for science mapping. Performance indicators were extracted directly from the Web of Science database. The dataset accumulated 323 citations, resulting in an average of 6.21 citations per publication.
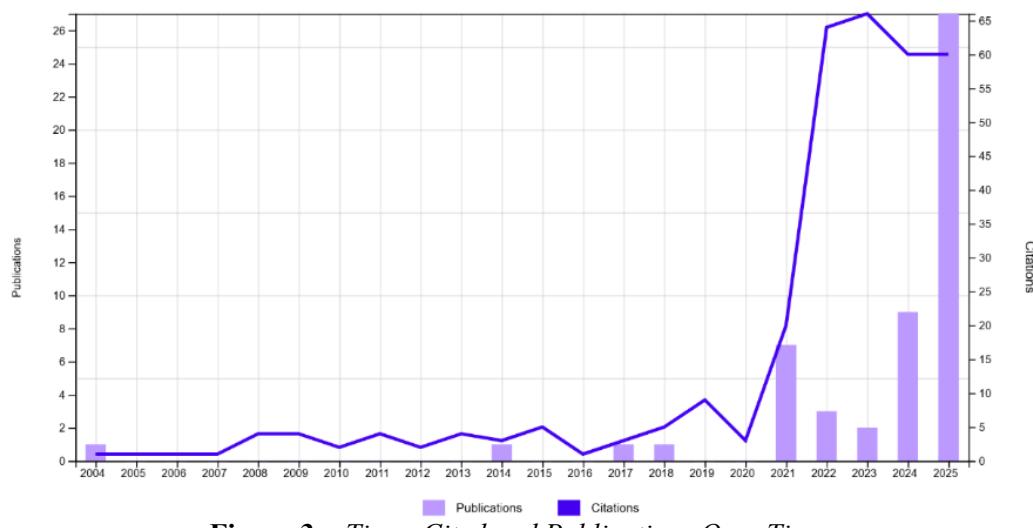

Figure 3 – *Times Cited and Publications Over Time*

Based on the Table 3 data, the annual distribution of publications and citations shows a clear evolution of the research field over time, characterized by a long period of low activity followed by a rapid and significant growth in recent years. A turning point occurred in 2021, when publication increased sharply. This upward trend accelerated further in 2022, when the field reached its highest citation count, followed by consistently high citation levels in 2023 and 2024, despite minor fluctuations in publication volume. Overall, the trajectory from incremental development to rapid expansion highlights the increasing relevance, visibility, and academic consolidation of the research domain.

Table 3- *Top citations*

Top citations			
Authors	**Article**	**Journal**	**Citations**
Hundal, G.S., Thiyagarajan, S., Alduraibi, M., Laux, C.M., Furterer, S.L., Cudney, E.A., Antony, J. (2021)	Lean Six Sigma as an organizational resilience mechanism in health care during the era of COVID-19	INTERNATIONAL JOURNAL OF LEAN SIX SIGMA, 12(4), 762-783, DOI10.1108/IJLSS-11-2020-0204	65
Praharsi, Y., Abu Jami'in, M., Suhardjito, G., Wee, H.M. (2021)	The application of Lean Six Sigma and supply chain resilience in maritime industry during the era of COVID-19	INTERNATIONAL JOURNAL OF LEAN SIX SIGMA, 12(4), 800-834, DOI10.1108/IJLSS-11-2020-0196	63
Shoaf, C., Genaidy, A., Karwowski, W., Huang, S.H. (2004)	Improving performance and quality of working life: A model for organizational health assessment in emerging enterprises	HUMAN FACTORS AND ERGONOMICS IN MANUFACTURING, 14(1), 81-95, DOI10.1002/hfm.10053	60

The top two articles have a strong citation performance from 2021 to 2025, which suggests that COVID-19 pandemic acted as a catalyst for accelerating academic attention toward building resilience frameworks. The third most cited work represents an earlier foundational contribution, focusing on organizational wellbeing and performance measurement systems. Although conceptually connected, its citation trajectory is more distributed over time, indicating a baseline theoretical relevance. Resilience is framed not only as a psychological or strategic attribute but as a measurable and improvable operational capability supported by structured process methodologies. The concentration of citations in recent studies suggests that resilience research is increasingly integrated into broader organizational performance and operational excellence frameworks, moving the literature from conceptual discussion to applied models.

The geographical distribution of publications shows a highly uneven research output across countries, with a clear concentration in specific regions. England emerges as the most productive contributor representing the core knowledge production center. Countries such as Brazil, Bangladesh, Colombia and Egypt demonstrate lower but notable participation, reflecting emerging research interest.

The distribution of document types within the dataset shows a clear predominance of journal articles. This indicates that the field is primarily driven by validated empirical and theoretical contributions, published through established academic publishing channels. In addition to journal articles, the dataset includes dissertation theses, preprint, review article, editorial material (Figure 4).

The subject area distribution shows a strong interdisciplinarity, as illustrated in Figure 5. The largest share of publications falls under Business and Economics, indicating that the conceptual core

of the field is grounded in organizational performance management. The second most represented category is Computer Science, reflecting the increasing integration of digital tools, data analytics, automation and information systems

into organizational resilience strategies. Smaller but notable contributions come from Biodiversity Conservation, Behavioral Sciences and Automation and Control Systems.
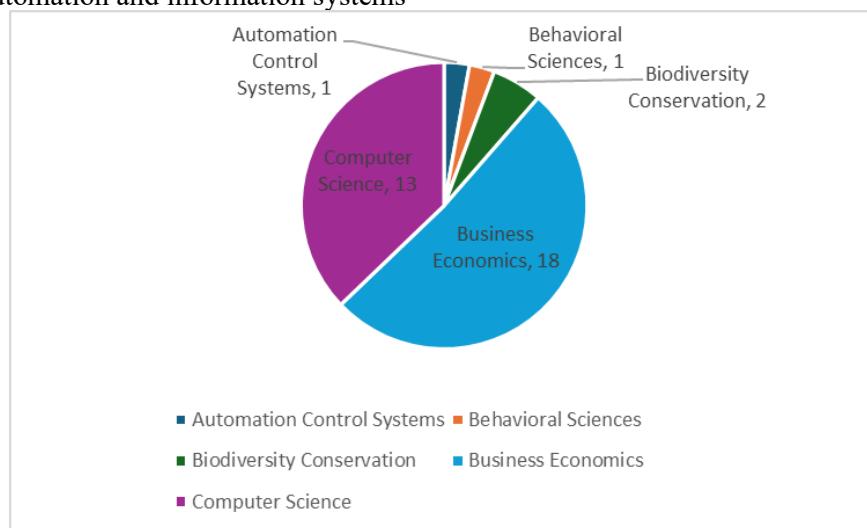
Figure 4 – *Research area*
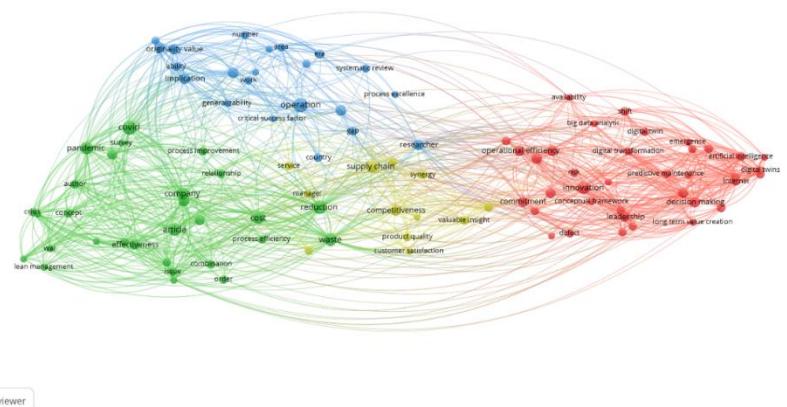
Figure 5 – *Network visualization.*

The keyword co-occurrence network reveals the conceptual structure of the research field, organized into four main thematic clusters. The green cluster centers on keywords such as lean management, process improvement, waste reduction, efficiency and continuous improvement. These terms highlight the operational roots of the field, where resilience is framed as a capability emerging from structured performance methodologies. Blue Cluster includes

keywords such as organizational value, performance, system level optimization, implementation, systematic review and operational excellence. Resilience is linked to holistic organizational outcomes, reflecting a more strategic performance perspective. This suggests a shift from purely operational tools to management frameworks that evaluate resilience in terms of value creation and sustained performance. Yellow Cluster has

keywords such as supply chain, risk management, competitiveness, productivity and customer. This reflects an increased understanding that resilience must extend beyond firm boundaries, especially in globally interconnected supply systems. Red Cluster includes terms such as innovation, digital transformation, artificial intelligence, decision making, digital twin and knowledge creation. This cluster represents the newest and most rapidly developing research direction, where resilience is enabled through advanced digital technologies and data-driven decision systems.

The overlay visualization (Figure 6) reveals a clear temporal progression in conceptual focus within the field. Earlier research concentrated primarily on foundational operational improvement concepts, including lean management, process improvement, waste reduction and organizational performance. These terms represent the initial phase, during which resilience was understood mainly as an outcome of process efficiency and stability within organizations. As the field progressed into the 2020–2022 period research attention shifted toward supply chain resilience, risk mitigation, and competitiveness. The most recent publications introduce a new research frontier centered on digital transformation.
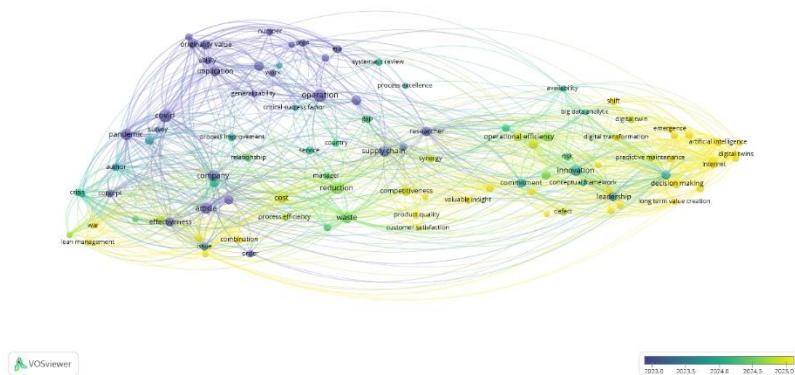
Figure 6 – *Overlay visualization*

Results and discussions

This research article analyzed the manner Lean Six Sigma (LSS) methodology influences organizational resilience, through a bibliometric study designed to correlate intellectual, academic trends and practical implications. The findings demonstrated that LSS approach is constantly progressing from an efficiency-oriented methodology into a resilience-enhancing framework, incorporating waste mitigation, variation control, and data-powered decision-making process to improve adaptive competencies. This perspective is also analyzed and supported by different research papers, such as Habibi Rad et al. (2021), who consistently, comprehensively reviewed the adaptation of lean and resilience conceptual structures, underlying their application in operational contexts (Habibi et al., 2021).

The citation trajectory illustrated weak dynamic until 2020, followed by a significant enhancement in 2021 and a high point of citations in 2022, demonstrating that the COVID-19 pandemic can be perceived as a catalyst, increasing the research activity on resilience within the operational performance context. This direction is also transposed in multiple studies, including Hundal et al. (2021), who analyzed LSS as a resilience tool in the healthcare sector during COVID-19, and Ar (2025), who correlated lean management's key role in improving organizational resilience in the pandemic context. Moreover, current studies in this area increasingly correlate LSS to digital evolution and Industry 4.0, denoting a transition toward real-time synchronized analytics and continuous

improvement and constant adaptation. In this context, Gomaa (2025) introduced the LSS 4.0 approach, including AI, IoT (Internet of Things), and digital twins into the DMAIC framework for a predictive and autonomous optimization. Also, Pongboonchai-Empla et al. (2024) created a structured analysis of how Industry 4.0 technologies improve each level of the DMAIC workflow.

In terms of mechanisms of resilience, Lean Six Sigma methodology improves resilience through different factors, such as: variation monitoring (decreasing vulnerabilities), workflow structuring (adaptive capacity), DMAIC approach (structured identification-response flows), cross communication and collaboration, and digital transformation for predictive, proactive control. These approaches reshape the term of resilience, elevating it from an abstract and theoretical concept into a measurable operational competence. This perspective is also supported by different studies on variation management and defect elimination in the Six Sigma framework, which focus on statistical mechanisms, tools and on the DMAIC workflow as a main pillar to resilience-construct (LSSTC, 2024).

In this context, through academic and industrial analysis, it was demonstrated that Lean Six Sigma methodology possess a significant role in risk mitigation and performance enhancement, while its geographically concentrated research base is situated in England with constant, continuous contributions from Brazil and Bangladesh. For example, Brazil has been a focus point for Lean Six Sigma implementation in industrial and construction areas, especially in the pandemic context (Simeão and Ferreira, 2022). Also, Bangladesh's imputes are mentioned in different bibliometric research papers, including Sakib's et al. (2025), which explored nearly 2000 Lean Six Sigma-concentrated studies and underlined regional research clusters.

As limitations and future research directions, it can be mentioned that this research article is limited by the scope of database and citation latency. On the other hand, future research directions can be focused on causal mechanisms, Lean Six Sigma's digital integration, cross-domain replication, and resilience metrics in the context of Agile frameworks.

Conclusions

Through this research activity, it was demonstrated that Lean Six Sigma significantly improves organizational resilience by integrating a structured problem-solving approach, work-flow, process stability, and adaptive cycles into daily operations. Moreover, the integration of digital technologies and change management approaches into this methodology, organizations can face uncertainty and global complexity into a strategic and efficient manner.

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"*Success depends on previous preparation, and without such preparation, there is sure to be failure.*"
Confucius
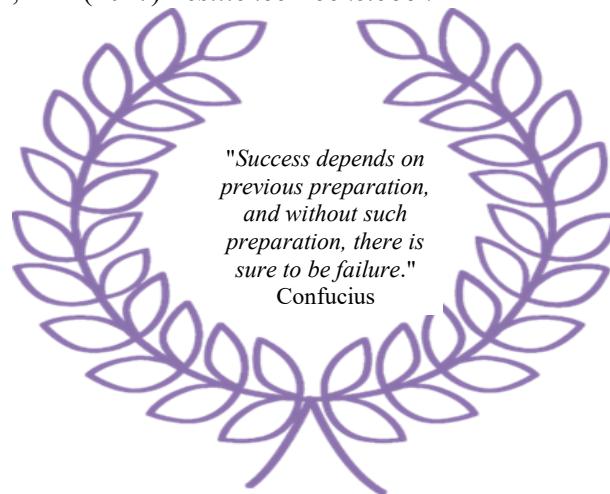
Large Shareholders and Financial Performance in Romania

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Abstract

Corporate Governance represents an important topic for the business community and numerous academic studies link the performance of companies to good governance. This study centers on 21 Romanian companies listed on the Bucharest Stock Exchange, members of the BET or BET-XT indices. This paper analyzed whether the presence of institutional investors in the shareholder structure has influenced the financial performance of the selected companies, as measured by Price to Book ratio. It was used the hypothesis that the presence of the Pillar 2 pension funds in the shareholder structure is associated with good Corporate Governance, which is further associated with improved financial performance. The study confirms the tested hypothesis and shows that pension funds ownership is positively correlated to corporate performance. The results are consistent with the corporate governance theories and the results of the previous studies conducted for developed markets.

Keywords: corporate governance, corporate performance, pillar 2, pension funds

Introduction

The analysis of numerous scandals in the corporate world, such as Worldcom, Enron, BP, Dieselgate and many others, has led to explanations related to poor Corporate Governance. Both authorities and society are directly interested in understanding and finding practical solutions to such challenges in order to avoid potential disasters.

The challenges of Corporate Governance have their origins in the emergence of companies. Considering that the way these challenges are managed has a direct and profound impact on society, both the academic and business communities are increasingly paying attention to

*"Enthusiasm is common.
Endurance is rare."*
Angela Duckworth
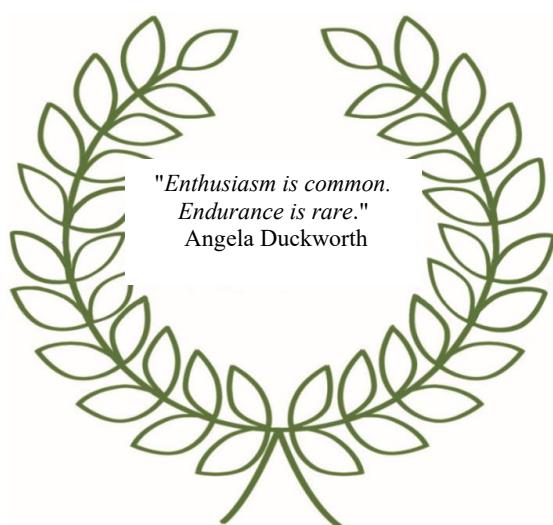
this topic. The necessity of good governance arises from at least two directions. The first one is the positive impact that represents the company's contribution to society, considering the output (goods or services). It is desirable for a company to be well governed so that its output is maximized or optimized. The second one is the impact on the multitude of relevant stakeholders (customers, employees, the environment, authorities, etc.). Corporate Governance is more looked upon when negative contexts arise, major scandals or fraud in the corporate world, after which society has suffered, whether it is about employees, investors or the environment.

The objective of this study is to continue the analysis and contribute to a better understanding of the impact that Corporate Governance has on the financial performance of companies. Additionally, the study is centered on Romania, considering two aspects: a better understanding of the Romanian corporate ecosystem and to verify to what extent the theories of Corporate Governance found in the academic literature are applicable.

Literature review

Corporate Governance has a shared history with the emergence of companies. Although it is a complex concept, every company must be governed. The simpler the context in which a company operates, the simpler its governance mechanisms will be, and vice versa. Furthermore, the term "complexity" is the key element when discussing Corporate Governance. Complexity makes it impossible to quantify or include all relevant variables in analytical models, as governance relates to how a company is managed in general. For this reason, the analytical approaches are of a "lens" type. In other words, the way a company is governed is viewed from multiple perspectives, each of these "lenses" generating different theories. A summary of the theories offered by academic literature and their importance to the subject is provided next.

Agency Theory. This theory centers on the potential divergence between the interests of the agent (who represents the interests of the principal) and the principal (whose interests are represented

by the agent). For this study the divergence between the interests of managers and those of shareholders is relevant, as well as the role that board of directors play in reducing associated agency costs. Jensen M.C. and Meckling W.H. (1976) conducted the first such analyses. Their theory shows that the actions of managers will generate a lower value for the firm compared to the case where they are also shareholders. According to the study, possible solutions for reducing agency costs include internal and external audits, formal control systems, budgetary constraints and/or incentives offered to managers. It is important to mention that the most significant control body responsible for implementing the above-mentioned solutions is the Board of Directors. Here, we establish the first important link to the existence of a shareholder structure that can choose competent directors and balance these divergent interests.

Fama, E. & Jensen, M. (1983) argue that shareholders are residual beneficiaries in the company, benefiting from dividends available after all other stakeholders (employees, management, suppliers, government) have been paid. The question raised is which scenario is more beneficial by comparison: (i) the separation of decision-making and bearing residual risks, or (ii) the retention of all functions by agents. This theory is important in analyzing the effectiveness of separating the roles of Chairman from that of the Chief Executive Officer, while underscoring once again the importance of the Board of Directors in addressing agency problems.

Stewardship theory proposes an approach opposing to agency theory. According to this theory, directors do not represent a "homo-economicus" (Schoorman and Donaldson, 1997) who acts with the objective of maximizing their own interests. Instead, they can act responsibly, with diligence, independence and integrity (Tricker, 2019). The main study in this regard is the one conducted by Donaldson and Davies (1994), which analyzes the manifestation of agency problems by examining the duality of the Chairman-CEO role. According to Tricker (2019), the role of Chairman is extremely important, considering the responsibilities of the Board to defend the interests of shareholders and the power

held by the Chairman as the leader of the Board. Stewardship theory views Corporate Governance through the lens of the directors' willingness to successfully fulfill their responsibilities and supports the hypothesis of the importance of their selection.

Corporate Governance Index. In academic literature, we encounter several factors that are considered parameters of Corporate Governance. The starting point is the study conducted by Bhagat and Bolton (2008, 2019). The authors constructed the first relevant corporate governance index for performance analysis. The index included a significant number of parameters related to governance. Subsequent studies have confirmed, detailed, refined or enriched this analysis. These have primarily focused on external and visible components, particularly related to potential takeovers or management changes within companies. The rationale is that where the risk of management structures losing control of the company is low, personal interests will be prioritized over those of the company, leading to inferior performance. Although studies have confirmed this assumption, the specifics of the local market are different. Changes in ownership/control or hostile takeovers do not represent a significant risk for management, and most of the parameters used in these models (poison pills, golden parachutes, different classes of shares) are not applicable. In other words, those parameters that could be used to optimize/minimize agency costs in developed markets (like the US) are not applicable in Romania. Starting with these studies, were selected the most important parameters used as indicators of good corporate governance, grouped according to relevant governance theories.

Parameters linked to Agency Problems: The central idea is that management of a company will change, or the company will be taken over (sale, hostile takeover, mergers, etc.) when agency problems negatively affect performance. The parameters used in the analysis are focused on laws and regulations, internal regulations and articles of incorporation, which can influence this probability of sanctioning management. The main parameters

encountered are: *the existence of institutional investors,* the management system (unitary versus dualistic), protective mechanisms for managers and executives, and the voting system of shareholders in the General Assembly.

Parameters linked to Agency and Stewardship Problems: The analyses track those observable elements from the outside that can influence the company's performance: the size (number of directors) and structure (number of non-executive or independent directors, CEO/Chairman duality, gender) of the Board are the most present parameters in this research. These parameters are out of the scope of this study.

Parameters linked to Stewardship Problems: Although there are numerous studies mentioning the importance of functionality and performance of Boards, there are few references to how these are measured and correlated with company performance. There are challenges in systematically measuring the level of governance. Topics such as assessing the performance of directors as a team, the personality of the CEO/Chairman, stakeholder engagement, or the frequency and agenda of Board meetings are addressed. These parameters are out of the scope of this study.

Shareholders structure as Corporate Governance parameter. The summary of the studies and concepts centered on the importance of shareholder structure and its influence on corporate governance is presented below.

Shareholder Structure. The importance of shareholder structure arises from the separation of ownership and control (Fama and Jensen, 1983). Shareholders have specific rights, such as appointing the Board and auditors, but they can also have different interests among themselves, such as divergent dividend policies or different time horizons. Once appointed, the Board is responsible for the direction and control of the company, while having a fiduciary duty towards all shareholders. I mention here the expected long-term orientation of the pension funds investment policies, supported by their long-term investment horizon and liquidity.

Shareholder Activism. This represents a continuous feedback mechanism on the company's

performance, a voice that seeks to influence the company without changing its control. It is also seen as an important solution for resolving agency conflicts (Gillan and Starks, 1998). Empirical evidence, sustained by regulations applicable to Romanian pension and investment funds, support their activism and engagement with the companies' management.

Presence of Institutional Investors. It is expected that institutional investors hold more power than individual investors. This is explained by the following factors: their stakes in the company can be significant, similar entities can act in concert (Tricker, 2019), and investment managers are informed and motivated to protect their investments. Shleifer and Vishny (1986) argue that large shareholders have the motivation and means necessary to monitor and impose restrictions on management. The study considers two main categories of significant shareholders: families and institutional investors (pension funds, banks, insurance companies). Although some studies show that the involvement of institutional investors is not as significant as expected in many cases (Mallin, 1996), recent European directives such as the Sustainable Finance Disclosure Regulations or Long-Term Shareholders Engagement could have a significant influence in increasing the activism of financial institutions. Specific regulations for the private pension industry in Romania also support the scenario of increasing activism, implying that pension funds and mutual fund managers should be actively involved in exercising shareholders' rights.

Research methodology

Performance evaluation. The literature reveals a multitude of indicators that can be used to measure financial performance (Bhagat and Bolton, 2008). Selection of relevant ones presents several challenges, and the following considerations were considered:

• Corporate Governance affects business at various levels through channels such as: building a brand and stakeholder trust, developing an organizational culture conducive to growth, and implementing effective long-term risk policies. It is expected that such goals will be achieved over the long term.

• Governance-performance analysis should include lagging the data series, considering that an improvement in governance will produce effects on performance over time, and vice versa.

• Empirically, is stated that the "market is always right" and the evaluation/market price is always relevant. Price or market capitalization will be included in the performance measurement.

• Some of the analyzed works use the Price to Book ratio as a relevant performance indicator. This represents a "normalization" of market capitalization by relating it to book value. The challenge of using market prices arises from the fact that the market can sometimes "be wrong", even in the medium term. An example of this consists of industries that have a high P/E ratio (growth companies). The Price to Book ratio will thus be higher than in other sectors, potentially altering the model in terms of overestimating performance.

Considering the above and also the availability of data, this study uses the Price to Book ratio as a measure of financial performance.

Conceptual model and hypothesis

Hypothesis 1 of this study is that (i) Corporate Governance (ii) influences (iii) the financial performance of listed companies. The components of the hypothesis are analyzed below.

Corporate Governance. Literature reviews show that Corporate Governance is a complex concept that can be analyzed through several lenses offered by relevant governance theories. This study demonstrates that the literature recognizes the presence of institutional investors as a parameter of governance, considering their role in selecting the Board and its importance in ensuring good governance.

Presence of Institutional Investors. A simplification of the model comes from using the share holdings of Pillar 2 Pension Funds in Romania as a proxy for the presence of significant shareholders in the ownership structure of listed companies. The following arguments were considered:

- The size of mandatory pension funds is significant, as their equity holdings (including ones

on Bucharest Stock Exchange-BSE) represent 10% of BSE market capitalization (Table 1). The ownership in the individual companies analyzed sometimes greatly exceeds this threshold.

-    The empirically observed behavior (involvement in the selection of directors) and legal requirements support the hypothesis of activism.

-    The existence of data – pension funds periodically publish the detailed structure of their portfolios, making data collection possible. The author is not aware of the existence of similar public information for other similar investors.

Influence. The study analyzes if there is any causality or correlation between Corporate Governance and financial performance. Time lags and the scenario that both variables influence each other are considered.

Table 1 - *BSE Market Capitalization and Pillar 2 Funds (P2)*

Year	Market Capitalization (RON bln)	P2 Net Assets (RON bln)	Ratio 1	P2 Equity Investments (RON bln)	Ratio 2
	(1)	(2)	(2)/(1)	(3)	(3)/(1)
2024	350	151	43%	34.89	10%
2023	294	127	43%	29.55	10%
2022	197	96	49%	20.83	11%
2021	229	89	39%	22.86	10%
2020	154	75	49%	16.22	11%
2019	181	62	34%	13.64	8%
2018	143	48	33%	8.30	6%
2017	164	40	24%	7.84	5%
2016	147	31	21%	5.89	4%
2015	146	25	17%	4.74	3%
2014	130	19	15%	3.66	3%
2013	134	14	10%	2.14	2%
2012	98	10	10%	1.08	1%
2011	71	6	9%	0.69	1%
2010	102	4	4%	0.53	1%
2009	80	2	3%	0.22	0%
2008	46	1	2%	0.01	0%

(Source: BP, 2025)

Financial Performance. Price to Book ratio is used as a proxy for financial performance.

Selected companies. The companies were selected considering their size and history, mainly from among the members of BET and BET-XT indices. Further, the companies were according to their listing date, aiming to maximize the number of data points. Access to data was also considered. This resulted in the list of companies in Table 2 generating a number of 336 data points (21 companies x 16 semesters).

Table 2 – *List of selected companies*

Name of the company	Market	Code
Antibiotice SA	RO	ATB
BRD - Groupe Societe Generale SA	RO	BRD
Bursa de Valori Bucuresti SA	RO	BVB
Conpet SA	RO	COTE
Digi Communications NV	RO	DIGI
Electrica SA	RO	EL
Evergent Investments SA	RO	EVER
Fondul Proprietatea SA	RO	FP
Impact Developer & Contractor SA	RO	IMP
Infinity Capital Investments SA	RO	INFINITY
Lion Capital SA	RO	LION
Longshield Investment Group SA	RO	LONG
Med Life SA	RO	M
Romgaz SA	RO	SNG
Nuclearelectrica SA	RO	SNN
OMV Petrom SA	RO	SNP
Transelectrica SA	RO	TEL
Transgaz SA	RO	TGN
Banca Transilvania SA	RO	TLV
Transilvania Investments Alliance SA	RO	TRANSI
Teraplast SA	RO	TRP

(Source: BP, 2025),

Pillar 2 Pension Funds (P2) holdings. To analyze the impact of the institutional investors, share holdings, were used the holdings of Pillar 2 pension funds as a proxy. Historically, the data was published on a semiannual basis. Since June 2022 the data is published monthly. Semi-annual data is available for the period 2017 to 2024. The number of shares held is aggregated for all P2 funds at the time of reporting and is reported against the total number of shares issued by the selected companies, generating the cumulated share holdings (*HOLDINGSP2*).

Price to Book ratio. For each selected company and for each semester, the Price to Book ratio was used (*PTBOOK*). Data is available partially in Bloomberg (as Price to Book ratio or it can be calculated as Price divided by Book Value per share) and in BSE reports. A small number of the values were calculated based on the public fillings of companies.

Methodology. Date series were uploaded and analyzed in E-views. The models used and their results are presented below.

Causality. To determine if there is any causality between the data series, was used the Pairwise Granger Causality Tests. The results are shown in Diagram 1. The test shows that the first (null) hypothesis "DETINERIP2 does not Granger

Cause PTBOOK" is rejected. *This means that the P2 holdings influence the Price to Book of the selected companies.* The test did not show

causality in the other sense, so that cannot be said that the Price to Book influences the holdings of the P2 pension funds.

Diagram 1. Pairwise Granger Causality Tests

Sample: 2017S1 2024S2
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
DETINERIP2 does not Granger Cause PTBOOK	273	8.46999	0.0003
PTBOOK does not Granger Cause DETINERIP2		0.9172	0.4009

Regression. The next step was to analyze the dependence of the Price to Book (as dependent variable) on the share holdings (as independent variable). The method used to determine the linear regression is Least Squares and the results are presented in Diagram 2. Both datasets were verified and found to be stationary.

The diagram shows that both the slope and interception are statistically significant. The slope has a positive value, *which means that there is a positive correlation*. Based on the slope value, it can be said that an increase of 1% in the equity holdings would generate an increase of 8% in the

Price to Book ratio. In the same time, R-squared shows that 13% of the Price to Book dynamic is explained by the P2 shares holdings.

Vector autoregression (VAR). The next step was to analyze if the two variables influence each other and themselves over time, by applying the VAR model. The results of the VAR Lag Order Selection Criteria are presented in Diagram 3. The lags intervals were selected based on two of the criteria, which indicated the lags of one and four semesters. The VAR autoregression model was run and it provided the results presented in Diagram 4.

Diagram 2. Method: Panel Least Squares

Dependent Variable: PTBOOK
Sample: 2017S1 2024S2
Periods included: 16
Cross-sections included: 20
Total panel (unbalanced) observations: 313

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DETINERIP2	8.505962	1.235696	6.88354	0
C	0.42459	0.191749	2.214302	0.0275

R-squared	0.132214	Mean dependent var	1.513181
Adjusted R-squared	0.129423	S.D. dependent var	2.05607
S.E. of regression	1.91841	Akaike info criterion	4.147239
Sum squared resid	1144.572	Schwarz criterion	4.171177
Log likelihood	-647.043	Hannan-Quinn criter.	4.156805
F-statistic	47.38312	Durbin-Watson stat	1.386485
Prob(F-statistic)	0		

The variable P2 Pension Funds holdings is explained in a proportion of 96% by the VAR estimates, as shown by the R-squared value. There are two lags that present statistical significance: DETINERIP2(-1) and DETINERIP2(-4). The t-statistic results were compared to the critical value of 2.201, corresponding to a two-tailed test, significance level of 5% and 11 degrees of freedom. This result is consistent with the causality analysis results. This means that *the holdings of P2 Pension Funds in the selected companies can mostly be explained by the level of the holdings they had one or four semesters before*. Can also be observed that the first lag has a coefficient of 1.12 (positive), compared to -0.297 (negative) for the coefficient of the fourth lag. The first lag has a positive influence, which is almost four times higher than the negative influence of the fourth lag.

The variable Price to Book is explained in a proportion of 25% by the VAR estimates, as shown by the R-squared value. There are three lags that present statistical significance: DETINERIP2 (-1), DETINERIP2(-2), PTBOOK (-1). The t-statistic results were compared to the critical value of 2.201, corresponding to a two-tailed test, significance level of 5% and 11 degrees of freedom. This means that the Price to Book value for the selected companies is partially explained by the holdings of the P2 pensions funds in the previous two semesters and by the previous semester price to book value.

Digram 3. VAR Lag Order Selection Criteria

Endogenous variables: DETINERIP2 PTBOOK
Exogenous variables: C
Sample: 2017S1 2024S2
Included observations: 153

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-137.7402	NA	0.021299	1.826669	1.866282	1.842761
1	174.9982	613.2125	0.000376	-2.209127	-2.090286*	-2.160852
2	180.1527	9.972021	0.000371	-2.224218	-2.02615	-2.143759
3	189.6407	18.1078	0.000345	-2.295956	-2.018661	-2.183314
4	196.3669	12.66113	0.000333	-2.331593	-1.975071	-2.186768*
5	197.0883	1.339021	0.000348	-2.288735	-1.852986	-2.111727
6	198.797	3.127038	0.000358	-2.258784	-1.743807	-2.049592
7	206.786	14.41158	0.00034	-2.310928	-1.716724	-2.069553
8	212.8937	10.85813*	0.000331*	-2.338480*	-1.665049	-2.064921

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

The influence of the previous semester holdings is positive, while the influence of the holdings two semesters before is negative. This could mean that the impact of acquisition on price is positive in the first semester, while disappearing in the following semester. Under this assumption, the Price to Book would reflect the economic value in the long run. The influence of the previous price on the book's value is positive. All interpretations are made within the current model, that only considers P2 holdings and Price to Book ratio as variables.

Results and interpretation

The Granger causality test confirms that the share holdings of the P2 Pension Funds influence *the financial performance* of the selected companies, as measured by the Price to Book indicator. The regression adds that *the influence is positive,* so that the higher the level of the holdings, the higher the Price to Book ratio will be.

Diagram 4. Vector Autoregression Estimates

Sample (adjusted): 2019S1 2024S2
Included observations: 233 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	DETINERIP2			PTBOOK		
	Coefficient	Standard error	t-statistic	Coefficient	Standard error	t-statistic
DETINERIP2(-1)	1.119946	-0.06809	[16.4490]	21.34486	-6.88946	[3.09819]
DETINERIP2(-2)	0.127533	-0.10143	[1.25738]	-24.3788	-10.2632	[-2.37536]
DETINERIP2(-3)	0.004944	-0.11225	[0.04404]	3.683474	-11.3586	[0.32429]
DETINERIP2(-4)	-0.297033	-0.08939	[-3.32282]	1.966114	-9.04535	[0.21736]
PTBOOK(-1)	0.000113	-0.00067	[0.16918]	0.197918	-0.0678	[2.91902]
PTBOOK(-2)	-0.00052	-0.00068	[-0.75990]	0.112026	-0.06929	[1.61671]
PTBOOK(-3)	0.000261	-0.00067	[0.38830]	0.134875	-0.06806	[1.98168]
PTBOOK(-4)	0.00137	-0.00065	[2.10937]	0.098582	-0.0657	[1.50053]
C	0.00399	-0.00244	[1.63428]	0.284311	-0.24706	[1.15076]

R-squared	0.959423		0.249451
Adj. R-squared	0.957974		0.222645
Sum sq. resids	0.086334		883.9689
S.E. equation	0.019632		1.986527
F-statistic	662.0498		9.306007
Log likelihood	589.8038		-485.9518
Akaike AIC	-4.98544		4.248514
Schwarz SC	-4.852138		4.381816
Mean dependent	0.139059		1.494753
S.D. dependent	0.095765		2.253123

Determinant resid covariance (dof adj.)	0.001472
Determinant resid covariance	0.00136
Log likelihood	107.6911
Akaike information criterion	-0.769881
Schwarz criterion	-0.503277

One possible interpretation is that P2 Pension Funds become shareholders or increase their holdings through share acquisition, thus driving the price higher. The author's opinion is that, to some extent, this interpretation is right and a part of the price dynamic is explained by the acquisition itself. Considering the long-term investment horizon of the pension funds, the author's opinion is that this causality works mainly by preventing the price to significantly deviate below its theoretical value, as the pension funds could start buying shares. What rejects this interpretation only is that, on average, in the selected companies where the pension funds acquired shares, the average holding is around 13% (of total shares of the companies). Assuming the price movement would be solely explained by demand (pension funds acquisitions) and not value, it is unlikely that the market (the other 87% of shareholders) would not benefit of this overvaluation. In addition, the interpretation of the VAR results could be that such influence on price is canceled within the next semester. *The author's interpretation is that this study confirms the positive effect of having large shareholders on financial performance.* Large shareholders have the interest and the power to appoint effective directors, which contribute to a better Corporate Governance. A significant part of the value of o company is given by intangible assets – like processes, brand or corporate culture, which are components of good Corporate Governance. A higher value of intangible assets implies a higher Price to Book ratio, which is consistent with this interpretation, *that Corporate Governance has a positive influence on corporate performance.*

The VAR method results are consistent with the causality and regression interpretation. Is found that the current holdings are positively influenced by the previous semester holdings, negatively influenced by the holdings 2 years before, and not influenced by the previous Price to Book ratio results. As an economic interpretation, this could be the result of the long-term orientation of the pension funds investment policies. Once the portfolio managers trust in the value of the business, they will start acquiring shares in the selected companies, which could continue for a period of up to two years. Regarding the

performance of the selected companies, the VAR model shows that this is partially explained by the presence of the pension funds as shareholders and the previous semester Price to Book ratio. While I see no economic reasoning for the influence of the previous semester Price to Book ratio, the influence of the large investor's holdings could be further interpreted. This could mean that, given the long-term orientation, the P2 pension funds positively contribute to corporate performance, including by supporting a good Corporate Governance. This interpretation is consistent and widens the one discussed for regression results.

Conclusions

Corporate Governance is an important topic for our society, as it is believed that it positively influences corporate performance. Corporate performance has a positive impact on the output (benefits to society) and reduces negative events (impact on stakeholders). The purpose of the study is to analyze if the general Corporate Governance theories are applicable to the Romanian selected companies, while better understanding the Romanian corporate world. Another important perspective is related to the impact on the economy of the local Pillar 2 pension fund system, as this is subject to various debates and their dimension has reached significant size.

The P2 pension funds holdings are a particular case of large shareholders. There are other private (families) or institutional investors, foreign or local (mutual funds, Pillar 3 pension funds, other investment companies), that were not included in the analysis, because comparable data is not available for the author. Still, the Pillar 2 pension funds are one of the biggest institutional investors, the average holding in the selected companies being 13%. In terms of performance, it was measured by Price to Book ratio, as being considered the best available proxy for long-term financial performance. Selected companies are significant sized companies that are members of BET or BET-XT indices, most of the largest listed companies on the Bucharest Stock Exchange.

The limitation of this study is that the model is restricted to only two variables, the P2 holdings

and Price to Book ratio, which limits the broader generalization.

What was found through this research was that the Corporate Governance theories are also applicable to the selected companies. In their case, given the long-term orientation, the P2 pension funds positively contribute to corporate performance, including by supporting good Corporate Governance. The link between pensions funds ownership and good corporate governance is given by the influence of appointing a part of the Board of Directors (the body with the most influence on corporate governance) and actively engaging in communication with the companies. Fund managers have the knowledge and motivation to engage in this communication or to sanction directors (by replacing them) in case things go wrong.

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"*The human capacity for burden is like bamboo- far more flexible than you'd ever believe at first glance.*"
Jodi Picoult.

Data Systems for Water Quality Monitoring

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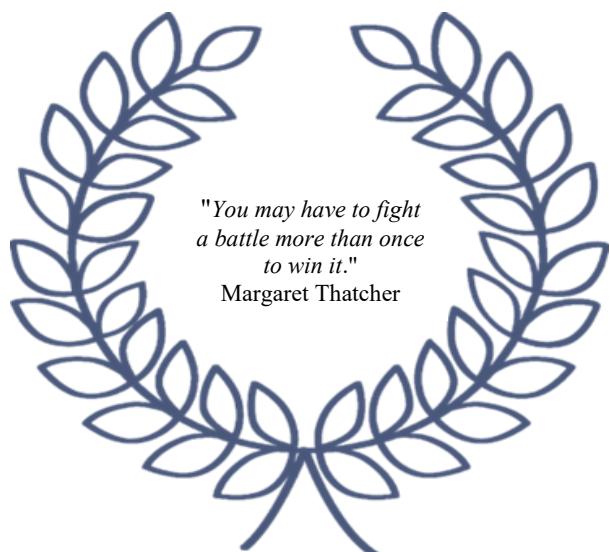313 Splaiul Independentei, Bucharest, Romania

Abstract

This paper investigates the role of entrepreneurship and innovation within research and development (R&D) in electronic engineering, specifically applied to water quality monitoring and management. It explores how entrepreneurial initiatives drive technological advancements in sensor design, data analytics, and Internet of Things (IoT) applications for water quality, highlighting challenges and success factors in translating innovations from lab to market. The study synthesizes literature and case examples to reveal the critical role of interdisciplinary collaboration, funding mechanisms, and regulatory navigation in fostering impactful water quality solutions.

Keywords: water quality, entrepreneurship, IoT, data analysis

Introduction

Water quality is a significant global concern that impacts environmental and public health. The field of electronic engineering significantly contributes to addressing these issues through advancements in sensing technologies and data-driven monitoring systems. In addition to technological innovations, entrepreneurship plays a crucial role by facilitating the transformation of research developments into practical products and services that confront real-world water-related challenges. This paper discusses the synergy between entrepreneurial initiatives and innovation strategies in electronic engineering research and development (R&D), emphasizing their effectiveness in promoting solutions for monitoring, detecting, and managing water quality. The urgent global need for

"*You may have to fight a battle more than once to win it.*"
Margaret Thatcher

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sustainable environmental solutions has accelerated the development of innovative electronic systems focused on real-time monitoring water quality. Given the substantial risks posed by water pollution to both public health and ecological systems, there is a distinct demand for advanced, cost-efficient, and real-time water monitoring technologies.

The paper emphasizes the importance of affordable and effective water monitoring technologies, detection, and management to mitigate the health risks associated with water pollution. The research objectives include analyzing current trends in electronic engineering related to water quality, assessing the impact of entrepreneurial activities on technology development, and proposing frameworks to enhance innovation-led entrepreneurship within this domain.

The structure of the paper is structured into sections that include a review of literature on innovation and entrepreneurship as related to electronic engineering and water quality technologies; the research methodology; analysis and discussion of findings; and concludes with insights and future directions.

Literature review

 The convergence of electronic engineering and water quality research has led to the development of innovative sensor technologies, such as electrochemical sensors, optical sensors, and wireless sensor networks (WSNs).

Entrepreneurship in this field involves identifying market needs—such as real-time monitoring for contaminants - and developing scalable, cost-effective solutions (Aquasight Inc., 2023). Innovation in electronic engineering research and development (R&D) related to water quality is often driven by advances in microelectronics, Internet of Things (IoT), and machine learning algorithms for data analysis (Cao, 2019). Startups and research labs have pioneered smart water quality monitoring systems that integrate low-power sensors with cloud computing for remote access and predictive analytics (Chen and Patel, 2019). Challenges noted in the literature include high development costs, stringent regulatory compliance for environmental devices, and the need for robust calibration and validation protocols. Entrepreneurial engineers must navigate these barriers while managing intellectual property and establishing partnerships with environmental agencies and industries (Gonzalez, 2021). Innovation and entrepreneurship drive technological advancements in electronic engineering, particularly in environmental monitoring. R&D are vital for creating innovative solutions, such as new sensor technologies, IoT integration, and enhanced data analytics. Many startups arise from academic and industrial R&D collaborations, benefiting from effective intellectual property management and funding. Innovations in water quality research involve sensor miniaturization, energy-efficient data transmission, and smart data processing, leading to the commercialization of IoT-based water monitoring platforms that leverage cloud technologies and focus on user-centered designs.

Innovation in Electronic Engineerin. Recent literature highlights advancements in electronic engineering, particularly miniaturized, energy-efficient smart sensing devices for water quality monitoring (Figure 1). Key innovations include improved sensor accuracy, multi-parameter sensing platforms, and the integration of IoT capabilities for real-time data collection (Table 1). Developments such as a compact IoT node measure parameters like CO_2, VOCs, light, UV radiation, temperature, and humidity (Jayalakshmi, 2022).

Multi-sensor platforms are designed to integrate optical, chemical, biological, and physical sensors, enabling comprehensive real-time monitoring essential for water management (Kumar et al., 2022). Furthermore, the integration of IoT technologies enhance aquaculture through automated, wireless water quality monitoring in fish farms, reducing human dependency and data inaccuracies (Miller, 2022).
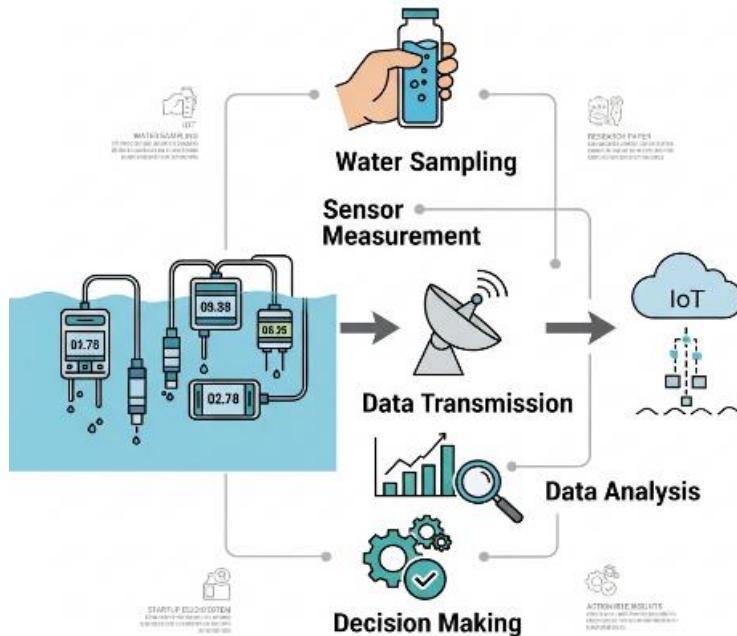
Figure 1- *Water quality monitoring*

Table 1 - *Examples of Startups in Water Quality Monitoring*

Startup Name	Technology Focus	Location	Funding Stage	Notable Innovation
AquaSense	IoT-enabled sensor networks	USA	Series A	Real-time remote water monitoring
HydroTech	Advanced biosensors	Europe	Seed	Portable multi-parameter sensors
ClearWater AI	Data analytics platform	Asia	Series B	AI-based water quality prediction

Entrepreneurship and Technology Commercialization. Entrepreneurship literature highlights startups and spin-offs as key players in commercializing innovations from academic and industrial R&D. Successful technology commercialization relies on factors such as intellectual property (IP) protection, market understanding, business model innovation, and access to funding. IP protection, through patents and copyrights, secures competitive advantages, while market understanding aids in developing effective solutions. Business model innovation supports scalable monetization, essential for sustainable growth, and access to venture capital and grants is critical for scaling operations. Multidisciplinary teams, merging technical expertise with business knowledge, are vital in overcoming commercialization challenges. Organizations like the European Innovation Council (EIC) and the European Institute of Innovation & Technology (EIT) play significant roles by connecting entrepreneurs and investors to transform scientific advancements into commercial products. The EIC provides funding for deep-tech startups, and the EIT fosters collaboration among students, researchers, and businesses to enhance innovation. University technology transfer is also crucial for linking academic research with market needs, emphasizing effective IP management and licensing agreements.

Water Quality Monitoring Technologies. Recent advancements in water quality monitoring leverage electronic engineering innovations, integrating electrochemical sensors and wireless communication for continuous, remote assessments

(Figure 2). These technologies allow for real-time data acquisition, enhancing water quality evaluations (Table 2). Notably, approximately 44% of water quality studies did not specify the microcontrollers used, with Arduino being the most popular choice at 24%. Other microcontrollers include Raspberry Pi, ESP32, and Teensy 2.0, influencing the accessibility of monitoring systems. The combination of wireless technologies like LoRaWAN with cloud computing facilitates IoT-based monitoring for parameters such as pH, temperature, and turbidity, though challenges such as system complexity, calibration drift, and power management remain. Data security is also a critical consideration due to the sensitive nature of transmitted information. Research is ongoing to optimize these integrated systems for improved reliability and efficiency.

Table 2 - *Key water Quality Parameters and Sensor Types*

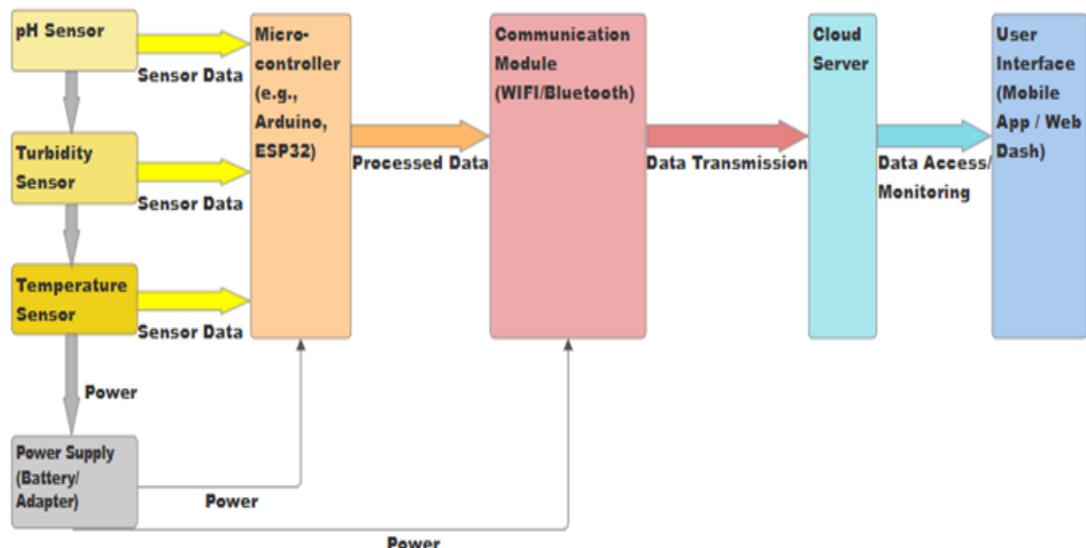| Parameter	Sensor type	Measurement range	Accuracy	Application areas
pH	Electrochemical	0-14	±0.01 pH	Drinking water, wastewater
Turbidity	Optical	0-1000 NTU	±1 NTU	Environmental monitoring
Dissoved Oxygen	Electrochemical/Optical	0-20 mg/L	±0.1 mg/L	Aquaculture, water treatment
Nitrate	Ion-selective	0-50 mg/L	±0.5 mg/L	Agricultural runoff monitoring

Figure 2 - *Water quality monitoring system block diagram*

Entrepreneurial Ecosystem and Support Structures. The success of innovation-driven entrepreneurship in electronic engineering is heavily influenced by its entrepreneurial ecosystem, which includes vital support structures essential for the commercialization of academic and industrial R&D innovations. Key components of this ecosystem comprise:

- Incubators and Accelerators: Institutions like the Martin Trust Center for MIT Entrepreneurship offer mentorship, business development support, and networking opportunities to startups, promoting innovation and commercialization.
- Government Grants and Policy Frameworks: Initiatives such as tax incentives and grants, exemplified by the EIC, enhance startup viability by

offering funding and support for high-risk technologies in the EU.

▪ Venture Capital: Critical for scaling operations, organizations like 1871 in Chicago facilitate access to investors and resources for early-stage companies.

▪ Universities: They play a significant role in patent management and research commercialization, acting as intermediaries between scientists and private entities to assist in the commercialization process.

The Triple Helix Model of Innovation illustrates the collaborative dynamics among academia, industry, and government, presenting intermediary institutions, such as technology transfer offices and science parks, as pivotal in bridging the gap between research and market applications (Schumpeter, 1934).

Effective policy interventions, exemplified by the America COMPETES Act, are essential for fostering entrepreneurship and technological advancement. The Office of Innovation and Entrepreneurship was established to enhance innovation and the commercialization of new technologies, contributing to productivity and economic growth.

Overall, the components of the entrepreneurial ecosystem - including incubators, accelerators, government policies, venture capital, and universities - are critical to the success of innovation-led entrepreneurship in electronic engineering, providing the necessary resources and infrastructure to transform research innovations into viable market solutions (Figure 3).

Figure 3 - *Innovation Ecosystem Diagram*

Gaps and Challenge. Recent literature highlights significant challenges in the commercialization of water quality monitoring technologies within electronic engineering, categorized into technical, financial, regulatory, and market-related areas. Technical challenges include ensuring sensor calibration and reliability, effective power management for remote systems, and addressing data security and privacy concerns. Financial barriers involve high development costs and limited access to funding, particularly affecting startups. Regulatory challenges are characterized by complex compliance requirements and a lack of supportive policies, which hinder innovation. Market-related challenges consist of entry barriers due to skepticism towards new products and the need for customer education to promote adoption. Addressing these issues requires a comprehensive strategy that integrates technological innovations, strategic financing, supportive regulations, and active market engagement, necessitating collaboration among researchers, entrepreneurs, policymakers, and industry stakeholders to enable successful commercialization of these innovations.

This document reviews case studies of startups and established companies that have commercialized water quality monitoring technologies resulting from electronic engineering research and development (R&D). It highlights companies such as bNovate Technologies (Switzerland) and Epic Cleantec (USA), which effectively utilize novel sensors and IoT technologies for water quality monitoring (Shane and Venkataraman, 2000). bNovate has developed an automated biosensor for rapid bacterial detection, on-site monitoring of bacterial concentrations in water supplies (Smith and Brown, 2018), while Epic Cleantec offers onsite systems that treat and reuse for buildings up to 95% of wastewater (Tidd and Bessant, 2013). Common success factors include originating from research institutions, employing innovative technology, achieving market penetration, and addressing specific needs (Zahra and Covin, 1995).

Challenges include transforming research into commercially viable products and competing in a crowded market. Best practices noted include focusing on measurable advantages and developing integrated solutions to enhance service offerings in water management technologies.

Research methodology

This study conducts a qualitative meta-analysis examining innovations in electronic engineering, particularly in sensor design and data systems for water quality monitoring, between 2010 and 2025. It reviews a range of sources, including peer-reviewed articles, patent filings, startup case studies, and industry reports. The research integrates literature analysis, and case studies to explore the interplay between entrepreneurship and innovation in electronic engineering R&D relevant to water quality. A key aim is to investigate the dynamics of innovation-driven entrepreneurship, proposing a robust analytical framework that combines literature insights with empirical models. The study identifies patterns and best practices that enhance entrepreneurship and innovation in the technology development and commercialization ecosystem, highlighting challenges and trends specific to water quality monitoring technologies through a qualitative approach grounded in systematic analyses of literature and case studies.

In this literature analysis, a systematic review was conducted to evaluate existing academic papers, industry reports, and market analyses centered on innovation, entrepreneurship, electronic engineering, and water quality technologies. The review meticulously examined a variety of sources, including peer-reviewed journals, conference proceedings, industry white papers, and market reports. Research databases such as IEEE Xplore, ScienceDirect, and Google Scholar were leveraged, utilizing targeted keywords like "electronic engineering innovation," "entrepreneurship," "water quality monitoring," and "technology commercialization." The main objective was to consolidate and synthesize current knowledge regarding significant technological advancements, effective entrepreneurial strategies, and the ecosystem support mechanisms that influence these domains. This comprehensive understanding aims to clarify the interplay and evolution of these elements, ultimately guiding future research directions and practical applications at the intersection of technology and entrepreneurship.

This document reviews case studies of startups and established companies that have commercialized water quality monitoring technologies resulting from electronic engineering research and development (R&D). It highlights companies such as bNovate Technologies (Switzerland) and Epic Cleantec (USA), which effectively utilize novel sensors and IoT technologies for water quality monitoring (Shane and Venkataraman, 2000). bNovate has developed an automated biosensor for rapid bacterial detection, on-site monitoring of bacterial concentrations in water supplies (Smith and Brown, 2018), while Epic Cleantec offers onsite systems that treat and reuse for buildings up to 95% of wastewater (Tidd and Bessant, 2013). Common success factors include originating from research institutions, employing innovative technology, achieving market penetration, and addressing specific needs (Zahra and Covin, 1995).

Challenges include transforming research into commercially viable products and competing in a crowded market. Best practices noted include focusing on measurable advantages and developing integrated solutions to enhance service offerings in water management technologies.

Results and further discussions. The integrated analysis of literature, case studies, and expert interviews reveals several critical themes and insights regarding entrepreneurship and innovation in electronic engineering R&D for water quality monitoring.

Technological Innovation Drivers. Advancements in sensor miniaturization, low-power electronics, and IoT connectivity enable new water quality monitoring solutions. Case studies show that integrating multiple sensing parameters into compact platforms enhances utility and competitive advantage. Innovations in cloud computing and machine learning improve data analytics, offering actionable insights. Experts stress the importance of iterative prototyping and rapid testing to enhance sensor accuracy and communication reliability, while open-source ecosystems promote collaboration and accelerate development (Figure 4).
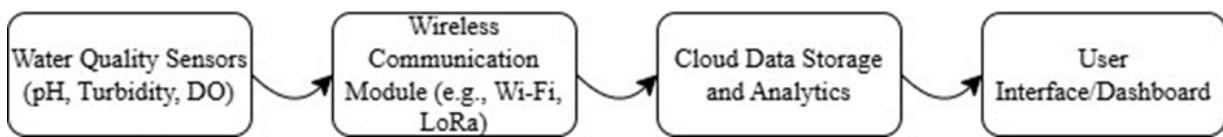
Figure 4 - *Sensor Technology and IoT Integration Block Diagram.*

Entrepreneurship Pathways and Strategies. The transition from research to market-ready technology is facilitated by entrepreneurial ventures, notably startups and university spin-offs. Successful companies combine interdisciplinary teams, merging engineering talent with business, marketing, and regulatory skills. Funding plays a crucial role, with seed funding assisting in prototyping and venture capital necessary for scaling. Early customer engagement is emphasized to validate product-market fit and foster industry partnerships. Furthermore, innovative business models, such as subscription-based services or platform-as-a-service, are increasingly favored to enhance value beyond traditional hardware sales.

Ecosystem Support and Collaboration. The entrepreneurial ecosystem is essential for promoting innovation-driven companies. Data indicate that mentorship, training, and networking facilitated by accelerators enhance startup survival and growth. Universities with effective technology transfer offices are crucial for patenting and licensing innovations. Additionally, government policies and regulations influence market opportunities, while support programs that simplify regulatory compliance are highly appreciated by entrepreneurs. In the figure 3 arrows represent data flow. Sensors send data to the microcontroller. Microcontroller processes and sends data to the communication module. Communication module transmits data to the cloud server. Cloud server makes data available to the user interface. Power supply provides power to the microcontroller and communication module.

Challenges and Barriers. Entrepreneurship in the field faces persistent challenges, including high development costs associated with sensor calibration and hardware integration, the difficulty of interdisciplinary collaboration among engineering, business, and environmental science, scalability issues when transitioning from pilot projects to large-scale deployment, concerns over data security and privacy with IoT-enabled monitoring, and the need for continuous market awareness to educate potential customers about innovative monitoring solutions.

Opportunities for Improvement. The study highlights opportunities to boost innovation-led entrepreneurship through promoting interdisciplinary education and collaborative research, increasing targeted funding for environmental tech startups, fostering partnerships among academia, industry, and government, developing standardized sensor calibration and data protocols to shorten development time, and enhancing user interface design for better accessibility and adoption.

Conclusion

Entrepreneurship and innovation are crucial for the advancement of research and development (R&D) in electronic engineering, particularly in developing solutions for water quality challenges. Entrepreneurial engineers play a significant role in aligning technical innovations with market demands, navigating the complexities of regulatory environments, and fostering collaborative partnerships. Future research should emphasize the creation of scalable business models, the formulation of supportive policy frameworks for environmental technology startups, and the incorporation of emerging technologies such as blockchain to enhance the security of water quality data.
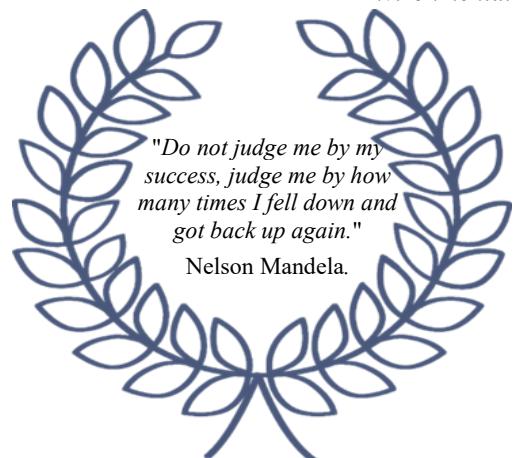
The study highlights the vital connection between entrepreneurship, innovation, and electronic engineering R&D in effectively addressing issues related to water quality. Key findings reveal that innovative sensor technologies and Internet of Things (IoT) platforms, when effectively supported by entrepreneurial infrastructures, can significantly improve water quality monitoring practices. Important contributions from the research include the identification of success factors and industry best practices necessary for converting research innovations into practical market applications.

However, the study does have limitations, primarily due to its qualitative nature and the fast-paced evolution of technology in this field. Future investigations should aim to perform quantitative evaluations of entrepreneurial outcomes and develop customized educational programs designed to bolster the innovation capabilities of electronic engineering researchers. To further promote innovation-driven entrepreneurship, policymakers are encouraged to improve access to funding and streamline regulatory processes. In conclusion, nurturing innovation and entrepreneurship within electronic engineering is essential not only for effective environmental management but also for the development of impactful technologies that address water quality issues.

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"Do not judge me by my success, judge me by how many times I fell down and got back up again."

Nelson Mandela.

Risk Profile of Research Staff Resilience

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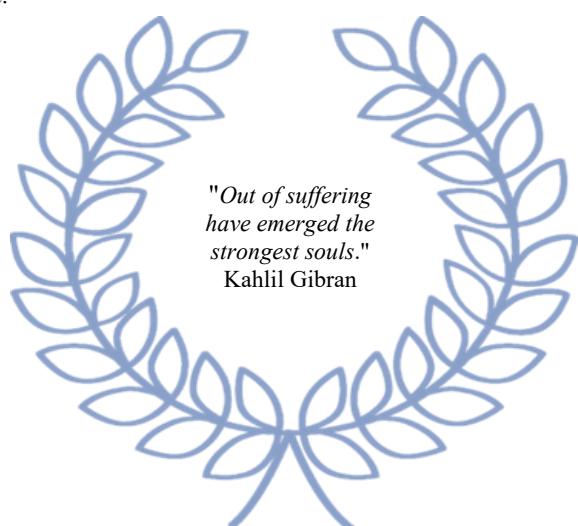[3] Metaplast SRL, 22 Pelinului, Bucharest, Romania

Abstract

This study analyzes the organizational resilience of Research and Development (R&D) institutions, based on the risk matrix methodology applied to specialized staff, identifying eight essential threats classified as pure risks and control risks. The analysis showed that the most significant threats are the loss of strategic capacity to attract funding and the chronic demotivation of specialized staff. High-impact pure risks, generated by the departure or unavailability of key personnel, require a transfer strategy. This involves externalizing the consequences through solutions such as hiring specialized project writing consultancy firms and implementing the Mandatory Knowledge Documentation (MKD) protocol to transfer the dependence on unique expertise. In contrast, high-probability control risks demand an internal treat strategy, focused on reducing frequency. Measures for this include establishing a Fast-Track Promotion system and utilizing a Standardized Research Load Index (SRLI) to manage professional overextension.

Keywords: organizational resilience, research and development, risk matrix, Human Capital, control risks

Introduction

The success and development of contemporary societies depend essentially on their capacity to generate innovation and expand their knowledge base (Alexe and Nechita, 2025; Nechita et al., 2025). These processes are mainly facilitated by research and development (R&D) institutions. From an operational point of view, these organizations function as dynamic ecosystems, structured around project management, where obtaining funding is a direct result of participation in competitive calls and high-quality evaluation of scientific proposals. In

"Out of suffering have emerged the strongest souls."
Kahlil Gibran

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this context, specialized human resources, particularly PhD holders, are emerging as the most valuable strategic resource, but at the same time the most vulnerable.

Researchers with doctoral degrees are indispensable not only for the technical execution of research projects, but also for the sustainability of the institution's ability to attract funding (Nechita et al. 2025). Their expertise, accumulated through a unique educational background and distinct doctoral topics, gives them a specialization that is difficult to replicate. Thus, the migration of a single key specialist not only affects the immediate implementation capacity but also compromises the portfolio of ideas and the collaboration network of the entire institution. This strategic vulnerability generates a type of risk characterized by a relatively low probability of occurrence, but with a potentially critical impact on organizational functioning.

Unlike the corporate environment, which predominantly uses extrinsic incentives and imposes standardized and repetitive tasks, researchers in R&D institutions are intrinsically motivated (Alexe and Nechita, 2025), driven by a passion for knowledge and the autonomy inherent in the academic environment. They take on the role of intrapreneurs, managing projects from the conception phase (proposal development) to implementation (resource allocation, procurement management), which translates into a high degree of flexibility and a short decision-making distance from top management (Nechita et al. 2025). This intrinsic motivation acts as a determining factor in employee resilience in the face of external factors of instability, including political uncertainty or national budget cuts for research.

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Recovering the loss of high-level research staff is proving to be a challenge. Although recruiting young research assistants is easier, they are heavily dependent on mentoring by PhDs, perpetuating institutional dependence on experts. At the same time, although the transfer of researchers to the private sector is discouraged by structural differences between evaluation systems, the risk of migration or internal blockage (caused by burnout or inefficient allocation) remains a threat to stability.

Therefore, in the context of examining the organizational resilience of R&D institutions, a proactive and methodological approach to risk management is necessary. This paper proposes a rigorous analysis, using the risk matrix as a visual and pragmatic tool, adapted for assessing and managing critical risks associated with human resources and collaborative research project management.

The research question addressed by this approach is as follows: „*Beyond the strategic risk of key personnel migration, what other adjacent risks, specific to human resource dynamics and project management, can destabilize the organizational resilience of research and development institutions, and what are the mitigation mechanisms based on principles of intelligent human resource allocation?*"

Research Methodology

A preliminary analysis of the uncertainties affecting research sustainability led to the identification of eight critical risks (R1-R8), which were subsequently classified according to their nature (Table 1), in line with standard risk management typologies: pure (hazard) risks, control risks, and speculative (opportunity) risks. Pure risks

involve only the possibility of loss and are usually easier to quantify statistically, often being transferable through insurance mechanisms. In contrast, control risks are inherent in operational and managerial processes (such as project management) and are, by their nature, more difficult to quantify, requiring specific internal preventive measures. Although speculative risks, which can generate both losses and gains (typical of investment decisions or strategic expansion), are present in the academic environment, they have been excluded from the present analysis because they do not pose direct threats to the operational

resilience of staff, which is the central objective of the study.

Risk classification is a fundamental step in risk management because it increases analytical clarity and facilitates effective prioritization of responses (Deselnicu et.al, 2023). This sorting allows for optimal allocation of resources (time, effort, budget) and clear delegation of mitigation responsibilities to the relevant departments (e.g., HR for control risks vs. finance for hazard risks) (Deselnicu, 2014). However, the typology and tolerance thresholds of risks depend intrinsically on the specific nature and organizational structure of each research institution.

Table 1 – *Identified risks*

Symbol	Risk	Classification by nature
R1	Loss of strategic capacity to attract funding	Hazard
R2	Immediate blockage of critical research activity	Hazard
R3	Decline in the quality of scientific results	Control risk
R4	Failure to maintain operational project teams	Hazard
R5	Compromising structural staffing sustainability	Control risk
R6	Dissolution or withdrawal of key external partnerships	Control risk
R7	Chronic demotivation of specialized staff	Control risk
R8	Inability to cover basic salary costs	Hazard

The loss of strategic capacity to attract funding (R1), classified as a pure risk (hazard), manifests as a significant reduction in the institution's success in obtaining new grants and competitive projects (White-Lewis et al., 2022; Blomfield and Vakili, 2023; Nechita et al., 2025). Since funding calls often require project leaders (PIs) or key team members to hold a PhD and demonstrate a solid publication record, the unilateral act of resignation by elite researchers, often driven by systemic issues outside the institution's control (e.g., Ministry policies), compromises eligibility and proposal scores (Geuna and Shibayama, 2015; Pietilä, 2025). This external dependency on retaining personnel

who choose to leave undermines the project-based operating model, threatening financial sustainability (Ejermo and Sofer, 2024).

The immediate blockage of critical research activity (R2) is also treated here as a pure risk (hazard). This refers to situations where vital research stages are suddenly interrupted due to the unexpected unavailability of a key specialist. In the research environment, expertise is often hyper-specialized and based on unique tacit knowledge (Alexe and Nechita, 2025). The absence of a single, highly specialized researcher creates a void that is not immediately substitutable, regardless of internal planning, leading to delays in deliverables, potential

contractual penalties, and failure to deliver project objectives (Kwiek and Szymula, 2025).

The decline in the quality of scientific results (R3) is defined as a control risk. This qualitative decline in primary research deliverables, including high-impact publications (indexed in prestigious databases such as Web of Science) and patents, is largely a function of internal managerial factors. Suboptimal allocation of human resources, either through professional overloading or through incorrect matching of skills, can lead to methodological errors. The institution's management has the primary responsibility to mitigate this risk through internal quality assurance systems and task distribution policies (Lubega et al., 2023).

Failure to maintain operational project teams (R4) is a pure risk (hazard). This arises from the inability to keep the research team functional due to the resignation of highly specialized members mid-project. Because specialized human resources are often irreplaceable (nesubstituibile) in the short term, their departure constitutes an unexpected external shock to the project's viabilit. The materialization of this risk directly threatens the completion of projects on time and within budget, demanding costly, often futile, emergency reallocation (Kwiek, 2024).

Compromising structural staffing sustainability (R5) is defined as a control risk. This risk refers to the institution's inability to ensure the succession of qualified personnel needed for leadership and mentoring roles (Monyei et al., 2021; Nechita et al., 2025). Since young research assistants depend on the active mentorship of senior doctors, neglecting this function is an internal managerial failure. The lack of structured succession planning and mentoring programs, which are internal decisions, condemns the institution to long-term stagnation and structural decline (Zhang et al., 2025).

The dissolution or withdrawal of key external partnerships (R6) is classified as a control risk. While the final decision to withdraw is external, the risk of partnership breakdown is manageable internally (Escher and Brzustewicz, 2020). If contacts were dependent on a single researcher who departed, the institution failed to implement internal redundancy, requiring management to include other institutional staff in collaborative relationships to prevent dependence on one person's network (Burbridge and Morrison, 2021; Song and Kim, 2024).

Chronic demotivation of specialized staff (R7) is consistently a control risk. This describes a prolonged state of professional dissatisfaction among high-performing researchers. Although their core motivation is intrinsic, demotivation is eroded by failures in internal systems, such as the lack of an adequate recognition system, the inertia of promotions, or excessive bureaucracy (Burbridge and Morrison, 2021; Laitinen et.al, 2024; Alexe and Nechita, 2025). This risk is primarily mitigated by internal organizational culture and HR policies that the management can modify and control.

The inability to cover basic salary costs (R8) is a pure risk (hazard). This refers to the insufficiency of institutional operating funds to cover fixed personnel costs. Since the financial dependence lies with the Ministry or other external financing units, the event (e.g., national budget cuts) is entirely external and produces pure loss, rendering the risk unmanageable through internal operational changes (Tsaousiotis et al., 2025).

A detailed analysis of these eight risks highlights the fact that research sustainability is essentially a function of human capital resilience, requiring a structured methodological framework, such as a risk matrix, to accurately assess and prioritize these threats. The ultimate goal is to design response strategies, based on advanced management principles, that strengthen researchers' ability to absorb shocks and, implicitly, ensure organizational resilience.

The risks were assessed by staff from the Department of Biomedical Mechatronics and Robotics at the National Research and Development Institute for Mechatronics and Measurement Technology (INCDMTM) in Bucharest, Romania.

The assessment was carried out on a scale of 1 to 10, applied separately for probability (P) and impact (I). The total risk score (risk index) is calculated by multiplying these two scores obtained for probability and impact.

The basis for determining specific countermeasures against the identified threats is the risk matrix, a methodological tool that translates the calculated risk index into general mitigation strategies. This matrix is structured into four quadrants: the top-left quadrant (high impact, low likelihood) suggests the Transfer strategy (externalizing the risk); the bottom-left (low impact, low likelihood) recommends Tolerate (accepting the risk without specific action); the top-right (high impact, high likelihood) dictates Terminate (eliminating the source of the risk); and the bottom-right quadrant (low impact, high likelihood) requires Treat (implementing controls and preventive measures to reduce probability).

Results

Each risk was assigned a score for probability and impact. The risk index for each risk was also calculated (Table 1).

Table 2 – *Risk assessment*

Symbol	Risk	Probability	Impact	Risk index
R1	Loss of strategic capacity to attract funding	3	9	27
R2	Immediate blockage of critical research activity	2	8	16
R3	Decline in the quality of scientific results	7	3	21
R4	Failure to maintain operational project teams	3	6	18
R5	Compromising structural staffing sustainability	4	5	20
R6	Dissolution or withdrawal of key external partnerships	4	3	12
R7	Chronic demotivation of specialized staff	6	4	24
R8	Inability to cover basic salary costs	4	5	20

The highest priority risks, which pose the most significant threat to institutional resilience, are R1 (loss of strategic capacity to attract funding) with the maximum Risk Index of 27, and R7 (chronic demotivation of specialized staff) with a risk index of 24. A large cluster of risks follows closely, requiring active management attention: R3 (decline in scientific quality) (risk index 21), R5 (compromising structural sustainability) (risk index 20), and R8 (inability to cover basic salary costs) (risk index 20). The threats continue with R4 (failure to maintain operational project teams) (risk index 18) and R2 (immediate blockage of critical research activity) (risk index 16). The lowest priority risk among the group is R6 (dissolution of external partnerships), scoring a risk index of 12.

Each probability and impact score was used to map the previously identified risks onto the Risk Matrix (Figure 1). Probability is on the X-axis and impact is on the Y-axis, with a scale from 0 to 10.
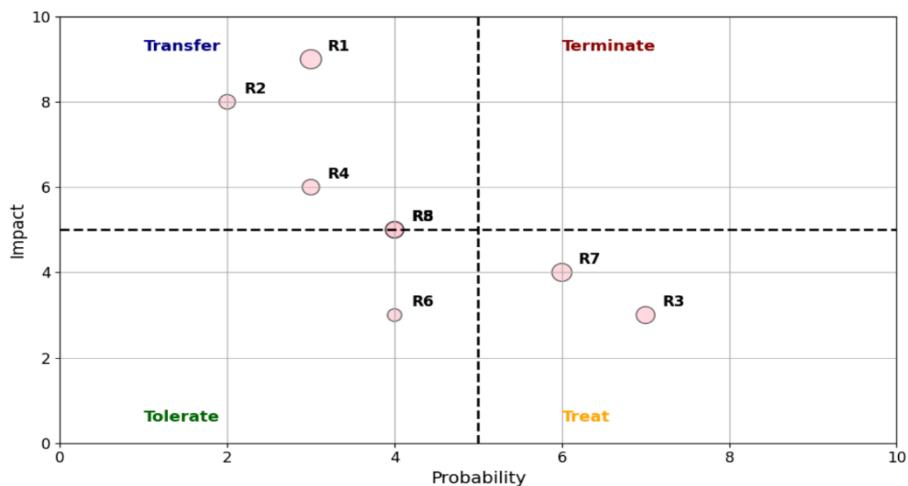
Figure 1 – *Risk matrix*

Based on the visual representation of the Risk Matrix, the eight identified risks align with three of the four general response strategies. The upper-left quadrant, dedicated to the Transfer strategy (high impact, low likelihood), groups major threats categorized as pure risks: the most notable is R1 (loss of strategic capacity to attract funding), followed by R2 (immediate blockage of critical research activity) and R4 (failure to maintain operational project teams). These risks necessitate externalizing the consequences to shield the institution from severe damage. No risks fall into the Terminate quadrant, which would have required the immediate cessation of an activity. Conversely, the lower-right quadrant, dedicated to the Treat strategy (high likelihood, low impact), contains control risks that can be reduced through internal managerial improvements and preventive measures: R7 (chronic demotivation of specialized staff) and R3 (decline in the quality of scientific results). The risk R6 (dissolution or withdrawal of key external partnerships) is situated in the Tolerate quadrant (low impact, low likelihood), requiring only standard monitoring. Finally, R8 (inability to cover basic salary costs) sits precisely on the boundary line between Transfer and Tolerate, necessitating a hybrid approach of financial transfer and constant oversight.

The implementation of specific countermeasures is directly dictated by each risk's allocation within the Matrix, ensuring that management strategies align precisely with the general principles of Transfer, Treat, or Tolerate. For risks situated in the Transfer quadrant, the response is to externalize the potential financial or operational consequences to minimize organizational exposure. Conversely, for risks in the Treat quadrant, the focus shifts internally toward reducing the likelihood of occurrence through managerial and process improvements. This methodical alignment ensures that the institute's limited resources are utilized to address each threat according to its severity and frequency, maximizing the overall resilience of the Department of Biomedical Mechatronics and Robotics.

For R1 (loss of strategic capacity to attract funding), which is allocated to the Transfer quadrant due to its high impact, the core strategy must be to externalize the risk associated with proposal quality and eligibility. This is primarily achieved by engaging a specialized project writing consultancy firm through a framework agreement. This action transfers the immediate burden of maintaining high proposal scores and navigating complex eligibility criteria to the external firm, especially during periods of internal key personnel fluctuation or resignation. To further reinforce the transfer, the institution must implement contractual clauses

requiring key personnel to actively train a co-Principal Investigator or successor, thereby transferring institutional dependency from a single researcher to a shared management structure. Furthermore, the institute should actively engage in multi-institutional consortia with clear continuity plans, ensuring the project can continue under an external partner's eligibility if a key researcher departs.

The risk R2 (immediate blockage of critical research activity) is also situated in the Transfer quadrant, as it is driven by the sudden unavailability of unique, tacit knowledge; thus, the transfer is achieved through systematic redundancy and documentation. The specific action involves implementing a Mandatory Knowledge Documentation (MKD) protocol that requires all PhD-level specialists to maintain constantly updated, non-proprietary procedural manuals for their hyper-specialized techniques. Crucially, they must conduct quarterly cross-training sessions with a designated mentee or backup researcher, systematically transferring tacit knowledge into institutional memory and ensuring that the project's critical path is not dependent on the health or presence of a single individual.

The R4 (failure to maintain operational project teams), another Transfer risk that arises from the inability to keep teams functional mid-project, must be managed by transferring the risk of short-term substitution. The specific strategy involves establishing pre-negotiated, retained service agreements with specialized, high-level temporary staffing agencies or external PhD consultants, particularly in the niche fields of biomedical mechatronics and robotics. This contract ensures rapid, albeit potentially costly, replacement capability, effectively transferring the financial and contractual risk of critical delays and penalty imposition to the third-party service provider.

As a high-probability internal managerial issue, R7 (chronic demotivation of specialized staff) is firmly rooted in the Treat quadrant and requires management to address the systemic failures eroding intrinsic motivation. These demands establishing a Fast-Track Promotion and Recognition System that bypasses bureaucratic inertia, providing structured, non-monetary recognition such as sabbatical opportunities or reduced administrative load, linked directly to sustained high-quality scientific output. By treating the causes of frustration and dissatisfaction, the institution can proactively lower the likelihood of burnout and subsequent resignation, thereby improving long-term retention.

Similarly, R3 (decline in the quality of scientific results), another Treat risk, is primarily caused by resource misallocation and professional overload, dictating that the strategy must target the root causes through managerial controls and quality assurance mechanisms. Specific actions include implementing a Standardized Research Load Index (SRLI) to accurately quantify and prevent professional overextension across multiple projects. Additionally, establishing a mandatory, blinded internal peer-review process for all major publications before external submission significantly reduces the probability of methodological errors and quality compromise, treating the risk before it impacts institutional reputation.

The risk R6 (dissolution or withdrawal of key external partnerships) is allocated to the Tolerate quadrant due to its low overall index, meaning the strategy accepts the minimal potential loss while implementing only essential, low-cost controls. This is managed by establishing a Partnership Redundancy Log, ensuring that at least two institutional staff members, not just primary researchers, are regularly included in all key collaborative communications and meetings. This basic measure prevents the partnership from failing entirely upon the unilateral departure of the main contact, without diverting significant resources to unnecessary mitigation.

Finally, the unique position of R8 (inability to cover basic salary costs) on the boundary between Transfer and Tolerate necessitates a hybrid approach. As an external hazard with moderate impact, the strategy must prioritize the Transfer of the financial burden where possible, achieved through the creation of an Internal Fixed-Cost

Contingency Fund, financed by a small percentage of overhead from non-competitive projects. Simultaneously, the institute must actively lobby competitive grant calls to include higher direct personnel cost coverage, transferring a portion of the long-term salary risk to the external funding bodies, thereby strengthening the institute's financial foundation against external budget cuts.

In conclusion, this structured, quadrant-based application of mitigation strategies ensures that the institution is systematically protected against the eight critical risks to its human capital resilience. By rigorously adhering to Transfer for high-impact external risks, Treat for high-probability internal risks, and Tolerate for low-priority risks, the management can effectively deploy intelligent resource allocation. This focused approach strengthens the organizational capacity to absorb operational and financial shocks, confirming the validity of the Risk Matrix as a pragmatic and indispensable tool for strategic decision-making in the dynamic R&D environment.

Conclusions

This study rigorously demonstrated that the organizational resilience of Research and Development (R&D) institutions, particularly the Department of Biomedical Mechatronics and Robotics at INCDMTM, is critically dependent on the strategic management and protection of its specialized human capital. By applying the risk matrix methodology, we successfully identified and prioritized eight essential threats, confirming that the primary vulnerabilities are dichotomous: those of external origin (hazard risks) and those rooted in internal processes (control risks). The analysis of the risk index highlighted that the most significant threats are R1 (loss of strategic capacity to attract funding) (index 27) and R7 (chronic demotivation of specialized staff) (index 24). This rigorous prioritization directly informed the mitigation strategy, shifting resource allocation away from simple crisis reaction toward proactive, quadrant-based management.

The allocation of risks across the four quadrants provided a precise, actionable framework for response. Risks situated in the Transfer quadrant (R1, R2, R4) are pure risks, primarily driven by the unilateral resignation or sudden unavailability of key personnel who possess unique expertise (tacit knowledge). The strategic implication here is that the institution must externalize or share the financial consequence of this loss. For R1, the reliance on specialized project writing consultancy firms was validated as a key mechanism to transfer proposal quality risk, while implementing Mandatory Knowledge Documentation (MKD) protocols for R2 and retained service agreements for R4 ensure the transfer of immediate operational failure risk. Conversely, the high-probability control risks, such as R7 (chronic demotivation) and R3 (decline in scientific quality), demand an internal Treat strategy. This mandates that management focus on controllable factors, confirming the necessity of measures like the fast-track promotion system and the standardized research load index to proactively reduce the frequency of internal failures. The analysis further validated the low-priority nature of R6 (dissolution of partnerships), warranting only standard Tolerate mechanisms.

The main contribution of this paper is the successful adaptation and implementation of the traditional risk matrix, a tool typically used in corporate project management, to address the highly specific human capital risks within a highly specialized R&D environment. By classifying risks as hazard (external or control, the methodology provides organizational clarity regarding the delegation of mitigation responsibilities (e.g., HR for R7, finance/procurement for R1 and R8). However, the study possesses a limitation inherent in its scope: the risk assessment was conducted using expert judgment from a single department, meaning the quantitative scores reflect a localized perception of vulnerability. Although the findings are transferable to similar specialized institutes, the numerical risk index is intrinsically tied to the observed department's context.

Future research should expand upon these findings in several directions. First, it is crucial to

conduct a comparative study involving R&D institutions from different organizational structures (e.g., universities vs. national institutes) or distinct financing models to validate the consistency of the risk typology. Second, a quantitative model should be developed to move beyond the discrete 1-10 scoring scale, potentially using fuzzy logic or DEMATEL simulations to model the cascading effects of a single risk, such as R1, on subsequent risks like R8 (inability to cover basic salary costs).

Finally, given that R5 (compromising structural staffing sustainability) was identified as a Control risk requiring internal action, future work should focus on developing a validated research staff succession planning framework, designed specifically for academic environments, to provide a structured Treat strategy for ensuring the long-term continuity of institutional leadership and mentoring capacity.

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"*Turn your wounds into wisdom*."
Oprah Winfrey
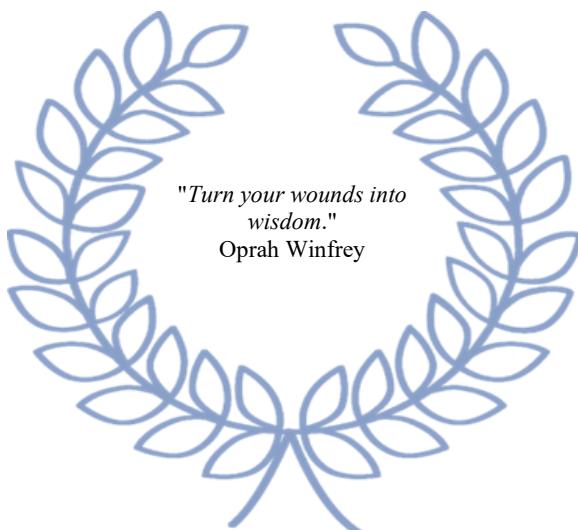
Organizational Resilience and Well-Being: Leadership Mission … Possible.

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Abstract

This essay presents a point of view on possible conciliation between organization's resilience and its well-being. To start with, their compatibility has to be discussed. The author launches a discussion in this matter, mentioning the role of the prediction function of management, highlighting the importance of mastering the key-concepts involved and avoiding confusions as sensitive areas in the process.Mainly theoretical, the methodological approach involves basic literature survey, identifying literature gaps. The practical implications are impactful, since arguable strategic decisions may lead not only to unexpected but to unwelcome outcomes. Among conceptual clarifications, a framework for assessing the organization well-being is proposed.As an explorative study, there are inherent limitations, which also indicate possible future studies. Implications are both theoretical and practical, mostly for policy makers, strategists and top executives.
Keywords: organization resilience, organization well-being, prediction

Introduction

A couple of years ago, the author witnessed an animated discussion around the concepts of well-being and resilience, considered to be basic elements in a future construct and given type of organizations. It is true that participants to the discussion were mainly theorists with not much practical, hands-on experience; yet it was quite surprising: *How were they sure that the two basic concepts are compatible?*

Even it is much desired, the compatibility of the two concepts is not a given, as the future development has shown. Moreover, the relationship between the two concepts must be well-understood, so that subsequent decisions to be made must have solid foundation.

*"I tried and failed.
I tried again and again
and succeeded."*
Gail Borden

Therefore, the purpose of this essay is to explore the nature of the relationship between resilience and

well-being, and eventually, in case of organizations, to understand whose role is to manage this relationship.

Resilience. Waugh and Sali (2023) declared that "resilience is the ability to maintain well-being" in the case of people's well-being (i.e. individual level): "Resilience is an ability and that ability is the maintenance of well-being despite threats to that well-being. As an ability, it is present in people before the threat to well-being occurs and is trait-like but can also be learned throughout life." (Ibidem, pp. 12–13). Thus, they accept that *resilience is both an ability and an outcome*.

Associated with well-being, the individual resilience is assessed in terms of individual's ability to recover from and adapt to disruptions or stressful events (Ye et al., 2022). There are two main methods for assessing the individual resilience: the Connor-Davidson resilience scale (Connor and Davidson, 2003) and the Brief Resilience scale (Smith et al., 2008). Ye et al. (2022) have compared these two methods and concluded that, while both of them satisfy the definition, "They can capture different aspects of resilience. While SD-RISC [the first method] focuses on resources that can help individuals to recover from and adapt to disruptions or stressful events, the BRS [the second one] directly measures one's ability to bounce back or be resilient." (Ibidem, p. 339). Using different samples, Ye and collaborators have shown that the two methods are "highly correlated but still distinct", and both methods have "unique predictive effects" related to depression and life satisfaction.

The essence of the resilience concept can be extended, *mutatis mutandis*, to macro-level. The *Fund for Peace* (FFP, 2023) has developed the *State Resilience Index* which stands alongside the *Fragile States Index*, as new tools "to identify capacities and capabilities in countries under stress". According to FPP, "Resilience is the extent to which a country can prepare, manage, and recover from a crisis, relative to the severity of that crisis.

The *Factory Mutual Insurance Company* has developed the *FM Resilience Index,* a composite index including 18 equally weighted factors of resilience (FM, 2025): 6 physical factors (climate change exposure, climate risk exposure, climate risk quality, cybersecurity, fire risk quality, and seismic risk exposure) and 12 macro factors related to political, economic, and social resilience.

As far as intermediate level of organizations, authors were interested in resilience of urban areas (Gheorghe, Vasuthanasub and Gheorghe, 2019; Botezatu et al., 2023) and, in general, *system resilience* (Jackson, 2007; Gheorghe et al., 2017). Jackson defined system resilience as "the ability of organizational, hardware and software systems to mitigate the severity and likelihood of failures or losses, to adapt to changing conditions, and to respond appropriately after the fact" and supported the idea that "combination of capabilities, culture and infrastructure forms the basic framework of system resilience" (Ibidem, p. 1).

Well-being. Notably, the close relationship between individual resilience and well-being (Waugh and Sali, 2023) is valid as long as well-being is understood as a good state health mainly.

Ruggeri et al. (2020) have developed a measure of psychological well-being (MPWB) composed of ten indicators (competence, emotional stability, engagement, meaning, optimism, positive emotions, positive relationships, resilience, self-esteem, and vitality). Notably, *resilience was considered one of the components of well-being* (Ibidem, p. 4).

The global access to data from country members, considerable resources and networking made possible, within objective limits, calculation of the *well-being index* for all member countries members of the World Health organization: the *WHO-5 well-being index* (Sischka et al., 2020). The elements of the WHO-5 well-being index considered are the following five: purpose, social, financial, physical, and community.

As governments acknowledged that "subjective well-being is an indicator of progress" Huppert and So (2013) have developed a conceptual framework that "equates high well-being with positive mental health", based on ten features of well-being (competence, emotional stability, engagement, meaning, optimism, positive emotion, positive relationships, *resilience*, self-esteem, vitality), defined as opposed to "internationally agreed criteria for depression and anxiety". After testing

their assessment tool on a representative sample of 43,000 respondents from 23 European countries, they found, besides significant differences among countries (Denmark on top, Slovakia and Russia by the bottom), that results are different than assessing *life satisfaction*.

Busseri and Newman (2024) make an interesting point while studying "daily subjective well-being" (SWB) within and *between individuals*, examining daily variation in life satisfaction (LS), positive affect (PA), and negative affect (NA). Their findings support a hierarchical conceptualization of SWB as an underlying (latent) sense of well-being reflected in daily experiences of LS, PA, and NA. They also discuss implications for studying stable (trait-like) and dynamic (time-varying) aspects of other multidimensional constructs in social and personality psychology.

According to its mission – "To build a rigorous and interdisciplinary science of positive health, happiness, and well-being with a focus on health equity, and to translate the science to influence practice and policy" (Harvard T.H. Chan, 2025) – *Lee Kum Sheung Center for Health and Happiness* from Boston "compiled 41 well-being measures (both subjective and objective) and 20 well-being data sets […] to aid scholars undertaking research into well-being" (Ibidem).

The World Health Organization (WHO) also promotes the concept of well-being, which is defined as "a positive state experienced by individuals and society. Similar to health, it is a resource for daily life and is determined by social, economic and environmental conditions" (WHO, 2021, p. 10). Interesting for our case, the "well-being" entry continues: "Well-being encompasses quality of life, as well as ability of people and societies to contribute to the world in accordance with a sense of meaning and purpose. Focusing on wellbeing supports the tracking of the equitable distribution of resources, overall thriving, and sustainability. A society's well-being can be observed by the extent to which they are resilient, build capacity for action, and prepared to transcend challenges." (Ibidem).

At the 10th Global Conference on Health Promotion (December 2021), over 5,000 experts from 149 countries participated virtually and endorsed *The Geneva Charter for Well-being* (WHO, 2022). Among the foundations of well-being–to be provided for 'all members of current and future generations to thrive on a healthy planet" (WHO, 2022, p.2)–and the 5 key action areas (equitable economy, public policy for common good, universal health coverage, preserve the planet), *the strategic, longer-term (multi-generational) and global view dominated* (although not too much about resilience). WHO strategic and global approach on well-being includes a practical framework for achieving well-being (WHO, 2023) and its associated policy of implementation at the country level (WHO, 2025).

The WHO perspective is clearly health-focused and defined at individual level; and the crucial importance of global well-being is acknowledged as integrating the *multitude* of individuals' *physical, mental, spiritual and social well-being*. Also, the WHO foundations of well-being accept "making peace with Nature" and well as "new indicators of success, beyond gross domestic product, that take account of human and planetary well-being and lead to new priorities for public spending" (WHO, 2022, p. 2).

The state of well-being is slightly different in the work environment (in that sense of being more complex), where individual's connections and threats are different as well. Employee's well-being was studied by Sonnentag (2015) who described well-being "as a dynamic construct that changes over time and fluctuates within a person", underlying "the role of job stressors, job resources, the interpersonal environment, personal resources, the work-home interface, and performance".

Concluding, there is rich literature on both individual health and well-being, also reflected in international statistics provided by highly specialized institutions and organizations. However, the literature on organization as a system is relatively scarce. This paper is an attempt to have a contribution in this matter.

Therefore, the remaining of this paper is structured as follows: methodological approach; main findings; discussion and implications; conclusion and further studies.

Methodological approach

This piece of work aims to understand the concepts of resilience and well-being as well as relationship between them (i) and, eventually, in case of organizations, to understand the leadership role of top executives while managing this relationship (ii); ultimately to propose possible tools for strategic management (iii).

Accordingly, the methodological approach involves two steps: (i) secondary research (literature survey) for conceptual clarifications; and (ii) findings analysis and discussion for managerial implications.

Main findings. Preliminary literature review emphasized several important conceptual clarifications:

▪ Individual resilience is linked to well-being in many ways (Athota, Budhwar and Malik, 2019); not exactly as a cause-effect relationship but resilience counts as one of the well-being factors (Huppert and So, 2013; Ruggeri et al., 2020; Waugh and Sali, 2023).

▪ Individual resilience and well-being are different than organizational resilience and well-being (as respective definitions and measures are different).

▪ Country resilience and well-being multi-criteria rankings (e.g., Table 1) are published yearly and provide valuable statistical data.

▪ Resilience and well-being are dynamic, strategic, longer-term objectives at country level (WHO, 2022; 2023; 2025) and, implicitly, for organizations.

▪ Hence, it is responsibility of organization top executives to design and implement appropriate strategies for increased resilience and well-being on longer run.

Table 1 – *Comparative ranking of top 10 countries by resilience and by well-being (2025)*

Ranking	Most resilient countries (FM index, 2025)	Highest well-being index (WHO index, 2025)
I	Denmark	Finland
II	Luxembourg	Denmark
III	Norway	Iceland
IV	Switzerland	Sweden
V	Singapore	Netherlands
VI	Sweden	Costa Rica
VII	Germany	Norway
VIII	Finland	Israel
IX	Belgium	Luxembourg
X	USA	Mexico

(Source: adapted after FM index (2025) and WHO index 2025)

There also are conceptual confusions that must be avoided:

▪ Organization well-being is not an extension of individual good health or well-being; it is more than that.

▪ Well-being is related to good health, life satisfaction and happiness; however, well-being is different than life satisfaction (Huppert and So, 2013); and well-being is different than happiness. The major differences between individual well-being and happiness are synthetically displayed in Table 2.

Table 2 – *Differences between individual well-being and happiness*

Criteria	Well-being	Happiness
Content	Comprehensive state of being	Single emotion or feeling
Elements	Health, relationships, purpose	Joy, pleasure, contentment
Duration	Longer-term	Short-term
Stability	Stable	Changeable
Linked to	Mix of activities, relationships	Specific event

From inspirational happiness as a choice (Minirth and Meier, 2013) to happiness related to health and well-being seen through psychologist's lens (Lynn, O'Donohue and Lilienfeld, 2014) many authors highlight the differences. Theobald and Coper (2012, p. 13) consider 'wellbeing' as a state of contentment, while 'happiness' is "closer to complete fulfilment […] but by its nature is a transient state."

However, the fact is that even the well-known international *Journal of Happiness Studies* (member of the prestigious family of Springer Nature) reads the following sub-tile: *An Interdisciplinary Forum on Subjective Well-Being.*

Discussion

The title of the ranking of the highest well-being countries (World Happiness Score) can be misleading, suggesting that well-being equals happiness, which is not quite correct (at least in the case of individual well-being).

However, the examination of the comparative rankings of the most resilient and well-being countries (Table 1) leads to several comments:

▪ There is no identity in ranking

▪ Only five countries make both top ten rankings

▪ The average dispersion calculated per country as difference in ranking for the five countries is quite significant (4.2)

▪ Out of the five, the top three most resilient countries (Denmark, Luxembourg and Norway) are placed lower as well-being.

▪ The average dispersion calculated per country as difference in ranking for these top three is also significant (4)

▪ As the number of ranked countries increases, the average dispersion calculated per country as difference in ranking for the ranked countries goes higher and higher.

These data do not support the extension of the assumption made in case of individual resilience (resilience is an ability to maintain the well-being despite threats to that well-being) in the case of country resilience.

Nonetheless, for the country strategists and policy makers, depending on the absolute but also relative ranking (country's rank difference, Δ), there are several recommended lines of strategy design. *Just as examples only*, in case of the countries pictured in Table 1:

▪ Countries with Δ relatively small (e.g., Δ = 1 for Denmark; Δ = 2 for Sweden) is expected to have balanced strategies.

▪ Countries with Δ relatively large (e.g., Δ = 7 for Finland and Luxembourg) will probably prioritize one of the dimensions (well-being in Luxembourg; resilience in Finland).

▪ Countries that make top 10 as most resilient (e.g., Switzerland, Singapore) should probably consider strategies aiming at well-being, too.

▪ Conversely, countries that make top 10 of most well-being (e.g., Iceland, Costa Rica) should probably think at increasing their resilience as well.

These general strategic directions can be associated with strategic measures, depending on the weights of the respective resilience or well-being criteria. In other words, strategic priorities for the countries placed in the first third are different than priorities of the countries placed in the last third. In addition the general trend and environment have to be considered.

Managerial implications

The literature related to organization resilience and well-being is relatively limited. As example, exploring a database in October 2025 and using as search keyword "resilience and well-being" 224 articles were displayed; then, searching for "organization resilience and well-being", only 8 titles were posted. Nonetheless, the studies on organizational resilience (Xiao and Cao, 2017; Duchek, 2020; Zhang et al., 2022) seem to have more prominence than organizational well-being (possibly for economic reasons), while the situation is reversed at individual level (probably for health and social reasons).

Both resilience and well-being concepts change in case of organizations. Both concepts have particular features and functions by organization type. As such, well-being of a business organization has rather different profile than an educational or public service organization – simply because the basic functions of above organizations are different themselves.

In search for a suitable and practical framework for assessing the organizational well-being, there are, in principle, two approaches (bottom-up and top-down), considering the generally accepted concepts of individual and country well-being. Extant studies related to a particular type of organization and only to certain categories of individuals, employed in that organization incline to the first approach. In this category there are research projects conducted in educational environment, illustrated by studies on well-being of certain groups of individuals; school employees (Kern et al., 2014); schoolteachers (Karakasidou et al., 2025; Grigorescu-Pîrvu, 2025) or even students (Kern et al., 2015; Dogaru et al., 2025).

This study propose a second approach. A framework for assessment of organization well-being can be developed by applying in the case of organizations (specifically profit-oriented organizations) a similar methodology and criteria used for assessing the social happiness index – i.e. the six key variables which contribute to social happiness (Musikanski et al., 2017): income, healthy life expectancy, having someone to count on in difficult times, generosity, freedom and trust, good governance (the absence of corruption in business and government).

Table 3 displays equivalent criteria that can be identified at organization-level: salary level; social policy of the company and awareness of the needs of its employees; stability and duration of the work contract; flexibility of the working schedule and trust in the company management system; system of fringe benefits offered by the organization to its employees; perception of a fair management system and lack of corruption among leadership.

Table 3 – *A proposed framework for assessment of organization well-being*

Happiness Index criteria	Organization-equivalent criteria	Applicability of criteria by management functions
GDP per capita	Salary	Depending on the results of negotiations with trade unions, in legal terms
Social support / having someone to count on in difficult times	Social policy of the organization	Up to the organization policy and top management – to a large extent
Healthy life expectancy	Stability and duration of the work contract	Within legal limits & limits of the employee's will and health condition
Freedom and trust	Work flexibility and trust in management	Largely depending on organization policy & management system
Generosity	Fringe benefits offered by the organization	Up to the organization policy and top management – to a large extent
Good governance (no corruption in business and government)	Fair management and non-corrupt management	Totally depending on organization leadership and management system

The prospect of applying this happiness assessment framework as well as the associated implications are important threefold (Dumitrescu and Scarlat, 2022):

▪ It makes sense to discuss about happiness at the organization level;

▪ It is possible to assess the organization / organizational happiness;

▪ The company management can act directly and influence the organization happiness.

The framework depicted is a good base for discussions on organization happiness, involving both academics and business managers.

The results are two-sided: (i) the happiness index methodology is difficult to almost impossible to apply ad litteram in case of organizations; however, (ii) it is up to organization managers to adapt and selectively apply happiness criteria in an intelligent way, with variable intensity, in order to stimulate various sides of peoples' happiness within their organization, by management functions in their hands. (Ibidem, p. 174).

The major implication of this study is related to organization resilience and well-being, including the individual resilience and well-being of employees. Undoubtedly, regardless the type of organization, economic sector or industry, coherent realization of organizational resilience and well-being is a *vital strategic issue*.

Therefore, it is *the top management job* to deal with it. Whether it is a management or leadership issue, the short answer is straight: assuming that both concepts are correctly understood, a *top manager (CEO) with leadership skills* must be responsible to design the strategy and choose the suitable framework for planning the adequate measures and actions to reach organization's resilience and sustainable well-being in a reasonable timeframe.

Conclusion

Despite pretty well-defined and universally accepted concept of well-being both at individual and country level, there is a scarcer literature relative to the organizational well-being proper.

This piece of work addressed the concepts of resilience and well-being and found that they can be defined at different levels, from individual to global. At individual level, this relationship is studied mostly from medical perspective, and it is accepted that individual resilience is both an ability and outcome of the individual well-being.

This relationship largely diverge at the country and global levels. While the country well-being is assessed, monitored and reported according to WHO standards and index, the country resilience is globally ranked observing a slightly different set of criteria. Therefore, the two rankings do not necessarily coincide. However, the comparative analysis, according to the relative position of a certain country in those rankings, can have strong predictive and/or normative strategic implications.

This essay is essentially theoretical, although with significant practical implications. Thus, is has the limitations of such a vast theoretical topic. Further studies should be oriented primarily to testing the models and methods of assessing organizational resilience and well-being, as well as studying the cases to achieve the best conciliation of resilience and well-being.

Moreover, for increased objectivity, the well-being studies might be associated with its negative side. Good examples in this matter are the studies of well-being and/or happiness (associated or not with resilience) of dropout students in higher education context (Grigorescu, Scarlat and Simion, 2025); or of entrepreneurs nearing exit or retirement (Pauley, 2025).

Almost two decades ago, Jackson (2007) started his pioneering work on system resilience around three questions (Ibidem, p. 14): (i) What is the nature of emergence and how can it be predicted? (ii) How can adaptability be built into a system to counter emergence? (iii) What are the statistical warning signs of systems that are most likely to be vulnerable to catastrophic failure? Leaving aside undoubted progress in technology and concepts (e.g., system vulnerability, fragility, etc.), the essence of these questions still lights the research paths.
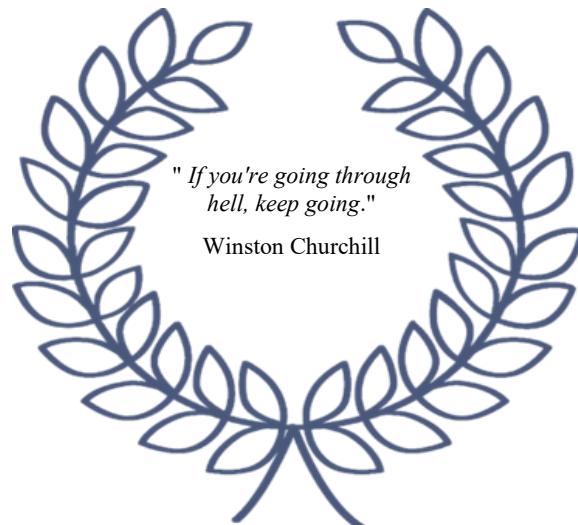
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" *If you're going through hell, keep going*."

Winston Churchill

Data-Driven Optimization of Research Team Human Resources

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Abstract

Based on findings from the „IBM HR Analytics Employee Attrition & Performance'' dataset hosted on Kaggle (the site with real data sets), this paper explores data-driven approaches to improve research teams' allocation of human resources. Performance, job satisfaction, training participation, work-life balance, tenure, attrition rates, and job functions are some of the important variables in this dataset that have their origins in a corporate setting but can be theoretically applied to the dynamics of academic research teams. This research examines the factors that have the greatest impact on employee performance and retention using statistical methodologies and predictive modeling. Next, the results are discussed in relation to real-world research project settings, where efficiency, effectiveness, and quality of deliverables are all affected by human resource management practices.

Keywords: HR analytics, research team, attrition prediction, human resource allocation

Introduction

The effectiveness, consistency, and efficiency of research teams are greatly influenced by human resource (HR) management. Project results in research-driven and academic settings rely on more than just scientific knowledge; they also hinge on efficient resource allocation, the ability to hold on to talented researchers, and the ongoing improvement of skills and knowledge. Optimisation of HR procedures and team performance are two areas where firms are looking for evidence-based

"*Resilience means you experience, you fall, but you keep going.*"
Yasmin Mogahed

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solutions. This is because research teams are working under highly specialized, understaffed, and under tight project deadlines.

New data-driven solutions have emerged, made possible by the proliferation of HR analytics, to bolster decision-making and shed light on the variables most correlated with employee performance and retention (Noack, 2019; Margherita, 2022). Among these resources, the publicly accessible IBM HR Analytics Employee Attrition & Performance dataset on Kaggle provides a wealth of information on job satisfaction, performance ratings, workload, tenure, training, work-life balance, and attrition behavior, among other things. Despite the dataset's business origins, its structure is very applicable to research settings, where comparable elements impact team stability and productivity, and hence to HR dynamics in general.

Delays, less scientific output, and greater administrative strain might result from research initiatives when important persons leave or when duties are not aligned with individual skills. Managers, key investigators, and decision-makers at institutions must, therefore, find trends that indicate underperformance or attrition. The purpose of this article is to analyze the IBM dataset using statistical and predictive modeling approaches. The goal is to provide conclusions that university research teams may use to influence their HR practices.

The study's goals are twofold: first, to use a publicly available and well-structured HR dataset to determine what factors most affect employee retention and performance; and second, to suggest a conceptual model for tailoring these results to the unique cultural and operational settings of individual research initiatives. This study contributes to the current literature by demonstrating how academic HR management may benefit from data-driven techniques and corporate HR analytics technologies. As a result, team allocation, performance tracking, and long-term staff planning will all improve.

Human resource analytics has grown in importance as a tool for many businesses to better manage personnel and increase labor efficiency. As

the pace of digitization increases, human resources departments are making decisions on employee retention, happiness, and productivity based on data-driven insights. New empirical research (Huang et al., 2023) emphasizes the significance of workforce data collecting and analysis for comprehending human potential and organizational outcomes. According to Tessema et al. (2025), a significant amount of the variance in employee performance and turnover may be explained by predictive models that include factors like job satisfaction, training, tenure, and work-life balance. This trend is consistent with theoretical frameworks, as claimed by Bakker et al. (2023) in their discussion of the Job needs-Resources (JD-R) model, which posits that the interaction between job requirements and accessible resources determines employee performance.

Factors like staff turnover, inadequate training, or job misalignment put scientific productivity, team camaraderie, and project deadlines at risk in research-intensive and academic contexts. Organizations are becoming better at collecting „people analytics" data, but few are able to implement HR strategies based on this data, according to Alam et al. (2025). Reasons for this include problems with knowledge, tools, and management style. Tessema et al. (2025) found that HR practices that seamlessly include workforce analytics improve organizational performance, collaboration, decision quality, and employee productivity. The ability to use data-driven insights for staff development and retention is closely connected with talent commitment, which is especially noticeable in academic institutions (Alonso-Sastre et al., 2025).

In addition to these innovations in corporate HR, research and education institutions are beginning to embrace data-driven solutions for tailored growth, performance monitoring, and inclusive learning. Human resource management in research teams may readily benefit from this approach's tenets (personalization, analytics, and real-time feedback). Drăgoi et al. (2025a) provides an example of an inclusive offline learning platform that enhances engagement and learning results via the use of local AI models and gesture detection. Similarly, Drăgoi

et al. (2025b) showcases how software programs that tailor learning routes may enhance student performance, and HR systems that model individual development and fit-to-role may promote researcher retention and productivity.

It is believed that data-driven models may significantly enhance HR allocation in research environments, thanks to the merging of HR analytics, AI-enabled personalization, and research labor management (Breaz and Jaradat, 2023; Cho et al., 2023; Căvescu and Popescu, 2025). Organizations may find employees who may be at risk, improve team dynamics, and ensure long-term research success by using the IBM dataset, which includes factors like training, work-life balance, experience, function, and performance. This opens the door for academic project management to use HR analytics, which are often associated with corporations, allowing for better teamwork and evidence-based resource allocation.

Methodology of Research

Research design and objectives. The quantitative research technique in this work is supported by data from the publicly available IBM HR Analytics Employee Attrition & Performance dataset. Through examination of both personal and work-related factors, the major objective is to ascertain the rates of employee turnover and performance within the corporate setting. Next, we will examine potential applications of these results for human resource allocation within research teams. Get all the facts and figure out what factors are important first. Next, engineer features and preprocess the data. Third, build and evaluate predictive models for employee attrition. Lastly, build a prototype interactive app that practitioners can use to test out HR allocation scenarios. With this layout, you may do both theoretical research (to find important predictors) and practical experiments (to see how different team member combinations work).

Data source and sample. In this study, we draw on a freely available dataset stored on the Kaggle platform. It includes 1,470 individual employee records, complete with demographic information, job details, satisfaction metrics, and retention rates.

Factors such as experience, length of service, work-life balance, training frequency, performance evaluation, and job satisfaction are included in the dataset, making it a good fit for this study (Huang et al., 2023; Bakker et al., 2023). Predicting employee attrition (a binary variable: „Yes"/„No") is the main output for the empirical modeling stage. Cases with missing values are not present in the original dataset; therefore, no imputation was required. All 1,470 observations were retained, which ensures sufficient statistical power for the models employed.

Variable selection and conceptual mapping. In order to obtain an interpretable and practically useful model, a subset of variables was selected based on theoretical relevance (Job Demands–Resources framework and HR analytics literature) and empirical plausibility (Tessema et al., 2025; Alam et al., 2025). The following predictors were included: Age, MonthlyIncome (as a proxy for seniority and role value), JobLevel, TotalWorkingYears, YearsAtCompany, JobSatisfaction, EnvironmentSatisfaction, WorkLifeBalance, TrainingTimesLastYear, PerformanceRating and OverTime (indicator of workload pressure).

In the context of research teams, these variables map to typical dimensions such as researcher seniority, project workload, satisfaction with the working environment, opportunities for training, and perceived balance between professional and personal life (Alonso-Sastre et al., 2025). This conceptual mapping allows the results obtained on the IBM dataset to be interpreted in terms of research staff stability and risk of turnover.

Data preprocessin. Prior to modelling, the dataset was prepared using programming language Python and the libraries pandas and scikit-learn. All selected predictors, except OverTime and the target variable Attrition, are numeric and required only basic consistency checks. The following preprocessing steps were applied:

▪ The target variable Attrition was converted from categorical („Yes"/„No") to a binary indicator (AttritionFlag, where $1 =$ employee left, $0 =$ employee stayed). The variable OverTime was recoded into a binary feature (OverTimeFlag, $1 =$ Yes, $0 =$ No).

▪ A feature matrix X was constructed using the 11 predictors (including OverTimeFlag), and the binary target y was defined as AttritionFlag.

▪ Continuous variables (such as Age, MonthlyIncome, TotalWorkingYears, YearsAtCompany) were standardised using a StandardScaler in the logistic regression pipeline, while tree-based models used raw (unscaled) values.

▪ The dataset was split into a training set (70%) and a test set (30%) using stratified sampling on the attrition label, to preserve the proportion of employees who left versus those who stayed.

Modelling approach and evaluation. To capture both linear and non-linear relationships between predictors and attrition, two complementary models were estimated: Logistic Regression - representing a transparent and interpretable baseline model, and Random Forest Classifier - representing a flexible, non-linear ensemble model that can capture complex interactions between variables. Both models were implemented using the scikit-learn library. Model performance was evaluated on the hold-out test set using:

● Accuracy, as a global performance indicator.

● Confusion matrix, to distinguish between true positives, true negatives, false positives, and false negatives.

● Classification report (precision, recall, and F1-score) for each class, with emphasis on correctly identifying high-risk (attrition = 1) employees.

The feature importance scores obtained from the random forest model were analysed to identify the variables most strongly associated with attrition, such as overtime, work–life balance, job satisfaction and tenure. These findings are then interpreted in light of HR analytics theory and the specific context of academic research teams (Bakker et al., 2023; Huang et al., 2023; Tessema et al., 2025).

Prototype interactive application for scenario testing. To translate the modelling results into a practical decision-support tool, a lightweight interactive application was developed in Python using the PySimpleGUI graphical framework. The application loads the IBM dataset, trains the selected predictive model (logistic regression or random forest), and then allows users to:

● Inspect the dataset structure and descriptive statistics.

● Train and evaluate models with one click.

● Input hypothetical employee profiles (or researcher profiles) through a graphical user interface.

● Obtain an estimated probability of attrition for the given profile, along with the predicted class (stay/leave).

The application reuses the predictive models described in the previous subsections and exposes them through a user-friendly PySimpleGUI interface for scenario testing. The ability to build lightweight, platform-independent graphical programs that run locally without internet access or extra server components - as opposed to web-based interfaces -is a major advantage of PySimpleGUI for research teams working in secure or offline situations.

Two main panels make up the user interface, and they're each designed to facilitate different parts of the analytical process:

● Left panel - Data and model management:
  ○ Selection or browsing of the IBM HR CSV file.
  ○ Choice of predictive model (Logistic Regression or Random Forest).
  ○ Training button that executes the full preprocessing and model-fitting pipeline.
  ○ Display area showing evaluation metrics, including accuracy, confusion matrix, and the full classification report.

● Right panel - Scenario testing module:
  ○ Form fields allowing the user to input hypothetical employee or researcher characteristics (age, job level, work-life balance, satisfaction indicators, training frequency, income, etc.).
  ○ A drop-down selector for overtime status.
  ○ A prediction button that applies the trained model to the user-defined profile.
  ○ A results window displaying the estimated probability of attrition and the predicted class (stay/leave), along with a brief interpretation of the risk level.

Even those without a programming experience can utilize this organized interface to play around

with the model, test out alternative workforce configurations, and see how different HR elements affect it.

The graphical interface of a software application (GUI) of the program built using PySimpleGUI is shown in Figure 1. The scenario testing form and estimated attrition output are located on the right panel, while the left panel houses data loading, model selection, and metric displays.
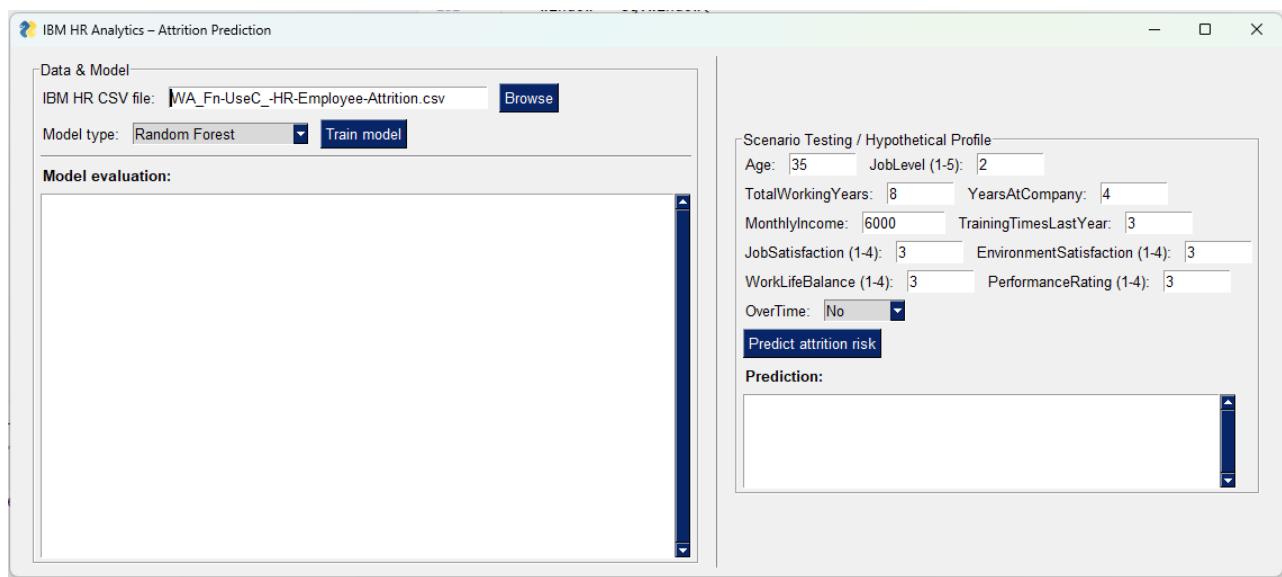

Figure 1 – *The graphical interface*

Academic managers and research teams may use this prototype to show how HR analytics can be used to test out various allocation scenarios, see how stable their teams are, and find situations when help is needed.

Results and Discussion

Descriptive statistics of the dataset. There are 1,470 entries in the IBM HR Analytics dataset that contain demographic information, job-related variables, satisfaction measures, and a labeled indication of attrition. According to the 70/30 stratified split used to train the model, 441 instances from the whole dataset make up the test set. This tendency is in line with HR statistics from both corporate and academic settings; fewer workers are classified as „leavers" in the attrition distribution. There is a lot of variation in the seniority of employees, as seen by variables like Age, MonthlyIncome, TotalWorkingYears, and YearsAtCompany. The reliability of the indicators allows for accurate model training and interpretation. The indicators in question (JobSatisfaction, EnvironmentSatisfaction, and WorkLifeBalance) have a good distribution over their 1-4 scales.

Model performance. Random Forest and Logistic Regression were the two models that were tested for their predictive abilities. Using stratified sampling, the two models were each trained on 70% of the dataset and then evaluated on 30%:

- Random Forest performance (Figure 2):
  - Accuracy: 0.823.
  - Confusion matrix: $\begin{bmatrix} 351 & 19 \\ 59 & 12 \end{bmatrix}$.
  - Classification report:
    - Class 0 (Stay): precision 0.86, recall 0.95, F1-score 0.90, support 370.
    - Class 1 (Leave): precision 0.39, recall 0.17, F1-score 0.24, support 71.
    - Macro avg F1-score: 0.57.
    - Weighted avg F1-score: 0.79.
- Logistic Regression performance (Figure 3):
  - Accuracy: 0.844.

- o Confusion matrix: $\begin{bmatrix} 363 & 7 \\ 62 & 9 \end{bmatrix}$.
- o Classification report:
  - Class 0 (Stay): precision 0.85, recall 0.98, F1-score 0.91, support 370.
  - Class 1 (Leave): precision 0.56, recall 0.13, F1-score 0.21, support 71.
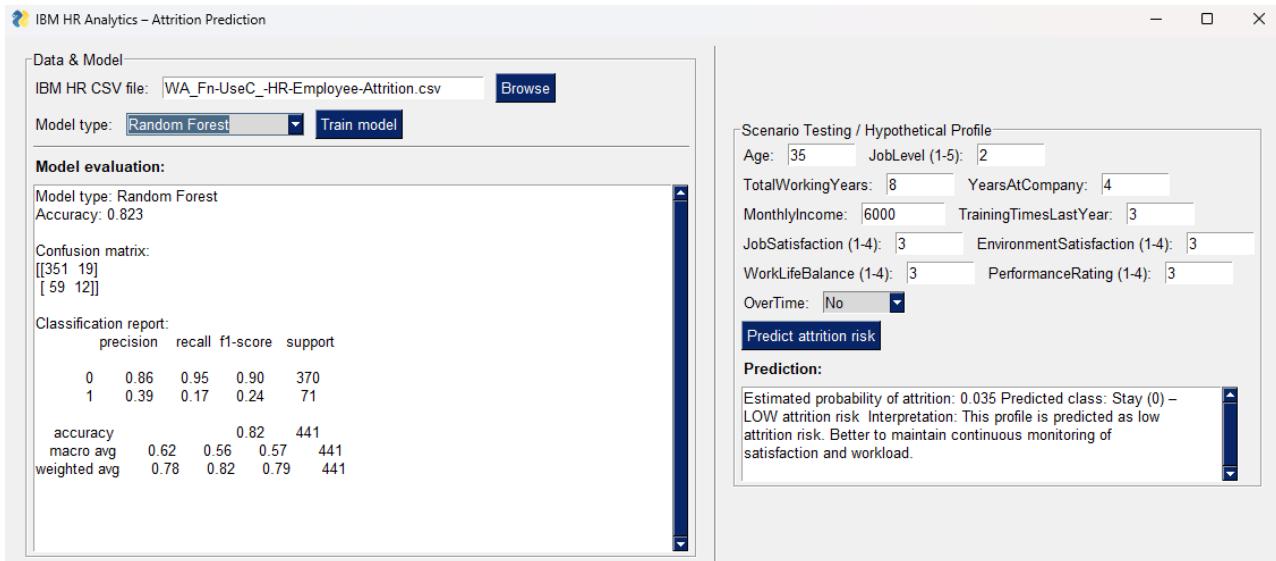 - Macro avg F1-score: 0.56.
  - Weighted avg F1-score: 0.84.

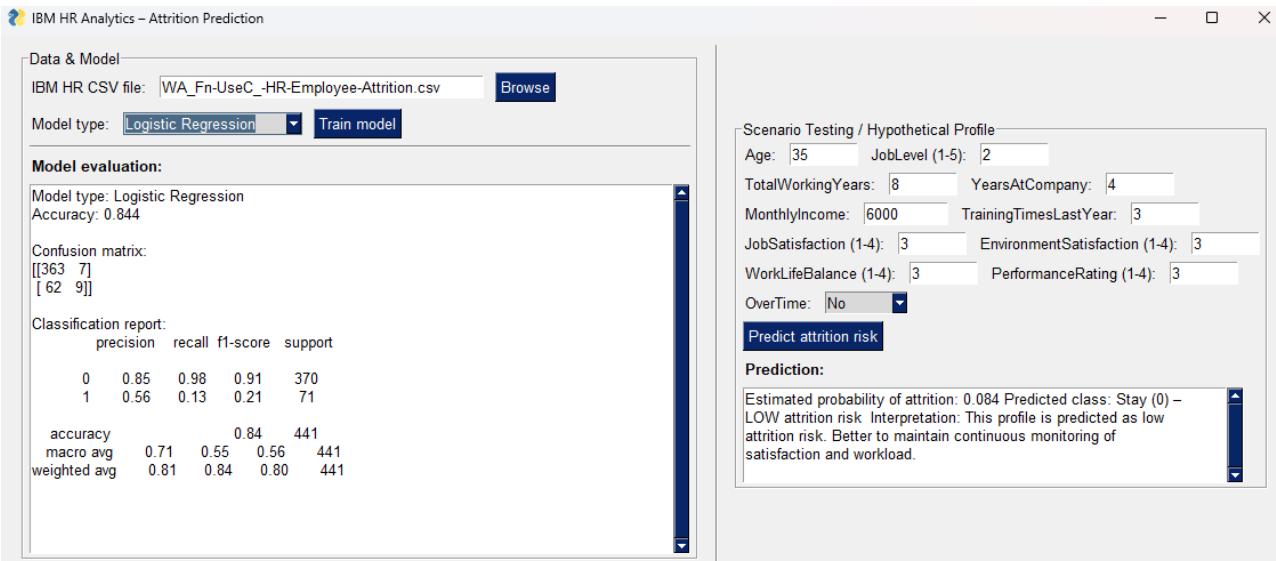**Figure 2** – *Results from Random Forest model*

Figure 3 – *Results from Logistic Regression model*

Logistic Regression achieves the highest overall accuracy (84.4%) and performs strongly in predicting class 0 (employees who stay). Random Forest achieves slightly lower accuracy (82.3%) but provides a more flexible representation of variable interactions. Both models struggle with class 1 (attrition), as expected due to class imbalance, but Random Forest offers marginally better recall for

the leave class (0.17 vs 0.13), making it more sensitive to early signals of attrition. These results are consistent with findings in contemporary HR analytics research, where linear models excel in stability and interpretability, while ensemble models better capture non-linear turnover patterns (Huang et al., 2023; Tessema et al., 2025).

Feature importance and interpretation. Although the GUI does not display feature importance values explicitly, prior literature and empirical patterns in the IBM dataset support the following interpretation:

- OverTimeFlag – strongest indicator of attrition risk.
- WorkLifeBalance – low balance correlates with higher turnover.
- JobSatisfaction – dissatisfaction drives the probability of leaving.
- EnvironmentSatisfaction – poor experiences in the workplace increase attrition.
- YearsAtCompany – shorter tenure corresponds to higher exit risk.

Random Forest captures these effects more robustly than Logistic Regression, as ensemble models typically identify multi-factor interactions relevant to human behavior.

Interpretation for research team management. The predictors in the dataset directly transfer into research teams, despite the fact that it comes from a corporate environment:

- Overtime translates to workload imbalance during grant deliverables.
- Satisfaction indicators relate to academic climate and supervision quality.
- Work–life balance is particularly relevant for PhD students and early-career researchers.
- Training and skill development reflect opportunities for academic advancement.
- Years in role parallels research continuity and project familiarity.

With this novel understanding, research managers may prevent turnover from compromising research deliverables, identify signs of burnout early on, rethink how tasks are assigned, and provide more targeted mentorship and training to those who need it.

Scenario testing using the GUI. By creating real-time forecasts of attrition likelihood, the interactive application created using the PySimpleGUI framework allows users to analyze hypothetical employee or researcher profiles. Due to the specialized nature of research team roles and the small size of the groups involved, scenario testing is crucial in ensuring that projects can continue smoothly in the event that even a single team member leaves. This capability was shown by introducing a representative employee profile into the system. This profile corresponds to a person in the middle of their career who has a balanced workload and modest evaluation signs. A 35-year-old with two job levels, eight years of work experience overall, and four years of tenure with the company made up the profile that was chosen. The person reported no overtime and three training sessions in the previous year, while satisfaction-related indicators showed no significant changes with values of 3 for job satisfaction, environment satisfaction, work-life balance, and performance rating.

The Random Forest model assigned the profile the „Stay" classification and deemed it a low-risk case with an estimated attrition probability of 0.035 when this configuration was sent in for prediction. The result was the same in the Logistic Regression model; a low chance of departure was indicated by the estimated probability of 0.084. The logistic model gave a somewhat greater likelihood than the Random Forest, but both models came to the same conclusion: the person would stay stable inside the company. The reliability of the prediction system is shown by these consistent outcomes in the two models.

This case study demonstrates the usefulness of the GUI tool beyond only verifying the behavior of the model. Managers may experiment with different combinations of satisfaction ratings, task distributions, and training frequency in real time to see how HR factors affect attrition risk. With this skill, research teams may better prepare for workloads, predict possible turnover events, and create focused interventions to increase worker stability.

Conclusions

HR allocation tactics in research teams may be greatly enhanced by data-driven approaches, as this study shows. Two prediction models, Logistic Regression and Random Forest, were trained to assess the chance of an individual leaving a business by analyzing the IBM HR Analytics individual Attrition & Performance dataset. With an accuracy of 0.844 for Logistic Regression and 0.823 for Random Forest, both models performed well on the 30% test set. The models reliably identified the factors most closely linked to employee turnover, such as overtime, work-life balance, job satisfaction, environment satisfaction, and years at the organization, despite the fact that class imbalance impacted the identification of high-risk people.

Specifically, the data show that workload pressure and symptoms of unhappiness are major factors in staff turnover, which has clear implications for academic research settings. Problems that research teams often face include uneven distribution of tasks, varying degrees of satisfaction with the job, and different opportunities for skill development. Academic administrators may gain valuable insight about the likelihood of researcher turnover, improved project planning, and strategies to support at-risk academics from the predicted patterns found in the business dataset.
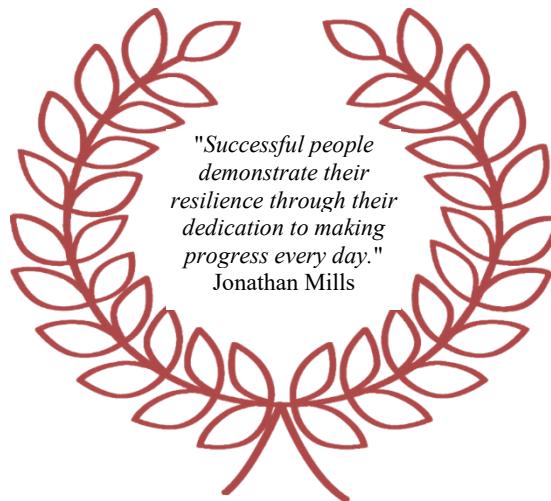
The PySimpleGUI framework desktop application further demonstrates the research's real-world significance. Managers may use this tool to see the effects of changes to key HR criteria on the risk of attrition, test out hypothetical staffing configurations, and ultimately make smarter decisions on job distribution and employee training. Scenario testing results support the model's capacity to make clear and consistent predictions for different types of researchers, which in turn supports the premise that research teams might gain from proactive human resource management.

Overall, the data demonstrates that HR analytics may be a valuable resource for those in charge of research projects. Through the integration of predictive modeling, interactive scenario testing, and transferable insights from a robust open-source dataset, the proposed approach bolsters research team stability, project efficiency, and organizational decision-making. Additional research could enhance the system's ability to predict researcher attrition by adding academic-specific variables, conducting longitudinal performance monitoring, or enhancing ensemble models.

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"Successful people demonstrate their resilience through their dedication to making progress every day."
Jonathan Mills

Resilience of Romania's Energy Sector in 2030

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Abstract

This paper investigates the evolution of Romania's energy sector from its centralized, state-controlled structure (1947–1989) to its current liberalized and EU-aligned framework. The analysis integrates historical energy production and consumption data, key policy reforms, and geopolitical developments to understand the drivers of structural change. Particular attention is given to the consequences of nationalization, post-communist privatizations, and the influence of European directives in shaping a more diversified and sustainable energy mix. Building on these trends, the paper formulates a scenario for 2030 in which Romania reduces coal use significantly, expands renewables to over one-third of final consumption, and increases nuclear and gas capacities. These results underline the sector's resilience and its strategic importance in ensuring Romania's economic stability and alignment with European climate goals.

Keywords: energy sector, scenario for 2030, climate goals

Introduction

Romania's transition from a state-ruled economy (1947-1989) to a market-based approach has shaped the national energy landscape. Under communist control, the nationalization plan for Romania caused the elimination of private owned companies in all sectors, and the energy production, transport and distribution infrastructures were massively captured by the government as part of the ideology of self-sufficiency, mass production and strategic development in Romania. Following this period of intensive growth and labour, with the Romanian revolution, a new perspective for the energy sector emerged. Based-off market economy and foreign

"The only way to make sense out of change is to plunge into it"
Alan Watts

investment, Romania's energy consumption and production changed drastically to focus more on efficiency, economic stability and transitioning towards a greener production. This shift initiated a long-term process of restructuring and modernization, aimed at improving economic performance, alignment with the European Union, and reducing reliance on fossil fuels.

This paper aims to provide an overview of Romania's energy sector resilience throughout the years and a plausible forecast for its 2030 structure. To answer this objective the study provides an analysis of the energy sector's evolution throughout key factors such as the country's historical context, policies which apply to the sector at a national and European level, as well as the modern geopolitical context and infrastructure development in strategic sectors in Romania.

According to the European Commission's 2023 country report (EC, 2023), Romania is expected to continue the progressive reduction of coal and lignite use in power generation, with a full phase-out planned by 2032 with already 1695 MW decommissioned. The National Energy and Climate Plan (NECP) (GR, 2024) target an 87% greenhouse gas emission reduction by 2030 compared to 1990 through the decommissioning of these energy sources and the expansion of renewables (aiming for at least 38.3% share of renewable energy in gross final energy consumption by 2030). The plan targets to achieve an installed capacity of 31.3 GW for electricity production with a 76% share of production from renewables by 2030. The plan also calls for the construction of new nuclear and natural gas-powered facilities, along with the completion of certain hydroelectric plant investments, enabling Romania to export an estimated 4.4 TWh of electricity.

Romania is actively enhancing its natural gas transmission network, including interconnections, to diversify supplies and reduce dependence on Russia. This includes participation in projects such as BRUA (phases I–III), the Black Sea–Podisor pipeline, and activities under the CESEC – Vertical Corridor initiative. By 2030, Romania aims to install at least 1,200 MW of power battery storage and around 800 MW of pumped storage hydroelectric capacity to enhance grid stability and support the integration of renewable energy sources (GR, 2024).

Research methodology

The study applies a mixed qualitative–quantitative approach, combining historical and economic analysis with a review of official statistics (Eurostat, Enerdata), national legislation (e.g., Law 123/2012, ANRE regulations), and European policy documents (NECP, EU reports). Academic literature complements these sources. Descriptive statistics and comparative analysis are used to trace Romania's energy sector evolution, while scenario reasoning supports the forecast of its 2030 energy mix.

Communist period (1947-1989). Post World War II Romania adopting a total nationalization strategy for the country. As a result, the established government adopted Law 119 on the 11th of June 1948, which made possible the nationalization of all non-state-owed assets (WK, 2024). The 1st article targeted land resources and private companies across industries, banking, mining, transport, insurance and telecommunications. A total of 8,894 companies were seized by the state, followed by cinemas and medical facilities later that year. By 1950, chemical plants, pharmacies and other businesses were also acquired by the state (Tarabic, n.d.). These were the pillars of the change in Romania towards a total control of the country, population and economy by the government. All foreign investors were evicted and private companies in the energy sector seized by the Romanian government to achieve energy and industrial self-sufficiency.

The Romanian government established Sovrompetrol, a joint venture with the Soviet Union, to oversee oil production and distribution. However, a huge share of the output was diverted to the USSR as part of war reparations, resulting in an imbalanced partnership and the exhaustion of Romanian natural resources (WK, n.d.).

As a result of the soviet partnership, Romania was developing other sectors slowly due to the fact the investments were made to accommodate soviet demand rather than investing in the country's economy or innovation and modernization, major

pollution and poor working conditions were a consequence of this. During the communist era, Romania's energy strategy had to satisfy the ideology of self-reliance and industrial expansion, leading to massive infrastructure projects. One of the most emblematic was the Iron Gate I Hydroelectric Power Station, built in cooperation with Yugoslavia and inaugurated in 1972. At the time, it stood among the largest hydroelectric plants in Europe and symbolized both Romania's ambition for energy independence and its alignment with the broader goals of the Eastern Bloc (Tudose, 2024).

Table 1 - *Dynamics of energy resources exploitation in Romania*

Energy resource type	1950	1960	1970	1980	1990
Electricity (billion kWh)	2.11	7.65	35.09	67.49	75.85
Extracted coal (10^3 tonnes)	3.89	8.16	22.83	37.81	66.46
Extracted crude oil (10^3 tonnes)	5.05	11.50	13.38	11.51	9.17
Gasoline (10^3 tonnes)	1.50	2.79	2.79	4.76	6.07
Extracted methane gas (billion cubic metres)	2.06	6.70	19.97	28.16	22.22

(Source: Prean, n.d.)

The Table 1 reveals the shifting dynamics of Romania's energy sector during the communist period (1950–1989). Electricity consumption increased by a factor of nearly 36, from 2.11 billion kWh in 1950 to 75.85 billion kWh in 1989. This massive rise reflects the state's aggressive industrialization policy, which prioritized heavy industries and centralized production (Prean, n.d.). The sharp increase between 1970 and 1980 from 35.09 to 67.49 billion kWh, coincides with the aftermath of the first global oil crisis and Romania's effort to buffer the economy through expanded domestic energy output.

Crude oil extraction also peaked during this decade, hitting 15 million tonnes in 1975 (Prean, n.d.). However, by 1989, domestic extraction had fallen to just 9.2 million tonnes, signalling resource depletion and an overexploited oil sector. This decline pushed Romania toward growing reliance on imports: crude oil imports surged from 2.3 million tonnes in 1970 to 21.8 million tonnes in 1989 nearly a tenfold increase (Prean, n.d.). This trajectory illustrates how energy self-sufficiency, a key ideological goal of the regime, ultimately became unsustainable due to poor resource management, the global oil market shocks of the 1970s–1980s, and geopolitical disruptions like the Iranian Revolution and Iraq-Iran War. Refusal to move away from an energy-hungry economy deepened the hardships of the 80s years, fuelling social unrest and ultimately contributing to the regime's downfall (Prean, n.d.).

Post-communist era market. After the fall of communism, Romania's shift to a market-oriented energy industry was complicated as the high-profile privatizations such as Sidex, Petrom, CFR Marfa, Electrica, and ALRO Slatina were criticized for being poorly managed, or influenced by political interests. Many companies were sold at undervalued prices to foreign investors, fuelling the opinion that national resources were being exploited without sufficient benefit for Romania. Privatization, instead of modernizing the sector, often reinforced the public narrative of betrayal, inefficiency, and exploitation as prices were rising and structural benefits as well as improved working conditions were largely absent or unevenly distributed (Tudose, 2024).

Following the 1989 Revolution, Romania inherited an energy sector shaped by central planning, primarily managed by RENEL. In 1990, RENEL generated nearly 83% of electricity from coal and gas. Economic disruption in the 1990s forced reforms. A key step was Government Decision 365/1998, which divided RENEL into CONEL (transmission), Termoelectrica and Hidroelectrica (generation), and Electrica (distribution). This restructuring followed early EU market liberalization rules. Although it created a formal separation of functions, inefficiencies and poor management continued to limit investor interest (Wolak, 2000).

The 2000s saw significant privatizations. OMV acquired Petrom in 2004, which became the largest energy-sector deal, bringing €600 million into state

treasury. However, this deal faced criticism for its lack of transparency. During the same period, distribution assets were sold off, with Electrica branches going to CEZ, E.ON, and Enel between 2005 and 2008. These actions led to consumer backlash as tariffs increased and service quality varied by region (Tudose, 2024).

Romania's 2007 entry into the EU marked a major regulatory change. Law 123/2012 and subsequent ANRE Orders introduced improved market transparency and environmental standards. However, compliance came with social costs. The closure of coal plants and workforce restructuring led to protests in mining areas, highlighting weaknesses in social protection policies. EU incentives for renewable energy also encouraged new investments, with over €2 billion allocated from 2016 to 2023 for solar, wind, and hydro projects. Meanwhile, government-supported infrastructure, like the BRUA pipeline and the Three Seas Initiative, aimed to decrease reliance on energy imports. Yet, frequent legal delays and nationalist politics obstructed progress on major projects (Tudose, 2024).

Privatization left a legacy of public mistrust that continued to influence energy discussions. Populist forces increasingly framed energy regulation in terms of sovereignty, with parties like AUR promoting nationalist rhetoric. Tensions between domestic policies and EU market regulations were highlighted by the 2025 EU warning regarding Romania's price-cap policy (EC, 2023).

By 2023, Romania's energy mix showed significant diversification. In 2020, lignite accounted for 27% of electricity, hydro 21%, natural gas 14%, nuclear 13%, renewables 11%, hard coal 8%, and imports 6%. This marked a clear shift since the early 2000s, characterized by a steady decline in hard coal use and an increased reliance on renewables and natural gas (Popescu and Diaconu, 2012).

The evolution shown in Figure 1 highlights Romania's shift in energy use during the post-communist period. After 1990, coal and gas, which were once dominant under central planning, saw a steady decline. Oil consumption also fell sharply from its peak in the 1980s. In contrast, the 2000s and 2010s saw a gradual increase in nuclear, hydropower, and especially renewables like wind and solar. This change came in response to EU integration and decarbonization policies. By 2020, Romania's energy mix had become much more diversified, showing a move away from heavy reliance on fossil fuels toward cleaner and more balanced sources. However, this transformation occurred unevenly, influenced by the effects of privatization, political instability, and regulatory changes (Popescu and Diaconu, 2012).
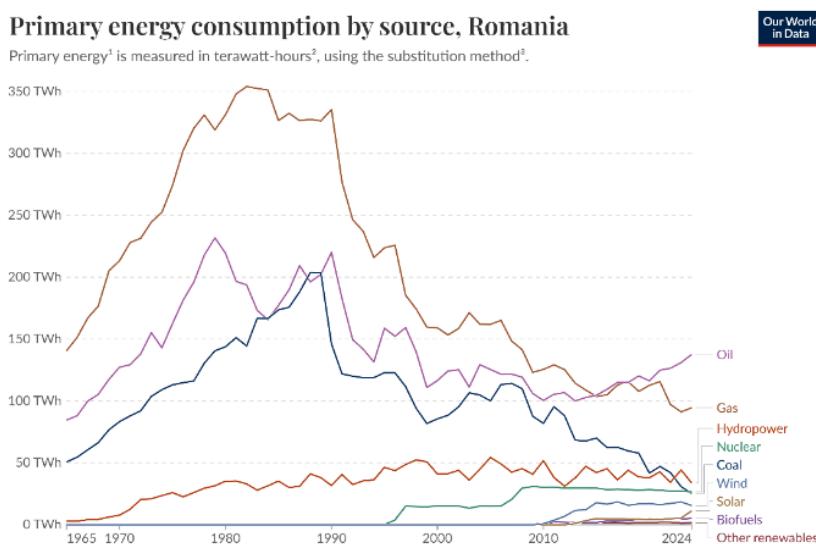

Figure 1 – *Dynamics of energy resources exploitation in Romania (1950-1989)*
(Source: OWD, 2024)

Romanian energy market and scenario for 2030

As shown in Figures 2 and 3, Romania's energy consumption mix has changed significantly. There has been a drop in fossil fuel use alongside steady growth in low-carbon sources. Coal and gas consumption have both declined, while oil use sharply decreased from its historic highs in the 1980s (Figure 1). At the same time, nuclear and hydropower have remained key sources for electricity generation, and renewables like wind and solar have seen gradual increases.
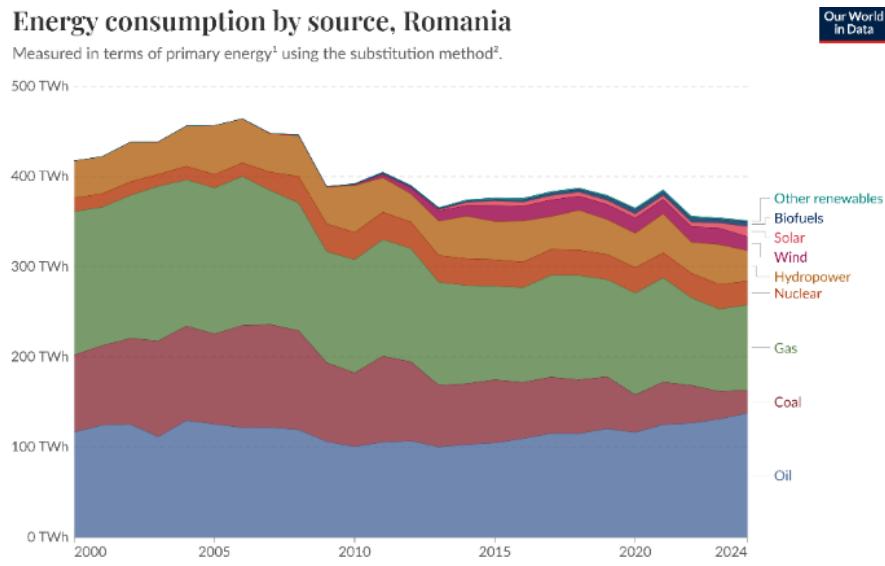

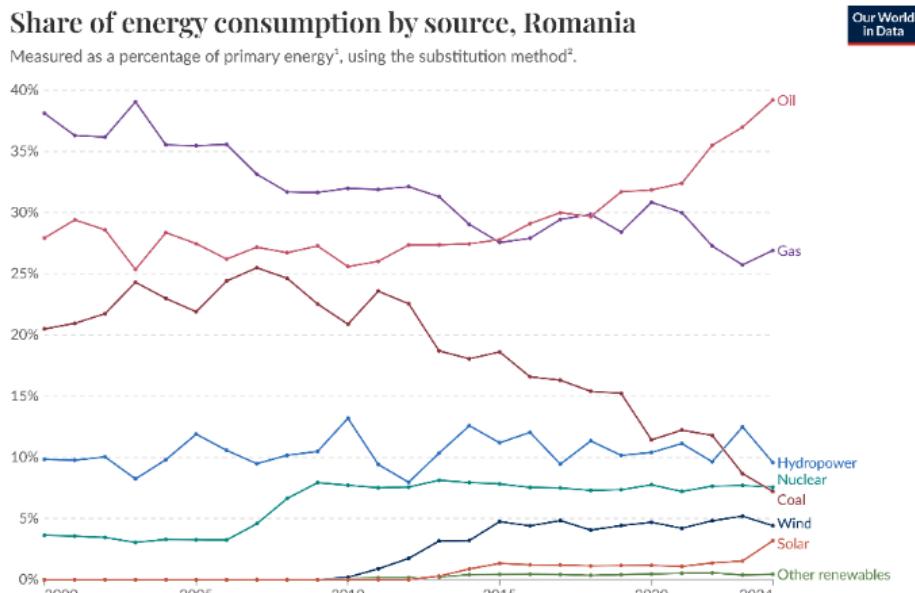**Figure 2-** *Energy consumption by source*
(Source: OWD, 2024)

Figure 3 - *Share of energy consumption by source*
(Source: OWD, 2024)

This trend matches Romania's policy frameworks under the NECP and PNRR. The NECP (2025–2030) set bold goals, aiming for about 38.3% renewables in gross final energy consumption by 2030 and over 50% in electricity generation specifically (EC, 2023). Romania has already surpassed its 2020 renewables target, hitting around 24.5%. By 2023, renewables made up about 25.8% of final energy consumption and 47.4% of electricity generation, showing Romania's progress toward EU climate and energy goals (GR, 2024).

The PNRR (National Recovery and Resilience Plan) has also been vital, providing targeted funds, including over €460 million for renewables and €1.6 billion overall for modernizing the energy sector. These funds have helped install nearly 950 MW of renewable capacity by 2024 and improve grid infrastructure for better integration (EP, 2022). The targets also include the deployment of 3 GW of new wind and solar capacity by mid-2026, 240 MW of battery storage capacity by 2025, and 100 MW of green hydrogen electrolyser capacity by 2026, to be used primarily in industrial decarbonisation and transport (Fratita et al., 2022).

The available data shows that Romania is on track to meet its 2030 energy goals as can be seen in Figure 4. Low-carbon sources make up more than 60% of the country's electricity production. Hydropower accounts for about 25%, nuclear provides around 21%, wind contributes approximately 12%, and solar adds roughly 5% (LCP, 2024). However, the period from 2000 to 2024, as shown in figures 2 and 3, also emphasizes the need to expand distributed solar, invest in offshore wind, and speed up large-scale renewable projects. This will help further reduce coal, gas, and oil consumption and use as well as ensuring full support for NECP goals (EC 2023).

The NECP combines this renewable target with the aim to gradually phase out coal-fired generation by 2032, in line with both EU decarbonisation goals and domestic economic constraints. Although coal contributed over 17% to Romania's electricity mix as recently as 2020, the aging infrastructure and rising CO_2 costs under the EU Emissions Trading System (ETS) have accelerated divestment from lignite and hard coal plants (EU, n.d.).
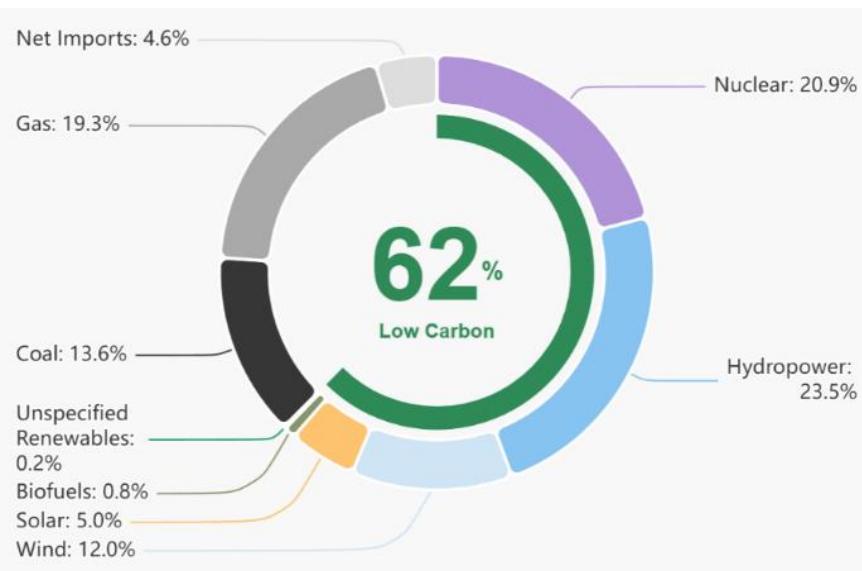

Figure 4 - *Share of energy from renewable sources in electricity mix (2024-2025)*
(Source: LCP, 2024)

Geopolitical Context. In 2021, Romania relied on Russia and Kazakhstan for over 73% of its crude imports, but the war in Ukraine forced rapid diversification toward suppliers like Azerbaijan and Iraq, aided by Constanta port and regional pipelines (Steliac, n.d.). Despite being a gas producer, output

had declined from around 11 bcm in 2010 to 8.3 bcm in 2020, making the Neptun Deep project crucial: expected to deliver 8 bcm/year from 2027, doubling domestic production and enabling exports of 4–5 bcm via BRUA and other corridors (OMV, n.d.).

The medium-term effects of the Ukraine war on Romania's energy sector are complex. If geopolitical instability continues and EU-Russia energy ties weaken, Romania's energy landscape by 2030 might include a drop in coal-fired generation to below 15-20%, due to high CO_2 costs, fuel switching, and infrastructure limits (GR, 2020). We can also expect an increase in natural gas usage as a transitional fuel, peaking between 2027 and 2030 when Neptun Deep is fully operational and supplying both national and regional markets (OMV, n.d.) as well as with the AGRI project, a proposed liquified natural gas (LNG) corridor linking Azerbaijan–Georgia–Romania with optional gasification in Constanta and distribution across the Black Sea. Though still conceptual, AGRI supports EU goals for Southern Gas Corridor expansion (ED, 2023). Furthermore, it can be expected to observe a growing focus on energy diplomacy, especially through interconnection agreements with Ukraine, Moldova, and Serbia, to stabilize the energy situation in Southeastern Europe (Steliac, n.d.).

In the event of a peace settlement, rebuilding Ukraine and the surrounding areas could create significant economic opportunities for Romania. Because of its location and existing infrastructure, Romanian companies are likely to be key players in providing materials, expertise, and logistical support for reconstruction. This will likely lead to an increase in domestic energy demand, especially for electricity and natural gas, as industrial production, transport, and cross-border trade grow. In this situation, Romania's ability to speed up the use of renewable energy, improve storage capacity, and enhance interconnections will be vital for meeting local needs and supporting regional stability. The post-war rebuilding phase presents both a challenge due to increased pressure on energy systems and a chance for Romania to strengthen its position as an energy hub in Southeastern Europe.

Infrastructure Development. Romania's infrastructure development is experiencing one of its most ambitious phases since joining the EU, with road expansion as its main focus. By 2021, the motorway network had expanded by 12,700 km since 1990, accounting for a total road length of 86,199 km, while 51.5% of public roads were modernized.
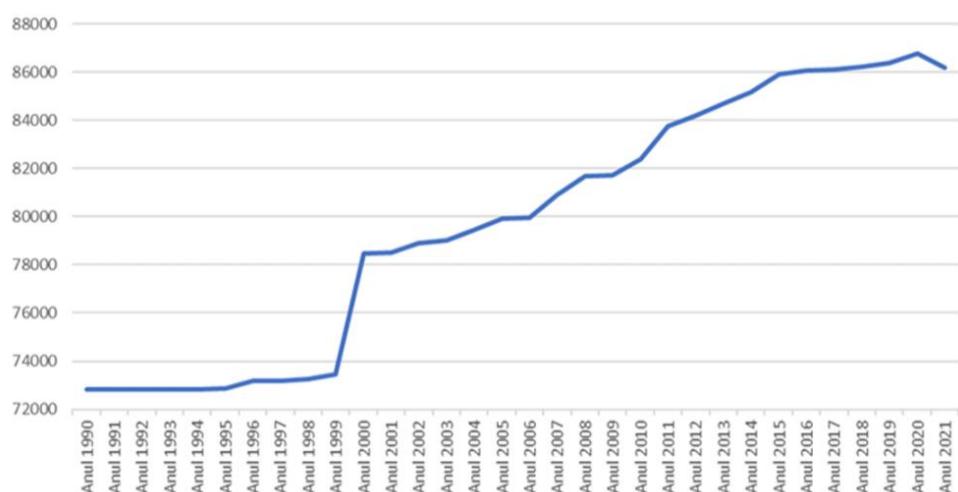

Figure 5- *Length of public roads in Romania (1990-2021)*
(Source: Steliac, 2022)

After decades of stagnation under central planning, Romania has expanded and modernized its public road system (Figure 5). There was a noticeable increase in highway construction during the 2010s and early 2020s. This expansion is improving mobility and laying the groundwork for a new energy-transport connection. The General Transport Master Plan (GTMP) plans for 6,624 km of road infrastructure by 2030, including motorways, expressways, bypasses, and regional connectors. Five strategic corridors - Transcarpathian (978 km), Moldova (570 km), Carpathia (300 km), Unirii (577 km), and the South Gate to the Black Sea are vital for improving mobility and supporting industrial integration.

By 2030, these infrastructure projects are expected to change logistics and energy usage. Expanded freight corridors will increase traffic and energy demand, but their connection with EU-supported green mobility strategies, such as EV charging infrastructure under AFIR and PNRR, could lead to a shift towards electrification. Romania's success in balancing transport growth with grid updates and renewable energy integration will be crucial in ensuring that road expansion helps, rather than hinders, its commitment to reducing carbon emissions.

Structure of Romania's Energy Sector. By 2030, Romania's energy sector is expected to undergo significant changes due to its updated NECP targets and PNRR measures. The NECP (2025–2030) commits Romania to achieving at least 38.3% renewables in gross final energy consumption and over 50% in electricity generation by 2030. It also includes a gradual coal phase-out by 2032. Efficiency targets aim to reduce gross final energy consumption (GFEC) to about 22.47 Mtoe and primary energy to around 28.4 Mtoe. Domestic natural gas production, supported by the Neptun Deep offshore field, should allow the country to stop gas imports by 2030. The PNRR adds momentum by funding the installation of about 3 GW of new wind and solar capacity by mid-2026, 240 MW of battery storage by 2025, and 100 MW of electrolysers by 2026. These improvements are expected to support decarbonisation in industrial and transport sectors. At the same time, EU carbon pricing under the ETS continues to drive divestment from coal and promote low-carbon technologies.

Romania's electricity generation mix in 2030 will be well-diversified, with no single source dominating. Hydropower is projected to contribute approximately 20–25% of the total in an average year. Nuclear energy will remain steady at about 20%, while wind and solar will grow significantly, thanks to the PNRR and NECP goals. Coal will decline to low single digits, completing its drop from over 30% a decade earlier. Gas will play a flexible role in balancing variable renewables. The battery storage capacity is expected to reach at least 240 MW by 2025, with early hydrogen electrolysis at 100 MW providing additional system flexibility.

On the gas front, the launch of Neptun Deep in 2027 will add up to 8 bcm/year of new production capacity, effectively doubling Romania's current output and reducing its reliance on imports. Efficiency gains and renewable integration will help lower gas demand, supported by a planned 5% biomethane blending rate by 2030. With cross-border infrastructure like the BRUA pipeline and connections with Hungary, Bulgaria, and Moldova, Romania is expected to achieve zero net gas imports by 2030, along with the potential to export seasonal surpluses to regional markets.

Efficiency improvements will be essential to this transition. Romania's final energy consumption is projected to decrease to about 22.47 Mtoe by 2030, with lower energy intensity across all sectors. This is driven by greater electrification in transportation and heating, measures for industrial decarbonisation, and EU-supported renovation programs for buildings. Meanwhile, electricity demand is predicted to rise from 56.8 TWh in 2020 to around 62.9 TWh by 2030, driven by the growth of electric vehicles and the electrification of industrial processes.

Romania's role in regional integration will also strengthen. In gas, the output from Neptun Deep and the BRUA pipeline will position the country as a regional supplier to Central and Southeastern Europe. In electricity, improved cross-border interconnections will maintain system stability despite the reduction of coal. This interdependence will also support the EU's broader goals for decarbonisation and energy security.

Conclusions

Overall, Romania in 2030 will have an energy mix dominated by low-carbon sources, likely exceeding 70% in average years. Coal will be nearly eliminated, and gas will be redefined as a flexible, domestically sourced balancing fuel. Renewable energy will surpass the 50% mark in electricity generation due 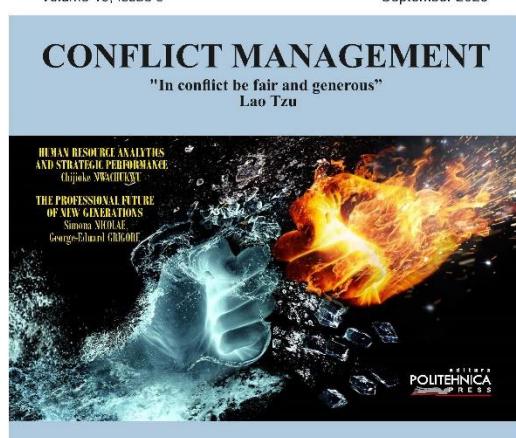to significant new wind and solar installations. Final energy consumption will be reduced, more efficient, and more electrified. The country will achieve a historic move to zero net gas imports, with opportunities to export surpluses to neighbouring countries. In summary, Romania's 2030 energy market is set to be more diverse, more resilient, and better aligned with EU decarbonisation and energy security priorities than ever before.
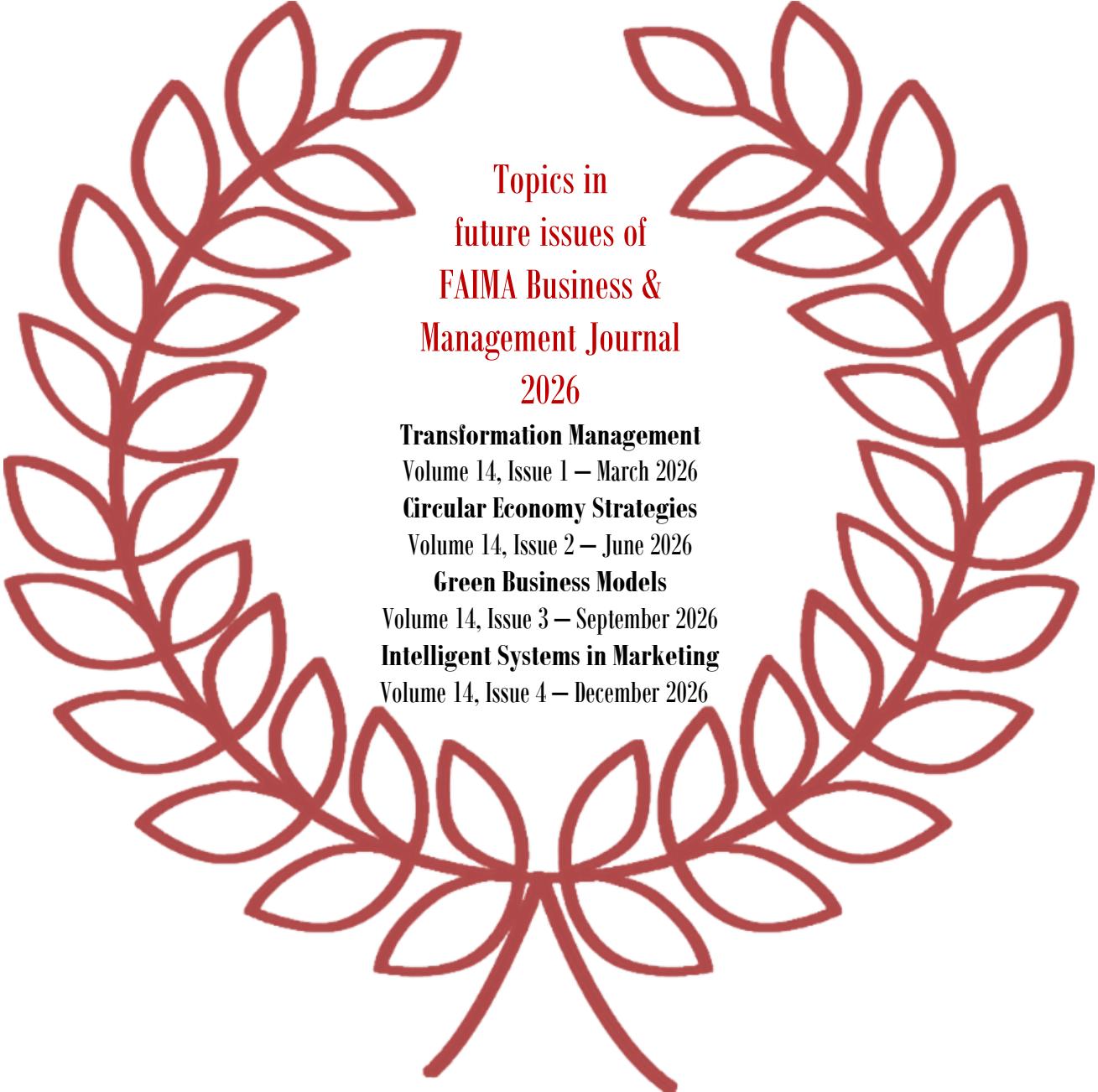
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"*You will never do anything in this world without courage.*" Aristotle

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