Balkans Journal of Emerging Trends in Social Sciences

– Balkans JETSS –

Vol. 9 – No. 1 – 2026

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Balkans Journal of Emerging Trends in Social Sciences

ISSN: 2620-164X

Balkans Journal of Emerging Trends in Social Sciences – Balkans JETSS

Aims and Scope

The mission of Balkans JETSS is to publish peer-review empirical research papers that test, extend or build theory and contribute to practice. All empirical methods – including, but not limited to, qualitative, quantitative, field, laboratory, and combination methods are welcome. Empirical, theoretical and methodological articles from all major fields of economics, management, tourism, law and the like are featured in the journal. Theoretical and/or review articles that integrate existing bodies of research and that provide new insights into the field are also encouraged.

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Manuscripts should not exceed 16 pages (450 word per page). This page limit includes all figures, tables, appendices and references.

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https://www.balkans-jetss.org

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Publication frequency – one volume, two issues per year.

Publisher – Association of Economists and Managers of the Balkans, Belgrade, Serbia.

Co-publisher – Faculty of Tourism and Hospitality – Ohrid, University "St. Kliment Ohridski" – Bitola, Ohrid, North Macedonia.

Printed by Skripta Internacional, Belgrade, Serbia

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Issue DOI:
https://doi.org/10.31410/Balkans.JETSS.2026.9.1

CIP – Katalogizacija u publikaciji
Narodna biblioteka Srbije, Beograd
316.42
BALKANS Journal of Emerging Trends in Social Sciences : Balkans JETSS / editor-in-chief Aleksandar Trajkov. - Vol. 1, no. 1 (2018)- . - Belgrade : Association of Economists and Managers of the Balkans, 2018- (Belgrade : Skripta Internacional). - 25 cm
Polugodišnje.
Dostupno i na: http://www.udekom.org.rs/balkans-jetss.html .
ISSN 2620-164X = Balkans Journal of Emerging Trends in Social Sciences
COBISS.SR-ID 270984460

Balkans JETSS (2026) 1: 1-10
DOI: https://doi.org/10.31410/Balkans.JETSS.2026.9.1.1-10

Original Scientific Article

The Economic Impact of Internet Usage in Balkan Countries

Albina Hysaj[1]

Received: August 30, 2025 / Revised: June 7, 2026 /
Accepted: June 25, 2026 / Published: June 30, 2026
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Abstract: *This paper attempts to analyze the impact of internet usage on economic growth in nine Balkan countries, namely Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, Serbia, Croatia, Bulgaria, Greece, and Romania, from 2010 until 2022 by incorporating several control variables such as foreign direct investment, governmental expenditures, net exports, and labor. Through a cross-sectional panel data analysis, the results indicate that internet usage, foreign direct investment, and labor have a statistically significant positive effect on economic growth. However, other variables such as governmental expenditures and net exports have a statistically significant negative effect on economic growth. The findings of this paper hold important implications for policymakers: enhancing digital connectivity and investing in ICT infrastructure, alongside supporting complementary growth factors, can substantially contribute to fostering economic growth in the region.*

Keywords: *Internet usage; Economic growth; Balkan countries; Panel data analysis*

JEL Classification: O47, O33

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1. INTRODUCTION

The internet is one of the most significant innovations of the twentieth century. Considering the role of the internet as a communication network, its implications in technology, commerce, and information flow are indisputable. There exist several theoretical and empirical models that link the development of the internet with economic growth. Endogenous growth models emphasize the role of human capital, knowledge, and innovation in technology as leading forces of long-term economic growth (Novales et al., 2009), through different channels such as lowering information costs, increasing the efficiency of the market, and optimizing resource allocation (Brookes & Wahhaj, 2001; Țurcan et al., 2023; Wang et al., 2022).

Moreover, several empirical studies subjecting different regions worldwide confirm the significant contribution of the internet to economic growth. Czernich et al. (2011), who investigate the impact of broadband penetration on economic growth in OECD countries from 1996-2007, find that a 10-percentage point increase in broadband penetration would contribute to an annual 0.9-1.5 percentage point increase in per capita growth. A later study for Latin America indicates that for the period 2010-2018, the increase in broadband connections has a significant positive effect on the economic growth of the region (Alderete, 2022). Furthermore, studies for Asia and ASEAN countries confirm the existence of a positive impact of broadband penetration on economic growth (Alam et al., 2019; Camba & Camba, Jr., 2020).

Even though there is a growing body of literature confirming a significant positive effect of internet usage on economic growth, there is a lack of evidence regarding the Balkan countries. The Balkan region represents a particularly important case study since it is mostly dominated by transitional economies with rapid development, which show a significant digitalization process as a necessity to fulfil the criteria for EU integration.

Balkan economies have several structural characteristics as well. The informal economy, supported by a high level of corruption, is still a significant challenge for Balkan countries (Mungiu-Pippidi, 2015). Moreover, due to continuous high migration rates, the Balkan countries are still heavily reliant on remittances (Jushi et al., 2021; Ziberi & Alili, 2021). At the same time, the economy is mostly dominated by sectors such as construction and tourism that are not directly related to the digitization process. Considering all those challenges in Balkan countries, the question is raised while the usage of the internet has a significant effect on economic growth in the region. Analyzing the impact of internet usage in Balkan countries has a particular academic and policy significance, with a special emphasis on enriching the literature of information communication technology by offering insights from the region and enabling policymakers to support their decisions with empirical analysis.

This study's purpose is to inspect the influence of internet usage on economic growth in Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, Serbia, Croatia, Bulgaria, Greece, and Romania for the period from 2010 to 2022, through a panel data analysis. The following section is a brief literature review of the relevant studies, which is followed by an explanation of the method and methodology used to capture the relationship between the variables used. Additionally, the findings and the conclusions are discussed.

2. LITERATURE REVIEW

An increasing number of studies investigate the impact of the internet on economic growth or other macroeconomic variables. Salahuddin and Gow (2016) analyze the short-run and long-run

relationship of internet usage, trade openness, and economic development on economic growth in South Africa from 1991 to 2013. The authors find a positive long-run relationship between internet usage, economic development, and economic growth. Moreover, the findings indicate that internet usage and economic development Granger-cause economic growth, marking significant implications for policymakers. Also, Haini (2022), who investigates the impact of the internet on economic growth in Southeast Asian countries from 1999 until 2017, finds that the internet has a positive impact on economic growth. By using a fixed-effects method of moment quantile regressions, the author finds that the effect of the internet is stronger for developed countries compared to developing countries.

Appiah-Otoo and Song (2021) conduct very inclusive research regarding the impact of internet usage on economic growth. The authors compose the ICT index by using variables such as mobile, internet, and fixed broadband use, and make a comparison of the ICT index on economic growth in 123 low-, medium, and high-income economies from 2002 until 2017. The findings of their study reveal that in all groups, the ICT Index positively affects economic growth, but it seems to be more beneficial in low-income countries. Similarly, Bhattacharya and Ghosh (2020) analyze the influence that internet usage has on economic growth for the period 2002-2011 in 39 middle- and low-income countries by using a panel data regression. The authors find that there is a significant and positive impact of the internet on economic growth in middle-and low-income countries, even though this impact is shadowed by the financial crises.

Li (2019) applies dynamic panel data to analyse the impact of the internet on economic growth in the Belt and Road Region for the period between 1996 and 2014. The author finds that there is a positive effect of the internet on economic growth. Moreover, the findings reveal that the effects are stronger when the level of development is higher. However, the impact of the internet on economic growth is strongly related to several macroeconomic factors, such as capital, labour, technological development, international trade, the level of economic development, and the economic structure of the country. The study implies that joint efforts towards internet development in the region would contribute to a higher impact on economic growth.

Choi and Hoon Yi (2009) investigate the influence of the internet on economic growth in 207 economies for the period 1991-2000 by using the internet user ratio as an explanatory variable, accompanied by several control variables such as investment ratio, government consumption ratio, and inflation. The authors find that the internet has a positive and significant impact on economic growth in the countries analyzed. Bahrini and Qaffas (2019) also investigate the impact of ICT on economic growth in MENA and Sub-Saharan countries from 2007-2016 by using several indicators of internet usage, such as fixed and mobile phones, internet usage, and broadband adoption. The findings reveal that mobile phones, internet usage, and broadband adoption have a significant positive impact in all countries.

The study of Noh and Yoo (2008) is particularly significant as it investigates the impact of internet adoption and income inequality on economic growth in 60 countries from 1995 to 2002 using panel data. The findings reveal that the effect of internet adoption on economic growth becomes negative in countries with high income inequality, as the digital divide limits the growth-enhancing benefits of internet adoption.

Based on the review of the literature, most of the studies support a positive relationship between internet usage and economic growth. However, the empirical evidence comes from Asian, African, and OECD countries. Given the economic specifics of the Balkan countries and considering

that there is no study investigating the relationship between internet usage and economic growth in Balkan countries, this study aims to fill this gap. The main hypothesis of this study is:

Hypothesis One: There is a statistically significant positive relationship between internet usage and the GDP Growth rate in Balkan countries.

3. METHODOLOGY

This study uses balanced panel data analysis to investigate the relationship between internet usage and economic growth in nine Balkan economies, such as Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, Serbia, Croatia, Bulgaria, Greece and Romania, from 2010 until 2022. The dependent variable is the GDP growth rate as a proxy for economic growth. The explanatory variable is individuals using the internet as a percentage of the population. Moreover, other variables such as foreign direct investments, government expenditures, labor force participation, and net exports are used as control variables. All the data used are retrieved from the World Bank Database.

The general model is shown in equation 1:

$$GDP\ Growth_{it} = \beta_0 + \beta_1 \text{INTERNETUSERS}_{it} + \beta_2 \text{GOVEXP}_{it} + \\ + \beta_3 \text{NETEXP}_{it} \beta_4 \text{FDI}_{it} + \beta_5 \text{LABOR}_{it} + \mu_{it} \quad (1)$$

where,

- **GDP Growth** (GDP Growth_{it}) – dependent variable, GDP Growth Rate (%).
- **Internet users** ($\text{INTERNETUSERS}_{it}$)- independent variable, individuals using the Internet (% of population)
- **Governmental Expenditures** (GOVEXP_{it}) – independent variable, final consumption expenditure (% of GDP)
- **Net Exports** (NETEXP_{it}) – independent variable, net exports of goods and services (% of GDP)
- **Foreign Direct Investments** (FDI_{it}) – independent variable, foreign direct investment, net inflows (% of GDP)
- **Labor** (LABOR_{i}) – independent variable, labor force participation rate, total (% of total population ages 15-64)
- β_0 – intercept
- $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ – coefficients of the independent variables.
- μ_{it} – error term, capturing all unobserved factors affecting GDP growth.
- i – cross-sectional unit (country).
- t – time period (year).

Several tests are conducted to ensure that the OLS estimation is unbiased. Initially, a multicollinearity test is performed to ensure that there is no correlation among independent variables that would affect their impact on the dependent variable. Table 1 shows that all correlation coefficients are below 0.8, indicating no evidence of severe multicollinearity among the independent variables.

The stationarity of the variables is evaluated by using the Phillips-Perron estimation. The results shown in Table 2 indicate that GDP, foreign direct investment, internet users, and labor are stationary at the level, while other variables, such as governmental expenditures and net exports, are stationary at the first difference. All the following estimations will be based on those results.

Table 1. Correlation matrix

	FDI	GOV_EXP	INTERNET_USERS	LABOR	NET_EXP
FDI	1.00				
GOV_EXP	0.33	1.00			
INTERNET_USERS	0.15	0.20	1.00		
LABOR	0.06	-0.17	0.08	1.00	
NET_EXP	-0.54	-0.77	-0.11	0.11	1.00

Source: Authors' calculation using E-Views 10

Table 2. Series stationarity estimation

Variable	Philips-Perron	Level Prob	Philips-Perron	1st Diff Prob
GDP	93.82	0.00		
FDI	51.78	0.00		
GOV EXP	15.87	0.60	91.14	0.00
INTERNET_USERS	85.70	0.00		
LABOR	93.43	0.00		
NET_EXP	18.95	0.39	96.71	0.00

Source: Authors' calculation using E-Views 10

The Hausman test is utilized to determine whether the Fixed or Random Effect model is more appropriate. The results indicate a chi-square statistic of 5.84 with 5 degrees of freedom and a probability value of 0.32. Since the p-value is above the 5% significance level, the null hypothesis cannot be rejected, implying that the Random Effect Model is more appropriate for the analysis.

Heteroskedasticity is tested by regressing the squared residuals on GDP and GDP^2. The results shown in Table 4 show that GDP^2 has a positive and significant effect. Also, the F-statistic shows that the regression is significant as well, meaning that the variance of the residuals is not constant and heteroscedasticity is present.

Table 3. Hausman Test

Test Summary	Chi-Sq. Stat	Chi-Sq. d.f.	Prob.
Cross-section random	5.84	5	0.32

Source: Authors' calculation using E-Views 10

Table 4. Heteroskedasticity – Breusch-Pagan Test.

Dependent Variable: RESID01^2				
Variable	**Coeff**	**Std. Error**	**t-Stat**	**Prob.**
C	4.473	1.475	3.033	0.003
GDP	0.121	0.286	0.423	0.674
GDP^2	0.127	0.033	3.857	0.000
F-statistic	7.504	**Prob(F-statistic)**		0.00

Source: Authors' calculation using E-Views 10

The results of the LM test for serial correlation are shown in Table 5. Neither of the coefficients of lagged residuals is significant. Moreover, the probability value of the F-statistic suggests that the model is not significant. The results reveal that the model does not suffer from serial correlation.

One of the key assumptions of OLS estimation is the zero conditional mean assumption, which indicates that the error term is not correlated with the explanatory variables. As shown in Table 6,

the coefficient of correlation between the residuals and other variables is almost zero. Moreover, the mean value of residuals is zero (1.54E-16), indicating that the zero conditional mean assumption is satisfied.

Table 5. LM Test for Serial Correlation.

Dependent Variable: RESID01				
Variable	**Coeff**	**Std. Error**	**t-Stat**	**Prob.**
RESID01(-1)	0.148	0.104	1.418	0.159
RESID01(-2)	0.149	0.115	1.291	0.2
F-statistic	1.449	**Durbin-Watson stat**		2.073
Prob(F-statistic)	0.197			

Source: Authors' calculation using E-Views 10

Table 6. Correlation matrix of residuals

	FDI	**D_GOV_EXP**	**D_NET_EXP**	**INTERNET_USERS**	**LABOR**
RESID01	-9.88E-17	5.04E-16	2.35E-16	5.37E-17	2.54E-16

Source: Authors' calculation using E-Views 10

4. RESULTS

Based on the Hausman test, the Random Effect Model is the most appropriate. In order to correct for heteroskedasticity, the White diagonal method is used, and the estimation output is shown in Table 7.

Table 7. Estimation output

Dependent Variable: GDP				
Method: Panel EGLS (Cross-section random effects)				
White diagonal standard errors & covariance (d.f. corrected)				
Variable	**Coeff**	**Std. Error**	**t-Stat**	**Prob.**
C	0.0319	0.720	0.044	0.964
FDI	0.341	0.111	3.069	0.002
INTERNET_USERS	0.097	0.026	3.700	0.000
LABOR	0.326	0.128	2.549	0.012
D_GOV_EXP	-1.351	0.167	-8.045	0
D_NET_EXP	-0.322	0.148	-2.173	0.032
	Weighted Statistics			
R-sqrd	0.605	**Adj R-sqrd**		0.585
F-stat	31.28	**Prob(F-statistic)**		0

Source: Authors' calculation using E-Views 10

Table 7 presents the results of the Panel Estimated Generalized Least Squares (EGLS) estimator with cross-section random effects, using White diagonal heteroskedasticity-consistent standard errors and covariance matrix (d.f. corrected) to account for heteroskedasticity. The model is estimated using feasible generalized least squares (FGLS), with weighted statistics obtained from the EGLS transformation. The model explains approximately 60.5% of the variation in GDP growth ($R^2 = 0.605$), and the F-statistic indicates that the model is jointly significant.

Among the explanatory variables, internet users, foreign direct investment, and labour have positive and statistically significant effects on GDP growth, indicating that higher internet penetration, investment, and labour input contribute to economic growth. In contrast, government

expenditure growth and net export growth are negatively associated with GDP growth, suggesting that increases in these factors may exert short-term adverse effects on output.

The findings reveal that a one-unit increase in internet users is associated with a 0.097 percentage-point increase in the GDP growth rate. This suggests that higher internet penetration contributes to increased economic growth, possibly due to increased business productivity that comes from innovation and digitalization. Regarding the effect of foreign direct investments, a one-unit increase in FDI is associated with a 0.341 percentage point increase in the GDP growth rate. Also, a one-unit increase in labor is associated with a 0.326 percentage point increase in the GDP growth rate. These findings align with the endogenous growth theory, which determines technological progress, knowledge, investment, and efficient labor as the determinants of growth. On the other hand, a one-unit increase in net export is associated with a 0.323 percentage point decrease in the GDP growth rate. The findings indicate that increased net exports do not necessarily promote economic growth. Xi Wan et al. (2022), which investigates 130 developing countries, find that export-oriented policies may lead to deindustrialization, which reduces the contribution of the manufacturing sector to economic growth, particularly in developing and lower-income countries.

Regarding government expenditures, a one-unit increase in the government expenditure growth is associated with a 1.351 percentage point decrease in the GDP growth rate. The negative coefficient on government expenditure growth is consistent with the findings of Delgado (2023), who examined the relationship between public expenditure and economic growth in European Union countries during 2004–2019. The study found that total public expenditure has a statistically significant negative effect on economic growth, suggesting that higher levels of public spending do not necessarily translate into stronger economic performance, as they are aimed at increasing the well-being of the citizens.

The findings align with several studies that have explored the relationship between internet usage and economic growth. Choi and Hoon Yi (2009) concluded that the internet promoted economic growth from 1990 until 2000, utilizing cross-country panel data. Similarly, Czernich et al. (2011) reported that broadband infrastructure positively affects economic growth in OECD countries. However, it's noteworthy that some studies have observed a negative or mixed impact. For instance, Saidi et al. (2017) found that internet usage affects electricity consumption in the long run, which may indirectly influence economic growth.

Overall, the results highlight the importance of digital adoption, investment, and labour in promoting economic growth, while fiscal and trade factors may have complex short-term effects in the studied countries.

To assess the robustness of the findings, the model was re-estimated using a Fixed-Effects estimator with White-diagonal heteroskedasticity-consistent standard errors. The results, reported in Appendix A (Table A1), are consistent with the Random Effects model. Internet usage remained positively and statistically significantly associated with GDP growth, while the signs and significance of the remaining explanatory variables were unchanged. These findings confirm the robustness of the main results to an alternative panel estimation approach.

5. CONCLUSION

This study has investigated the role of internet users on economic growth in Balkan countries from 2010 until 2022, through a panel data approach by utilizing several controlling variables such as foreign direct investment, governmental expenditures, labour, and net exports. The results

indicate that internet usage, foreign direct investment, and labour have a significant positive effect on economic growth. On the other hand, governmental expenses and net exports negatively affect economic growth.

The findings of the study have significant implications. First, the positive effect of the internet on fostering economic growth emphasizes the role of connectivity in economic development. Investing in ICT infrastructure would contribute to boosting economic growth. Second, the positive effect of labor and foreign direct investment emphasizes that maintaining a good climate for investment and focusing on increased participation in the labor market are crucial for economic growth. Third, the negative impact of governmental expenditures and net exports suggests inefficiencies in public spending and trade. The right policies in public spending and diversification of exports may contribute to economic growth.

In conclusion, the study provides empirical evidence that internet usage plays a vital role in promoting economic growth in Balkan countries, reinforcing the importance of digital strategies as part of broader economic development policies. Strengthening ICT infrastructure, supporting investment, and enhancing labour market efficiency, while addressing structural inefficiencies in fiscal and trade sectors, can jointly create a more sustainable growth trajectory for the region.

This study has several limitations that should be acknowledged. Although the Random Effects model provides reliable estimates, endogeneity may still be present, as higher economic growth may also encourage more investment in digital infrastructure, while other unobserved factors could influence both internet use and economic growth. Future research could address these limitations by using alternative econometric approaches and broader measures of digitalization.

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APPENDIX A.

Table A1. Fixed effect model

Dependent Variable: GDP				
Method: Panel EGLS (Cross-section fixed effects)				
White diagonal standard errors & covariance (d.f. corrected)				
Variable	**Coeff**	**Std. Error**	**t-Stat**	**Prob.**
C	-0.957	0.731	-1.310	0.193
FDI	0.553	0.160	3.468	0.001
INTERNET_USERS	0.100	0.023	4.289	0.000
LABOR	0.288	0.131	2.203	0.030
D_GOV_EXP	-1.378	0.163	-8.479	0.000
D_NET_EXP	-0.332	0.146	-2.266	0.026
	Weighted Statistics			
R-sqrd	0.658	**Adj R-sqrd**		0.611
F-stat	13.93	**Prob(F-statistic)**		0

Balkans JETSS (2026) 1: 11-23
DOI: https://doi.org/10.31410/Balkans.JETSS.2026.9.1.11-23

Original Scientific Article

Climate Change in the Financial Spotlight: A Bibliometric Review

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Received: August 6, 2025 / Revised: June 6, 2026 /
Accepted: June 8, 2026 / Published: June 30, 2026
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Abstract: *Climate change is increasingly acknowledged as a systemic macroeconomic and financial risk with significant implications for stability, investment, and governance. This study presents a bibliometric analysis of 1,116 peer-reviewed publications (2000–2024) systematically retrieved from the Web of Science Core Collection. The findings reveal an interdisciplinary domain integrating environmental sciences, economics, policy, and quantitative modelling, with more than 64% of research output published after the 2015 Paris Agreement. Keyword analysis identifies "climate change" as the intellectual nucleus, interconnected with themes of adaptation, financial stability, green finance, and energy transition. Authorship patterns show both sustained contributions from prolific scholars and highly cited landmark studies. Geographical analysis highlights China, the United States, and the United Kingdom as leading contributors, complemented by influential European research. Overall, results confirm the climate–finance nexus as a rapidly expanding and policy-relevant field, central to advancing systemic resilience and enabling the transition toward a sustainable global financial system.*

Keywords: *Climate change, Financial system, Bibliometrics.*

JEL Classification: G20, Q54

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1. INTRODUCTION

Climate change is no longer solely an environmental concern; it now represents a significant macroeconomic risk with wide-ranging implications for financial stability, investment flows, and economic policy. Extreme weather events, rising temperatures, and biodiversity loss are already disrupting global supply chains, altering consumption patterns, and challenging traditional models of growth (IPCC, 2022). As the Intergovernmental Panel on Climate Change notes, without effective policy responses, climate change could reduce GDP by several percentage points in some regions by the end of the century. Global institutions such as the World Bank or the Organization for Economic Co-operation and Development (OECD) emphasize that the costs of inaction will far exceed the investments needed for a sustainable economic transition (OECD, 2021; World Bank, 2021). In this context, the financial system plays a central role - both as a source of climate-related risks and as a driver of the green transformation. Instruments such as green loans and climate-aligned investments are increasingly used to support low-carbon innovation and environmental sustainability (UNFCCC, 2015). Despite the growing relevance of climate-finance linkages, academic research at this intersection remains scattered across disciplines. Bibliometric analysis provides a systematic method to trace the development of this emerging field, identify influential contributors, and map evolving research themes.

Accordingly, this paper aims to provide a systematic bibliometric mapping of the climate change–financial system nexus by identifying its publication dynamics, dominant research themes, leading authors and journals, geographical distribution, and core intellectual contributions, thereby clarifying how this fragmented field has evolved and where its main research frontiers lie.

2. LITERATURE REVIEW

Empirical research underscores the multifaceted impact of climate change on macroeconomic and financial stability. Rising temperatures have been linked to declines in economic performance, with Burke et al. (2015) estimating that a 1°C increase in average temperature can reduce per capita GDP by up to 1.3% annually in warmer, developing countries. Kahn et al. (2019) further demonstrate that repeated climate shocks can cause long-term GDP losses of up to 10%, particularly in disaster-prone regions. Beyond growth, climate change also affects inflation and productivity. Cevik and Jalles (2023) show that a 1°C temperature rise corresponds to a 0.9 percentage point increase in inflation, disproportionately impacting low-income economies, while Szewczyk et al. (2021) report productivity declines of 1.5–2% in European sectors like agriculture and construction during heatwaves. From a fiscal standpoint, climate events disrupt economic and fiscal cycles (Billio et al., 2021) and raise public expenditures if mitigation is delayed (Fernando et al., 2021). Crucially, the effects are unequally distributed - Tol (2022) and the WMO (2024) note GDP losses of up to 8.3% in countries like Bangladesh and Ethiopia. In the financial sector, Campiglio (2016) argues that carbon pricing alone is insufficient to drive low-carbon investment, advocating for green macroprudential tools such as differentiated reserve requirements. Supporting this, Javadi and Masum (2021) find that firms exposed to climate risk face higher loan spreads, especially those with lower credit ratings. To address systemic vulnerabilities, Battiston et al. (2021) and Roncoroni et al. (2021) call for innovative stress-testing and network-based approaches that consider contagion effects and market dynamics, enabling policymakers to manage climate-related financial risks more effectively. Kashi and Shah (2023) show that sustainable-finance research has grown rapidly and increasingly integrates environmental, social and governance considerations into investment and corporate decision-making. Badareu et al. (2024) provide a recent bibliometric investigation of financial development and climate change and demonstrate that the field

has expanded markedly since 2016, while remaining dispersed across journals, institutions and geographical contexts. Recent bibliometric studies on green and climate finance also document a strong post-2019 increase in output and identify emerging themes such as renewable energy, sustainable development goals, green technology, digital economy and regional collaboration patterns (Mohamad, 2025; Wang et al., 2025). These studies confirm the dynamism of the broader field, but they do not fully isolate the financial-system perspective that includes banks, insurers, capital markets, investment funds, central banks, and financial-stability concerns.

Several gaps emerge from the existing literature on the relationship between climate change and the financial system. Although previous bibliometric studies have examined sustainable finance, green finance, or the relationship between financial development and climate change, they often adopt a relatively broad conceptual scope (Badareu et al., 2024; Kashi & Shah, 2023). Consequently, the specific role of the financial system, including banks, insurers, asset managers, capital markets, pension funds, central banks, and monetary authorities, remains insufficiently consolidated within a single bibliometric map. This represents an important limitation, as climate-related risks enter the financial system through multiple institutional channels that cannot be fully captured by studies focused exclusively on green finance, environmental performance, or sustainability-oriented investment. The literature is also fragmented across disciplines and methodological traditions. Environmental science studies tend to emphasise physical climate impacts (IPCC, 2022), while economic research often focuses on growth, inflation, productivity, and fiscal consequences (Burke et al., 2015; Cevik & Jalles, 2023; Kahn et al., 2019). Finance-oriented studies examine loan pricing, asset repricing, systemic risk, and financial stability (Battiston et al., 2021; Javadi & Masum, 2021; Roncoroni et al., 2021), whereas policy-oriented research discusses disclosure standards, regulation, transition planning, and climate governance. This fragmentation makes it difficult to identify the central intellectual anchors of the field and to assess how different research communities interact. A bibliometric review can address this limitation by mapping the thematic architecture of the field through keywords, citations, authors, countries, journals, and influential publications. Existing research also pays uneven attention to geographical and institutional asymmetries. High-output countries tend to dominate the literature, while regions with high climate vulnerability may remain less visible in citation-based analyses. This is particularly relevant because climate-related economic and financial impacts are unevenly distributed across countries and regions (Tol, 2022; WMO, 2024). Moreover, the policy relevance of climate-finance research depends not only on the volume of publications, but also on whether the literature connects bibliometric evidence with issues such as financial stability, climate stress testing, insurance-market resilience, disclosure standards, and transition-finance governance (Battiston et al., 2021; Roncoroni et al., 2021). The present study addresses these gaps by combining descriptive bibliometric indicators with an interpretive discussion of the climate-finance nexus and its implications for building a climate-resilient financial system.

From a methodological perspective, bibliometric analysis is appropriate for mapping large and interdisciplinary research domains because it enables the identification of publication dynamics, intellectual communities, influential authors, core sources, and emerging themes (Donthu et al., 2021; Županič & Čater, 2015). In climate-finance research, this method is particularly useful because the field is distributed across different disciplinary outlets and uses heterogeneous terminology, including climate risk, sustainable finance, green finance, financial stability, insurance, transition risk, disclosure and stress testing. A bibliometric approach therefore provides a structured way to synthesise this dispersed body of knowledge without reducing the analysis to a narrow disciplinary perspective.

3. RESEARCH METHODOLOGY

The final bibliometric corpus for this study comprises 1,116 peer-reviewed documents retrieved from the Web of Science Core Collection, representing a strategically refined subset of the broader literature on the intersection between climate change and the financial system.

The original query - combining climate change–related terms with finance- and governance-related concepts - yielded 1,710 records across all fields. The dataset was then narrowed by document type to include only articles and proceedings papers (1,527), followed by temporal filtering to publications from 2000 to 2024 (1,525). Restricting the language to English reduced the dataset to 1,511 documents, ensuring both scholarly rigor and linguistic consistency. The final thematic refinement, limiting the scope to specific research areas (Business Economics; Environmental Sciences Ecology; Science Technology Other Topics; Government Law; Engineering; Public Administration; Energy Fuels; International Relations; Development Studies; Mathematics; Social Sciences Other Topics; Computer Science; Operations Research Management Science; Sociology; Transportation; Urban Studies; and Social Issues), produced the final sample of 1,116 documents. The inclusion criteria were: indexing in the Web of Science Core Collection; publication as an article or proceedings paper; English language; publication year between 2000 and 2024; and thematic relevance to the relationship between climate change and the financial system. The exclusion criteria were: non-scholarly document types, publications outside the defined period, non-English records and records outside the selected research areas. This temporal span (2000–2024) captures nearly a quarter-century of academic development, including milestone events such as the Kyoto Protocol, the Paris Agreement, and the emergence of climate-related financial disclosure frameworks. Notably, a significant proportion of publications appear in the post-2015 period, reflecting the intensified scholarly focus following the Paris Agreement and the growing integration of climate risk into financial governance. The disciplinary distribution of the final dataset confirms the interdisciplinary nature of the field. The largest thematic clusters are drawn from Environmental Sciences and Ecology, but substantial representation also stems from Business Economics, Government Law, Public Administration, and Energy Fuels, underscoring the fusion of environmental, policy, and financial perspectives. Contributions from Computer Science, Engineering, Operations Research, and related disciplines highlight the increasing use of quantitative modelling, simulation, and data analytics in assessing climate-related financial risks. Additionally, publications in Urban Studies, International Relations, and Sociology indicate the embeddedness of climate-finance issues across institutional, governance, and societal contexts. In summary, the refined dataset offers a methodologically robust and thematically diverse foundation for bibliometric analysis, enabling the mapping of intellectual trends, the identification of high-impact contributions, and the exploration of research frontiers essential for building a climate-resilient financial system.

Table 2 provides an overview of the bibliometric characteristics of the final dataset comprising 1,116 documents published between 2000 and June 2024. These documents were sourced from 458 different publication outlets, including academic journals, books, and conference proceedings. Annual scientific production shows a sustained upward trajectory, with an average annual growth rate of 15.66%. The average age of the documents is 4.57 years, indicating that research in this field is relatively recent and expanding rapidly. In terms of impact, each document has received, on average, 23.91 citations, and the dataset as a whole contains 50,168 references. The thematic diversity is reflected in the 1,539 Keywords Plus (terms extracted from the titles of cited references) and 3,035 author-supplied keywords, underscoring the broad range of topics covered within the climate change–financial system nexus.

Table 1. Dataset Scope and Filtering Criteria

Filter	Description	No. of documents
All Fields	TS=(("financial system" OR "financial sector" OR bank* OR insurance OR insurer* OR "asset manager*" OR "investment firm*" OR "investment bank*" OR "capital market*" OR "stock market*" OR "financial institution*" OR "credit union*" OR "pension fund*" OR "mutual fund*" OR "central bank*" OR "monetary authority*" OR "development bank*") NEAR/10 ("climate change" OR "global warming" OR "climate crisis" OR "climate risk*" OR "climatic change*" OR "climate-related" OR "greenhouse gas*" OR "carbon emission*" OR "climate adaptation" OR "climate mitigation" OR "net zero" OR "low-carbon" OR "carbon neutral*" OR "energy transition" OR "transition risk*")) AND TS=("risk*" OR "vulnerability*" OR "exposure" OR "resilients*" OR "adaptation" OR "mitigation" OR "disclosure" OR "reporting" OR "compliance" OR "standard*" OR "framework*" OR "regulation*" OR "governance" OR "management" OR "best practice*" OR "implementation" OR "investment" OR "financing" OR "policy" OR "strategy" OR "strategies" OR "scenario analysis" OR "stress test*" OR "transition plan*")	1,710
Document Types	Articles; Proceedings Paper	1,527
Publication Year	2000 – 2024	1,525
Languages	English language	1,511
Research Areas	Business Economics; Environmental Sciences Ecology; Science Technology Other Topics; Government Law; Engineering; Public Administration; Energy Fuels; International Relations; Development Studies; Mathematics; Social Sciences Other Topics; Computer Science; Operations Research Management Science; Sociology; Transportation; Urban Studies; Social Issues	1,116
Final Sample	The total number of documents	1,116

Source: Own processing

Table 2. Descriptive statistics of the dataset

Description	Results	Description	Results
Timespan	2000-2024	Authors	2776
Sources (Journals, Books, etc.)	458	Authors of single-authored docs	196
Documents	1116	Single-authored docs	210
Annual Growth Rate %	15,66	Co-Authors per Doc	3,03
Document Average Age	4,57	International co-authorships %	31,09
Average citations per doc	23,91	article	1053
References	50168	article; proceedings paper	7
Keywords Plus (ID)	1539	article; retracted publication	2
Author's Keywords (DE)	3035	proceedings paper	54

Source: Own processing

The authorship analysis reveals contributions from 2,776 unique authors, with 196 authors responsible for single-authored documents. In total, 210 documents were single-authored, while the

average number of co-authors per document was 3.03. Furthermore, 31.09% of publications involved international co-authorship, highlighting the global scope of collaboration in this research domain. Regarding document types, the dataset consists of 1,053 journal articles, 54 conference proceedings papers, 7 hybrid records labeled as both articles and proceedings papers, and 2 retracted publications. This distribution illustrates the strong representation of peer-reviewed journal outputs, complemented by significant contributions from conference-based research, which often captures emerging topics and applied methodologies.

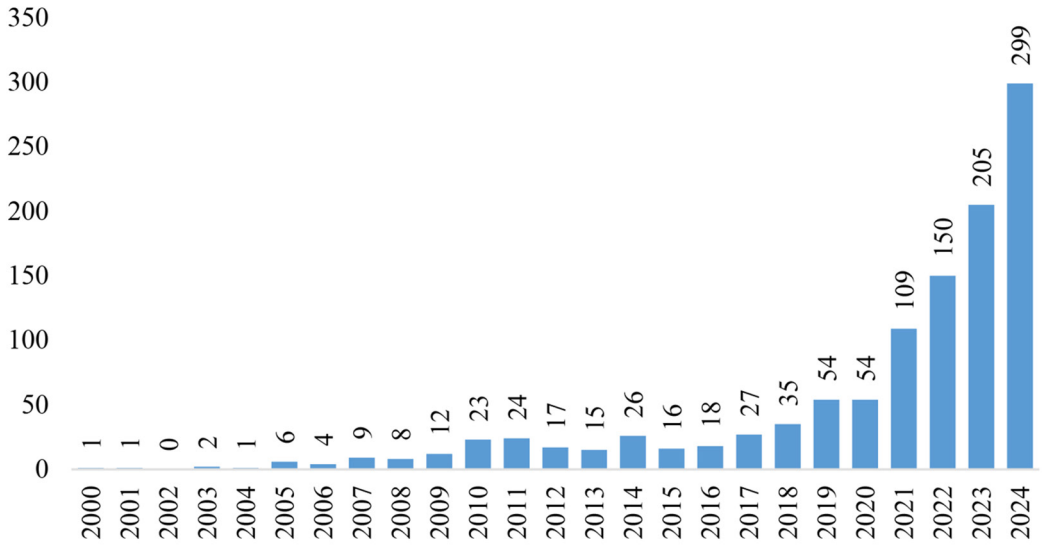

Figure 1. Publication trend
Source: Own processing

The publication trend from 2000 to 2024 shows steady growth in research on the climate change–financial system nexus, with a sharp rise in recent years. The early phase (2000–2009) saw minimal activity, rarely exceeding a dozen publications annually. Between 2010 and 2016, output increased gradually, reaching up to 26 articles per year. A turning point occurred in 2017, followed by rapid growth after 2019, from 54 publications in 2019 and 2020 to 109 in 2021. The upward trend accelerated further with 150 publications in 2022, 205 in 2023, and a peak of 299 in 2024. Over 64% of all publications appeared after 2015, reflecting rising regulatory focus, advances in climate risk modelling, and expanded funding for interdisciplinary research. This confirms the climate-finance nexus as an emerging priority in both academic and policy arenas.

4. RESULTS

4.1. Interpretation of Keyword Co-Occurrence Patterns

The co-occurrence analysis of keywords reveals the thematic architecture and intellectual priorities within the scholarly literature on the interplay between climate change and the financial system. The table presents the most frequently occurring terms among the 1,116 peer-reviewed documents in the final dataset, providing insight into dominant research agendas and conceptual clusters. Unsurprisingly, climate change emerges as the most prevalent keyword (304 occurrences), serving as the conceptual nucleus of the field. Closely related terms such as adaptation (41), sustainability (25), and climate risk (54) emphasize the literature's dual focus on systemic

climate-related risks and the capacity for institutional and economic resilience. This indicates a framing of climate dynamics not solely as environmental concerns but as integral factors in financial stability and policy-making. Terms such as carbon emissions (37), renewable energy (22), and energy transition (18) highlight an operational and policy-oriented approach to decarbonization, with an emphasis on both technological pathways and governance structures. The presence of ESG (20), green finance (27), and sustainable finance (25) reflects the growing integration of sustainability metrics into investment strategies, regulatory frameworks, and corporate reporting practices. From a financial sector perspective, keywords such as financial development (37), financial stability (37), banks (17), central banks (17), and stock market (17) point to the intersection between macro-financial stability and climate-related risks. Meanwhile, insurance (56) and risk management (21) highlight the role of risk transfer mechanisms and institutional resilience strategies. The appearance of geographically specific terms, notably China (27), indicates significant research activity focused on national or regional case studies, often in the context of regulatory innovation or large-scale transition policies. In summary, the keyword distribution illustrates a well-established and increasingly interdisciplinary research field, where environmental science, financial economics, and governance intersect. The prominence of terms related to finance, regulation, and decarbonization strategies underscores the field's evolution toward solutions-oriented research that supports a climate-resilient financial system.

Table 3. The most co–occurrence keywords

Keyword	Occurrences	Keyword	Occurrences
Climate Change	304	Sustainable Finance	25
Insurance	56	Climate Finance	22
Climate Risk	54	Renewable Energy	22
Adaptation	41	Risk Management	21
Carbon Emissions	37	ESG	20
Financial Development	37	Energy Transition	18
Financial Stability	37	Banks	17
China	27	Central Banks	17
Green Finance	27	Global Warming	17
Sustainability	25	Stock Market	17

Source: Own processing

4.2. Leading Authors and Citation Impact in Climate-Finance Research

An author-level analysis identifies the intellectual leaders whose work has shaped the evolving discourse on climate change and the financial system. The top authors in the dataset combine high publication output, strong citation performance, and thematic breadth across climate finance, economics, and risk governance. Muhammad Umar stands as both the most prolific and most cited author, with 8 publications and 947 citations, reflecting sustained research activity and broad influence. His work covers green finance, sustainable investment strategies, and the integration of climate risk into financial decision-making. W. J. Wouter Botzen (7 publications, 233 citations) focuses on climate risk perception, insurance markets, and adaptation economics, while Irene Monasterolo (7 publications, 605 citations) is known for pioneering climate stress-testing frameworks and green finance taxonomies. Stefano Battiston (6 publications, 451 citations) specializes in systemic risk modelling and climate-related financial networks, whereas Shouwei Li (6 publications, 82 citations) and Jyh-Horng Lin (6 publications, 39 citations) contribute to research on low-carbon investment pathways and energy transition economics. Several scholars achieve notable citation impact despite fewer publications. Ella Mae Matsumura, Rachna Prakash, and Sandra

C. Vera-Muñoz each have a single publication with 898 citations, demonstrating exceptional influence on sustainability reporting and climate-related disclosure practices. Nawazish Mirza (5 publications, 554 citations) bridges corporate finance with sustainability, and Van den Bergh, J. C. J. M. (3 publications, 555 citations) provides key insights into the economics of climate change mitigation and policy evaluation. This distribution reveals a dual structure in the field: a core group of prolific authors consistently contributing across multiple themes, and a smaller set of scholars producing landmark studies with disproportionate influence. Together, these authors represent the intellectual vanguard of climate-finance research, shaping theoretical frameworks, guiding empirical inquiry, and informing regulatory approaches for building a climate-resilient global financial system.

Table 4. Top 10 authors by documents and citations

№	Author	Documents	Citations
1	Umar, Muhammad	8	947
2	Botzen, W. J. Wouter	7	233
3	Monasterolo, Irene	7	605
4	Battiston, Stefano	6	451
5	Li, Shouwei	6	82
6	Lin, Jyh-Horng	6	39
7	Ji, Qiang	5	77
8	Johannsdottir, Lara	5	52
9	Mirza, Nawazish	5	554
10	Aerts, Jeroen C. J. H.	4	71
№	**Author**	**Documents**	**Citations**
1	Umar, Muhammad	8	947
2	Matsumura, Ella Mae	1	898
3	Prakash, Rachna	1	898
4	Vera-Munoz, Sandra C.	1	898
5	Monasterolo, Irene	7	605
6	Botzen, W. J. W.	3	555
7	Van Den Bergh, J. C. J. M.	3	555
8	Mirza, Nawazish	5	554
9	Battiston, Stefano	6	451
10	Campiglio, Emanuele	3	430

Source: Own processing

4.3. Geographical Distribution of Scholarly Output and Impact

The analysis of national contributions provides a macro-level perspective on where scientific leadership and research capacity are concentrated within the interdisciplinary field of climate change and financial systems. The top ten contributing countries reveal a geographically diverse yet asymmetrically distributed research landscape, shaped by differences in institutional capacity, policy priorities, and funding structures. China leads the dataset with 307 documents and 8,121 citations, reflecting its growing prominence in climate-finance research. This leadership is supported by significant national investments in green finance, renewable energy policy, and climate risk management frameworks. The United States follows with 205 documents and 5,809 citations, indicating sustained academic engagement with climate-related financial risks, supported by a broad research infrastructure and interdisciplinary collaborations between universities, federal agencies, and the private sector.

England (123 documents, 3,311 citations) and Germany (86 documents, 1,867 citations) represent core European contributors. The UK's strong performance is linked to its active role in shaping global climate finance governance - exemplified by initiatives like the Bank of England's climate stress-testing programs - while Germany's output reflects its expertise in environmental economics, sustainable finance, and systems modelling. Among mid-tier contributors, Australia (60 documents, 1,557 citations), France (60 documents, 2,760 citations), and Italy (60 documents, 2,114 citations) maintain a balanced mix of applied and theoretical research, often focused on energy transition strategies, adaptation policies, and financial market resilience. Notably, the Netherlands (42 documents, 1,540 citations) and Spain (41 documents, 1,583 citations) exhibit strong citation performance relative to their output. In the case of the Netherlands, this reflects concentrated, high-impact work on climate-economic modelling and transition risk assessment, while Spain's contributions emphasize climate policy, governance, and renewable energy integration. Canada (53 documents, 1,259 citations) completes the top ten, with research often centered on climate policy evaluation, sustainable investment frameworks, and adaptation in resource-dependent economies. Overall, the geographical distribution underscores a blend of large-scale producers and smaller but high-impact contributors, illustrating both the global reach and the uneven distribution of research capacity in climate-finance scholarship.

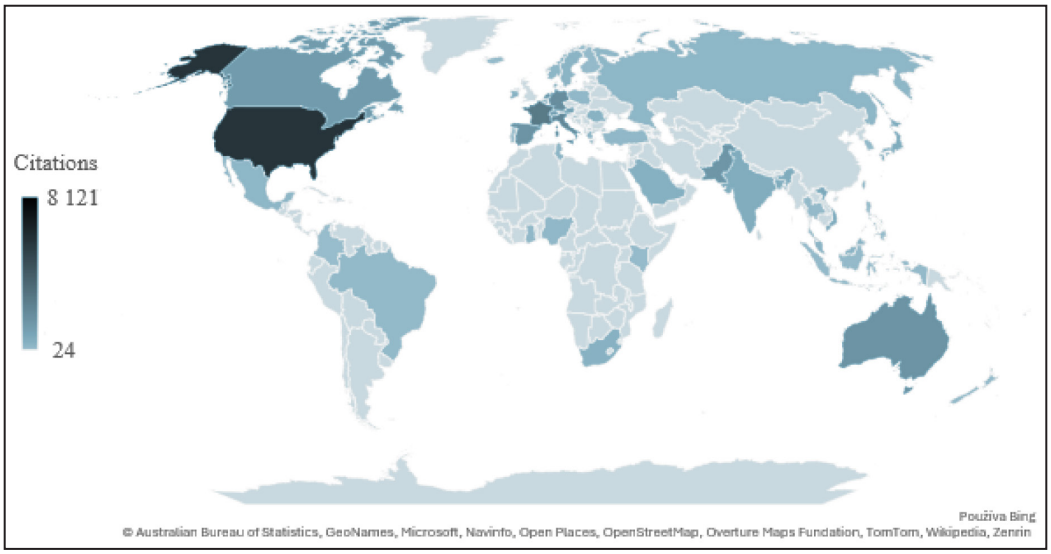

Figure 2. Geographical distribution
Source: Own processing

4.4. Core Publications and Intellectual Anchors in Climate-Finance Research

The most cited documents in the dataset highlight the conceptual and empirical cornerstones of scholarly work at the intersection of climate change and financial systems. These studies address a range of themes - from monetary policy and banking regulation to insurance mechanisms, loan pricing, and systemic financial stability - demonstrating the field's interdisciplinary depth. The most cited publication, "Beyond carbon pricing: The role of banking and monetary policy in financing the transition to a low-carbon economy" (404 citations), provides a seminal analysis of how central banks and monetary policy tools can accelerate the financing of low-carbon transitions. It has become a reference point for both academic debate and policy design in sustainable finance. "Insurance in a Climate of Change" (261 citations) offers

a comprehensive assessment of the insurance sector's role in mitigating and transferring climate-related risks, integrating perspectives from risk modelling, adaptation strategies, and regulatory frameworks. "The impact of climate change on the cost of bank loan" (256 citations) and "Climate risks and financial stability" (254 citations) each focus on the transmission of climate risks into the banking sector, exploring how physical and transition risks can influence credit risk, lending costs, and systemic stability. Finally, "Climate risk and financial stability in the network of banks and investment funds" (140 citations) applies network analysis to model the propagation of climate-related shocks through interconnected financial institutions, offering a methodological basis for climate stress-testing and macroprudential oversight. Together, these highly cited works form the intellectual backbone of climate-finance scholarship, shaping both theoretical frameworks and applied policy measures aimed at ensuring the resilience of financial systems in the face of climate change.

Table 5. Top 5 documents by citations

№	Document	Citations
1	Beyond carbon pricing: The role of banking and monetary policy in financing the transition to a low-carbon economy	404
2	Insurance in a Climate of Change	261
3	The impact of climate change on the cost of bank loan	256
4	Climate risks and financial stability	254
5	Climate risk and financial stability in the network of banks and investment funds	140

Source: Own processing

4.5. Leading Journals in Climate-Finance Scholarship

The distribution of academic output across journals provides valuable insight into the disciplinary scope and research priorities within the climate-finance nexus. The top five journals in the dataset highlight a strong presence of economics, policy, and environmental science perspectives, illustrating the field's inherently interdisciplinary nature. Ecological Economics leads in total citations, with 20 documents and 1,676 citations, reflecting its pivotal role in integrating ecological systems thinking with economic and financial analysis. Contributions in this journal frequently address the valuation of natural capital, the economics of climate mitigation, and the governance of sustainable investment. Energy Policy (10 documents, 1,522 citations) ranks second, underscoring the importance of policy frameworks and energy transition strategies in shaping financial risk landscapes. Articles in this outlet often link regulatory design to investment decision-making in low-carbon pathways. The Journal of Financial Stability (18 documents, 1,203 citations) is the leading finance-focused journal in the dataset, providing critical contributions on systemic risk, climate stress-testing, and the transmission of climate shocks through banking and capital markets. Energy Economics (22 documents, 1,067 citations) offers a complementary macroeconomic perspective, connecting climate and energy market dynamics to investment flows, asset pricing, and long-term economic resilience. Finally, Environmental Science and Pollution Research (36 documents, 1,065 citations) brings a strong environmental science base, with studies on pollution metrics, environmental risk assessment, and the implications of environmental degradation for financial stability and sustainable finance instruments. Collectively, these journals represent the intellectual infrastructure of climate-finance scholarship, bridging environmental science, economics, and policy. Their combined contributions ensure that both empirical evidence and theoretical insights are translated into frameworks for managing the financial risks of climate change.

Table 6. Top 5 journals by citations

№	Journals	Documents	Citations
1	Ecological Economics	20	1,676
2	Energy Policy	10	1,522
3	Journal of Financial Stability	18	1,203
4	Energy Economics	22	1,067
5	Environmental Science And Pollution Research	36	1,065

Source: Own processing

5. DISCUSSION

The results show that climate-finance research has moved from a marginal and fragmented topic to a rapidly expanding field with clear policy relevance. The sharp post-2015 increase in publications corresponds with the institutionalisation of the Paris Agreement and the growing recognition of climate risk in financial governance. This pattern is consistent with broader bibliometric evidence on sustainable finance and climate-related financial development, which also shows that the field has accelerated as regulatory, investor and central-bank attention has intensified (Badareu et al., 2024; Kashi & Shah, 2023).

The keyword structure confirms that the field is not limited to green finance or environmental investment. Instead, it combines several interconnected research streams related to climate risk, financial stability, insurance, carbon emissions, energy transition, ESG, sustainable finance, banks, and central banks. This supports the argument that climate change has become a systemic financial issue rather than a sector-specific environmental concern. The literature increasingly examines how physical and transition risks are transmitted through balance sheets, credit pricing, insurance mechanisms, market expectations and regulatory frameworks. The author and document analyses reveal a dual intellectual structure. The field is shaped both by sustained research programmes and by landmark publications that opened new pathways in monetary policy, banking regulation, insurance, systemic risk modelling and climate stress testing. This suggests that climate-finance research is still developing its theoretical coherence, while already producing policy-relevant tools for understanding and managing climate-related financial risks. The geographical distribution also has practical implications. Research capacity remains concentrated in major economies, while regions with high exposure to physical climate risks may be less visible in citation-based evidence. This imbalance matters because the financial consequences of climate change are unevenly distributed across countries and regions. Future research should therefore pay greater attention to emerging markets, small open economies and climate-vulnerable financial systems. Overall, the paper's contribution is both descriptive and interpretive. Descriptively, it consolidates a dispersed body of literature into a structured map of publication trends, themes, contributors and outlets. Interpretively, it shows that the climate-finance nexus is evolving toward a solution-oriented research agenda focused on resilience, disclosure, stress testing, transition planning and the mobilisation of finance for decarbonisation. This evidence is relevant for academics, policymakers, central banks, financial supervisors and financial institutions seeking to understand where the field is mature and where further conceptual and empirical development is needed.

6. CONCLUSION

This bibliometric analysis offers a comprehensive overview of the scholarly landscape at the intersection of climate change and the financial system. By systematically refining an initial dataset of 1,710 records from the Web of Science Core Collection to a final sample of 1,116 peer-reviewed documents, the study ensures methodological rigor, thematic relevance, and disciplinary breadth. The findings reveal a distinctly interdisciplinary field. Core research clusters span environmental sciences, economics, governance, and policy, supplemented by contributions from engineering, computer science, and social sciences. Keyword co-occurrence analysis identifies "climate change" as the conceptual anchor, surrounded by themes such as adaptation, climate risk, carbon emissions, and green finance, highlighting the integration of environmental and financial considerations in addressing systemic risks. Authorship analysis shows both sustained contributions from prolific scholars and high-impact landmark publications, reflecting a dual structure of steady thematic development and influential conceptual contributions. The geographical distribution points to global engagement, but also to an uneven concentration of research capacity in major economies. The most cited works form the intellectual backbone of the field, advancing understanding of monetary policy's role in low-carbon transitions, the financial implications of climate risks, and systemic resilience mechanisms. Leading journals serve as key platforms bridging scientific evidence, economic analysis, and policy relevance. Overall, the study highlights a rapidly evolving, solution-oriented research domain with increasing policy relevance. The observed trends point toward a continued expansion of climate-finance scholarship, driven by regulatory initiatives, methodological innovation, and cross-sectoral collaboration - elements essential for building a climate-resilient global financial system.

The analysis has several limitations. First, the dataset is limited to the Web of Science Core Collection and therefore may exclude relevant publications indexed in Scopus, SSRN, working-paper series or policy repositories. Second, the study is based on English-language articles and proceedings papers, which may underrepresent regional or non-English research. Third, bibliometric indicators capture visibility and citation impact, but they do not fully measure theoretical quality, policy influence or practical implementation. Finally, citation-based analysis may favour older publications and research produced in countries with stronger academic infrastructures.

Future research could extend the analysis by comparing Web of Science and Scopus datasets, applying longitudinal thematic evolution techniques, examining co-citation and bibliographic-coupling networks in greater detail, and focusing on underrepresented regions. Further studies could also combine bibliometric mapping with qualitative content analysis to examine how climate-risk disclosure, central-bank policy, insurance-market resilience, stress testing and transition-finance frameworks are treated in the literature. Such extensions would deepen understanding of how climate-finance research can support a more resilient and sustainable global financial system.

Acknowledgment

This research was supported by Technical University of Kosice, Faculty of Economics [grant number EkF TUKE P4/2024].

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Balkans JETSS (2026) 1: 24-37
DOI: https://doi.org/10.31410/Balkans.JETSS.2026.9.1.24-37

Original Scientific Article

Drivers of Customer Loyalty in North Macedonia's Mobile Telecommunications Industry

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Received: August 22, 2025 / Revised: June 6, 2026 /
Accepted: June 28, 2026 / Published: June 30, 2026
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Abstract: *This paper explores the role of Customer Satisfaction as a key driver of Customer Loyalty in the North Macedonian mobile telecommunications sector. The study employs quantitative research using survey data from 160 users and addresses the research gap by providing data-driven analysis of customer satisfaction factors and their influence on brand loyalty. Generational preferences and the importance of bundled service packages are also analyzed. The results underscore the importance of consistent service delivery, transparent pricing, and responsive support in retaining customers. Findings reveal that Customer Satisfaction is the strongest predictor of Customer Loyalty, followed by Service Quality, employee responsiveness, pricing fairness, and service assortment. Practical recommendations for telecom providers include hybrid customer service models, real-time feedback systems, and personalized engagement. The study offers strategic insights for organizations aiming to build loyalty in increasingly competitive and digitally evolving Telecommunication Industry.*

Keywords: *Service quality, Customer satisfaction, Customer loyalty, Telecommunication industry.*

JEL Classification: M31, L96

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1. INTRODUCTION

In today's increasingly competitive telecommunications environment, customer retention has emerged as a top strategic priority. Customer loyalty is no longer solely influenced by pricing or promotional offers but is deeply connected to the overall quality of service experience. With the rapid evolution of mobile technologies and rising consumer expectations, businesses must continuously assess how their service delivery impacts user perceptions and loyalty. Customers have become more empowered, informed, and demanding, leading organizations to shift their focus from aggressive acquisition strategies toward loyalty-building mechanisms. This paper aims to explore the intricate relationship between satisfaction and loyalty among mobile telecommunications customers in North Macedonia—a transitional economy with an evolving digital landscape. By identifying the core satisfaction drivers such as service quality, employee responsiveness, pricing fairness, network coverage, and bundled offerings, this study provides a targeted view of what motivates consumers to remain loyal in a saturated and price-sensitive market. It's important to note that customer satisfaction can vary among individuals, and different customers may prioritize different factors.

Mobile companies need to continuously adapt, innovate, and improve their products and services to meet the evolving needs and expectations of their customers (Jones & Suh, 2000).

Over the last twenty years, the telecommunications market has experienced significant instability and volatility, leading to several mergers and rebranding efforts. The quality and diversity of services and products are consistently improving, but prices exhibit a trend of monopolistic control. Understanding this dynamic is critical for fostering long-term value creation and positive brand reputation. Satisfaction is not a universal occurrence, and the identical service encounter doesn't yield equal contentment for all. This introduction sets the stage for understanding the importance of customer experience in building brand trust, especially in a regional market where customer expectations are rising amid digital transformation. Having to put into focus the Macedonian market of the telecommunication industry, it's important to add several additional factors that have an impact on the satisfaction level, such as local language support, tailored promotions, and integrated banking partnerships, which can enhance customer satisfaction with telecommunication providers within the country.

Central to this investigation is customer loyalty, which has emerged as a key managerial concern amid hyper-competition in the service industry (Bodet, 2008). With more telecom providers entering the landscape and mobile internet usage growing rapidly, this study is both timely and practically relevant for service providers aiming to maintain market share. Specifically, this research highlights the critical role of customer satisfaction and loyalty in achieving sustainable growth. By delivering empirical evidence on how these variables intersect, the findings offer actionable insights for telecom operators seeking to improve consumer perception, boost retention, and secure long-term profitability. Although customer satisfaction and loyalty have been extensively studied in developed telecommunications markets, empirical evidence from transitional economies such as North Macedonia remains limited.

This paper explores the structure and development of the North Macedonian telecommunication market, one of the smallest in Europe yet marked by strong infrastructure and competitive service offerings. Despite limited population size, the market features a diverse range of providers offering bundled services in mobile, internet, and television. The study focuses on how customer satisfaction — influenced by factors such as service quality, pricing, coverage, local support, and

personalization — plays a crucial role in building customer loyalty. This research aims to analyze how telecom companies in North Macedonia align their strategies to meet evolving customer needs and sustain loyalty in a dynamic, technologically progressive environment. The findings contribute to the existing literature by providing evidence from a small European telecommunications market and offering practical implications for providers operating in similar transitional economies.

2. LITERATURE REVIEW

The relationship between satisfaction and loyalty has been a subject of extensive academic and practical inquiry over the past decades. Customer satisfaction, as defined by Kotler and Keller (2006), is a person's feeling of pleasure or disappointment resulting from comparing a product's perceived performance to expectations. While satisfaction can result from a single interaction, loyalty develops over time through consistent and positive experiences. Oliver (1999) posits that loyalty evolves through cognitive, affective, conative, and behavioral stages, beginning with rational evaluation and culminating in commitment. The SERVQUAL framework introduced by Parasuraman et al. (1988) offers one of the most established models for evaluating service quality through five dimensions: reliability, assurance, responsiveness, empathy, and tangibles. Recent studies also reaffirm these relationships in the telecommunications sector. Abd-Elrahman (2023) examined telecom users during the COVID-19 pandemic and confirmed that service quality directly drives both satisfaction and loyalty. In the telecommunications sector, these translate into coverage consistency, staff professionalism, resolution efficiency, personalization, and the physical interface or devices involved. The performance model revolves around the concept that a customer's assessment of a product or service's actual performance and their anticipations of that performance exert a favorable influence on customer contentment (Spreng & Mackoy, 1996). Research by Zeithaml et al. (1996) emphasized that perceived service quality directly influences both satisfaction and behavioral intentions such as repurchase and word-of-mouth recommendations. The inclusion of the direct influence of perceived performance on satisfaction garners both theoretical and empirical validation, as underscored by Tse and Wilton (1988). In the context of the telecom industry, especially in emerging markets, studies suggest that customer expectations are evolving rapidly with increased digital access and service options. In North Macedonia specifically, empirical evidence underscores that mobile channel engagement, and digital marketing touchpoints have become critical drivers in shaping consumer perceptions and sustaining long-term brand loyalty (Petrovska et al., 2020; Veljanoska & Petrovska, 2018). Consequently, understanding how service quality, pricing, and frontline service interact with customer satisfaction is vital for telecom operators navigating these shifting consumer dynamics. Chaudhuri and Holbrook (2001) highlighted the dual role of satisfaction in forming both attitudinal and behavioral loyalty. Prior studies have highlighted the central role of responsiveness in dynamic service environments like telecom, where failure to address technical or billing issues promptly can lead to immediate customer attrition. Fornell (1992) suggests that customer satisfaction yields significant advantages, notably in terms of fostering loyalty. Loyal customers can establish a consistent and reliable source of future revenue for a company. This, in turn, leads to diminished price sensitivity, since higher satisfaction levels correlate with a greater willingness among customers to invest in the benefits of a product or service and to accept potential price adjustments. Customers who are content are inclined to endorse the company, thereby advancing its image and reputation. In transitional economies, such as those in the Balkans, customer loyalty is often shaped by contextual constraints, such as limited competition, pricing structures, and trust in institutions. Customer expectations represent a norm against which performance is compared, and they take many forms varying from some minimum tolerable level of performance through to some

concept of the ideal or perfect service (Ennew et al., 1993). Thus, while global models serve as a foundation, localized insights are critical for crafting effective loyalty strategies in such contexts. As Jones and Suh (2000) suggest, customer satisfaction in emerging markets like North Macedonia is also heavily influenced by localization—such as the availability of services in the local language, culturally relevant content, and regional promotions. Furthermore, factors such as price fairness, the perceptibility of prices, and the processability of prices may lead to dissatisfaction (Zielke, 2008). Beyond the diverse levels of product pricing, a combination of dimensions related to price awareness has the potential to influence customer satisfaction, as suggested by research from Diller (2000), Matzler and Pramhas (2004), and Matzler et al. (2006). Nawaz and Usman (2011) report that brand loyalty in telecommunications is associated with service quality, satisfaction, trust, and commitment, with service quality identified as an influential factor in their model. They also report indirect positive relationships of service quality and satisfaction with brand loyalty and emphasize customer-retention programs. The higher positive level of WoM (Word of Mouth) indicates a higher level of satisfaction among the telecommunication customers, and eventually the lowered level of negative WoM also indicates a higher degree of customer satisfaction (Ranaweera, 2007).

The Pareto principle (also known as the 80-20 rule) describes the general observation that a relatively small share of causes can account for a large share of consequences (Dunford et al., 2014). In customer management, it can serve as a heuristic for examining whether value or repeat behavior is concentrated among a smaller customer segment; it should not be treated as a fixed empirical rule for loyalty in this sample. Recent studies continue to confirm the importance of customer satisfaction as a driver of loyalty in the telecommunications sector. For example, Suchanek and Bucicova (2025) tested a post-COVID customer satisfaction model in the Slovak mobile telecommunications sector. They reported significant relationships among several customer-experience constructs, including perceived service quality, satisfaction, and loyalty. Similarly, recent research has shown that digital customer experience, omnichannel support, and personalized service increasingly influence customer retention in competitive telecommunications environments (Lemon & Verhoef, 2016; Sherovska & Petrovska, 2021). These findings suggest that customer loyalty is becoming increasingly dependent on overall customer experience rather than pricing alone.

Moreover, network quality in telecom serves as a key determinant of customer experience. Hoa and Ngoc (2015) found that service quality, brand image, and price perception each have a positive impact on customer satisfaction and that customer satisfaction is positively related to customer loyalty in the Vietnamese mobile telecommunications sector. More recently, Suchanek and Bucicova (2025) modeled customer satisfaction in the Slovak mobile telecommunications sector after the COVID-19 pandemic, highlighting the evolving relationships among perceived quality, satisfaction, and loyalty in a European telecommunications context.

Despite these findings, relatively little empirical evidence exists for the Western Balkan telecommunications market, particularly North Macedonia. Therefore, this study aims to address this research gap by empirically investigating the main determinants of customer loyalty.

Based on the reviewed literature, the following hypotheses were formulated:

H1: Service quality has a significant positive impact on customer loyalty.
H2: Employee service has a significant positive impact on customer loyalty.
H3: Price satisfaction has a significant positive impact on customer loyalty.
H4: Customer satisfaction has a significant positive impact on customer loyalty.
H5: Service assortment has a significant positive impact on customer loyalty.

Thereafter, a comprehensive model was developed to map the direct effects of Service Quality, Employee Service, Price Satisfaction, Customer Satisfaction, and Service Assortment on Customer Loyalty, as conceptualized in Figure 1. Because the available analysis is a simultaneous multiple regression, Customer Satisfaction is treated as a direct predictor rather than as a mediator.

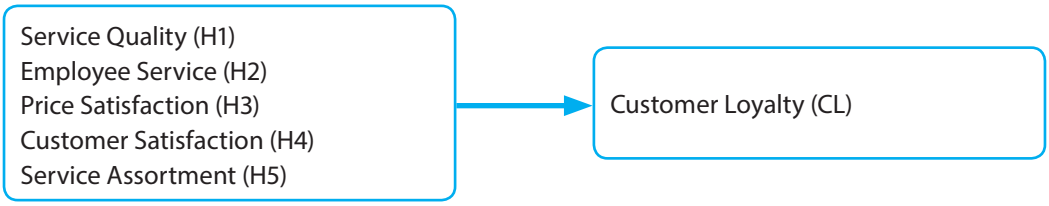

Figure 1: Conceptual Framework of Direct Predictors of Customer Loyalty
Source: Developed by the authors

3. METHODOLOGY

This research employed a descriptive and correlational design based on a structured quantitative survey. The questionnaire was adapted from previously validated customer satisfaction and service quality scales used in telecommunications research. The survey instrument was distributed both physically and digitally, collecting responses from 160 users of mobile telecommunications services across urban and rural areas in North Macedonia. The instrument (Appendix) featured twenty closed-ended items divided into five key categories: general demographics, service quality, pricing fairness, customer service responsiveness, and loyalty intentions, and the last three were open-ended questions. The Likert scale (1 to 5) allowed participants to rate their agreement with statements such as 'I am satisfied with the reliability of my provider's network' and 'I would recommend my provider to others.' The demographic section captured data on age, gender, education, employment status, and residential areas to assess variations across segments. Data analysis was conducted using IBM SPSS 25. Additionally, the final section of the questionnaire incorporated qualitative open-ended questions for respondents to describe service failures, post-sale experiences, and expected operational improvements regarding their telecom operators.

Data collection was conducted between March and April 2025 using both online questionnaires distributed through Google Forms and printed questionnaires distributed in person. Respondents were required to be active users of mobile telecommunication services in North Macedonia.

Descriptive statistics were used to profile the sample, while Pearson correlation and multiple regression tests were applied to examine associations between satisfaction variables and customer loyalty outcomes.

Table 1. Reliability coefficients and correlations among constructs. **p < 0.01

Construct	Items	Cronbach's α	1	2	3	4
1. Service Quality	6	0.892	1	0.73**	0.68**	0.70**
2. Responsiveness	5	0.844	0.73**	1	0.64**	0.68**
3. Price Fairness	4	0.812	0.68**	0.64**	1	0.64**
4. Loyalty	5	0.874	0.70**	0.68**	0.64**	1

Source: Own calculations

Scale reliability was assessed using Cronbach's alpha, with all constructs exceeding the acceptable threshold of 0.7, as shown in Table 1. Measures were also taken to ensure anonymity and

reduce response bias. Sampling was purposive and aimed to cover users from various providers to ensure diversity. Ethical considerations included informed consent, voluntary participation, and data protection in line with GDPR. A pilot test with 15 respondents helped refine ambiguous questions and improve the overall clarity of the instrument. The overall methodological approach is a positivist epistemology, aiming to uncover statistically significant relationships.

Table 2. Multiple Regression Analysis and Model Diagnostics
(Dependent Variable: Customer Loyalty)

Predictor Variables	Unstandardized Coefficients (B)	Standard Error (SE)	Standardized Coefficients (β)	t-value	p-value	Collinearity Diagnostics (VIF)
(Constant)	0.842	0.215	—	3.916	< 0.001	—
Service Quality (Q)	0.312	0.074	**0.346**	4.216	< 0.001	1.425
Employee Service (ES)	0.185	0.062	**0.226**	2.984	0.004	1.612
Price Satisfaction (PS)	0.214	0.068	**0.245**	3.147	0.002	1.554
Service Assortment (SA)	0.248	0.071	**0.284**	3.493	0.001	1.488
Customer Satisfaction (CS)	0.421	0.089	**0.371**	4.730	< 0.001	1.682

Note: Model Diagnostics: $R = 0.645$, $R^2 = 0.416$, Adjusted $R^2 = 0.397$, F-statistic = 21.944 ($df = 5,154$), $p < 0.001$, *Multicollinearity Assessment:* All Variance Inflation Factor (VIF) values are below 2.0 (ranging from 1.425 to 1.682), indicating no multicollinearity issues among the predictor variables.

Source: Own calculations

To evaluate the structural framework, Customer Loyalty (CL) was regressed simultaneously on Service Quality, Employee Service, Price Satisfaction, Service Assortment, and Customer Satisfaction. This specification estimates the direct association of each predictor with Customer Loyalty while holding the other predictors constant; it does not constitute a formal mediation test.

First, multi-collinearity diagnostics were performed; as reported in Table 2, all Variance Inflation Factor (VIF) values range between 1.425 and 1.682, sitting well below the conservative threshold of 2.5, confirming that the data meet all linear assumptions and that the sub-dimensions are distinct asset blocks. Second, the direct effects were evaluated in the simultaneous regression model. Customer Satisfaction had the largest standardized coefficient ($\beta = 0.371$), followed by Service Quality ($\beta = 0.346$); both were positive and statistically significant predictors of Customer Loyalty. Service Assortment (SA) was also positive and statistically significant (B = 0.248, beta = 0.284, p = 0.001). Accordingly, SA is treated as a substantive predictor and is evaluated under H5 rather than as a control variable.

In summary, this study adopted a structured quantitative approach to investigate the relationship between customer satisfaction and loyalty within North Macedonia's telecommunications sector. The reliability and validity of the data collection process were ensured through pilot testing, ethical safeguards, and the use of established analytical techniques. This methodological framework provides a solid foundation for drawing meaningful, data-driven conclusions about consumer behavior in a competitive and evolving market.

4. Results and Discussion

This section presents the empirical findings from quantitative analysis. The analysis takes a two-tiered approach to assess the conceptual framework: first, baseline correlations and general model predictive diagnostics, followed by a detailed hypothesis-driven analysis. Table 2 presents the multiple linear regression coefficients, standard errors, t-values, significance thresholds, and collinearity diagnostics (VIF) used to examine the direct effects within the framework. The overall model is statistically significant, with an adjusted R2 of 0.397; thus, the five predictors account for 39.7% of the variance in Customer Loyalty.

4.1. Hypothesis Testing: Service Quality and Customer Loyalty (H1)

The first hypothesis (H1) affirms a strong positive relationship between perceived service quality (Q) and customer loyalty (CL) in the mobile telecommunications industry. In the simultaneous multiple regression, Service Quality was a positive and statistically significant predictor of Customer Loyalty ($B = 0.312$, $\beta = 0.346$, $t = 4.216$, $p < 0.001$). These findings indicate that service quality is an important predictor of retention. In the context of the North Macedonian market, infrastructure reliability, including call stability and high-speed data coverage, remains an important element of the customer experience. This finding aligns with contemporary literature, such as Abd-Elrahman (2023), who identified service quality as a determinant of customer satisfaction during the COVID-19 period, and is consistent with Suchanek and Bucicova (2025), whose post-COVID Slovak telecommunications model examines perceived service quality as an important component of the customer satisfaction framework. Because the regression coefficient is positive and statistically significant, H1 is supported.

4.2. Hypothesis Testing: Employee Service and Customer Loyalty (H2)

Hypothesis H2 proposed that high-quality Employee Service (ES) significantly fosters stronger brand loyalty among subscribers. The regression model supported this relationship: Employee Service had a positive and statistically significant direct association with Customer Loyalty ($B = 0.185$, $\beta = 0.226$, $t = 2.984$, $p = 0.004$). This result indicates that service delivery, efficient complaint handling, and account management are relevant to customer relationships. Customer feedback also emphasized the importance of being heard and attended to promptly, especially during technical difficulties or contract clarifications. These findings support the practical value of responsive customer support and hybrid service channels. Based on the statistically significant regression result, H2 is supported.

4.3. Hypothesis Testing: Price Satisfaction and Customer Loyalty (H3)

Hypothesis H3 investigates the direct effect of Price Satisfaction (PS) on customer retention. In the simultaneous regression model, Price Satisfaction was positively and statistically significantly associated with Customer Loyalty ($B = 0.214$, $\beta = 0.245$, $t = 3.147$, $p = 0.002$). This result indicates that perceived pricing fairness is a significant predictor of loyalty when the other variables in the model are held constant.

Customer comments further indicated the practical importance of pricing transparency, particularly in relation to roaming charges, overage fees, and changes in promotional packages. Competitive and transparent pricing can therefore contribute to retention alongside the other predictors included in the model. Because the regression coefficient is positive and statistically significant, H3 is supported.

4.4. Hypothesis Testing: Customer Satisfaction and Customer Loyalty (H4)

Hypothesis H4 proposed a direct positive relationship between Overall Customer Satisfaction (CS) and Customer Loyalty (CL). In the simultaneous multiple regression, Customer Satisfaction was a positive and statistically significant predictor of loyalty (B = 0.421, β = 0.371, t = 4.730, p < 0.001), representing the largest standardized coefficient in the model. These results support H4 and indicate that, after accounting for Service Quality, Employee Service, Price Satisfaction, and Service Assortment, higher Customer Satisfaction is associated with higher Customer Loyalty. No indirect effect was estimated; therefore, the present analysis does not test or claim mediation.

4.5. Hypothesis Testing: Service Assortment and Customer Loyalty (H5)

Service Assortment (SA) was positively and significantly associated with Customer Loyalty in the simultaneous regression model (B = 0.248, β = 0.284, t = 3.493, p = 0.001). This finding indicates that customers who value a broader range of service and product options, including bundled offerings, tend to report stronger loyalty intentions when the other predictors are held constant. Therefore, H5 is supported.

4.6. Generational Preferences and Demographic Variations

Demographic patterns in the data provided additional depth to the findings. Users aged 18–34 consistently demonstrated higher satisfaction with mobile applications, self-service portals, and instant chat functions. They valued quick and autonomous problem-solving, often avoiding traditional contact centers altogether. In contrast, respondents over 50 years old favored stable pricing, in-person service, and verbal explanations of contracts or changes. These insights are essential for designing age-sensitive strategies in service personalization. Customer feedback also revealed high appreciation for bundled offers. Consumers preferred receiving mobile, home internet, and digital TV services from a single provider due to ease of billing, cross-platform access, and perceived loyalty rewards. Participants mentioned loyalty discounts, free international minutes, and increased data allowances as meaningful incentives that improved satisfaction.

4.7. Descriptive Insights and Regional Contextualization

Despite overall satisfaction with service quality and bundles, respondents raised critical concerns regarding prolonged resolution times, generic or automated responses to support queries, and occasional discrepancies between advertised packages and final invoices. Moreover, some users reported feeling disengaged post-sale, with no follow-up on satisfaction or service issues unless initiated by the customer. These findings highlight a gap in relationship management post-acquisition and are also consistent with Nawaz and Usman (2011), who reported positive relationships among service quality, satisfaction, and brand loyalty in the telecommunications sector.

5. CONCLUSION AND MANAGERIAL IMPLICATIONS

This study confirms that Customer Satisfaction is the strongest predictor of Customer Loyalty in the regression model (β = 0.371), followed by Service Quality (β = 0.346). While price remains important, the findings highlight that loyalty is also influenced by service quality, employee responsiveness, service assortment, and perceived price fairness. The regression results support H1-H5, including a direct positive relationship between Customer Satisfaction and Customer Loyalty and a significant positive effect of Service Assortment. The study does not infer a mediating role

for Customer Satisfaction because no indirect-effect mediation analysis was conducted. The findings underscore the need for a holistic, end-to-end approach in which service reliability, transparent pricing, responsive support, a relevant assortment of services, and overall satisfaction are prioritized to foster lasting customer relationships.

5.1. Managerial and Practical Implications

From a strategic standpoint, the findings underscore the necessity of investing in service excellence across all customer touchpoints. Telecom operators should invest in real-time feedback loops, CRM-driven personalization, and cross-trained customer service teams to reduce transfer delays and increase first-contact resolution rates. Proactive support strategies, such as notifying customers of potential service issues in advance, also contribute to trust-building. In a comparative context, these results are aligned with regional studies in Southeast Europe, where service quality and personalization are increasingly valued in maturing telecom markets. Unlike more price-sensitive developing markets, the North Macedonian customer base is evolving toward a model where the perceived value, rather than cost alone, determines loyalty. These empirical insights provide valuable guidance to both national and multinational telecom providers. With market saturation increasing and regulatory frameworks tightening, loyalty is no longer an accidental byproduct of limited competition; it must be engineered intentionally.

Customer Satisfaction emerged as the strongest predictor of Customer Loyalty ($\beta = 0.371$), followed by Service Quality ($\beta = 0.346$), while Employee Service, Price Satisfaction, and Service Assortment also had positive and statistically significant effects. Customers value ease, consistency, and personalized incentives—especially when receiving multiple services from a single provider. However, persistent gaps in post-sale engagement, delayed support, and automated responses signal a need for more human-centered service strategies. Across all segments, perceived value—more than cost alone—increasingly determines brand loyalty. As the market matures and competition intensifies, telecom providers must shift from reactive service models to proactive, personalized engagement across all customer touchpoints. In doing so, loyalty can be cultivated deliberately, not left to chance, ensuring long-term competitiveness in an evolving digital landscape. Unlike studies conducted in highly competitive Western European markets, the present study demonstrates that North Macedonian customers continue to place considerable emphasis on pricing fairness alongside service quality.

5.2. Future Research Directions

Emerging trends in mobile telecommunications, such as the rollout of 5G networks and the integration of AI-powered customer service, present significant opportunities for future research. Studies could examine the impact of these technologies on customer satisfaction and loyalty, especially in developing markets like North Macedonia. Moreover, corporate social responsibility (CSR) has become increasingly important in customer decision-making. Future research could explore how CSR initiatives, such as environmental sustainability or community engagement, influence customer perceptions of service providers and their loyalty, also could employ longitudinal research designs and probability sampling techniques.

Future studies should explore satisfaction and loyalty over time and in broader regional contexts, offering deeper insights into strategic decision-making in transitional markets. Future growth depends not on acquisition alone, but on the ability to build lasting relationships. Digital tools, self-service portals, and proactive communication strategies can reinforce loyalty by empowering

customers and reducing friction. Comparative analysis with neighboring countries in the Western Balkans could also reveal region-wide behavioral patterns, aiding in strategic planning for multinational operators. Ultimately, this study contributes to both theory and practice by offering actionable insights on how telecom providers can convert satisfaction into sustainable customer loyalty.

Acknowledgment

The authors wish to thank all participants who generously shared their experiences and perspectives, which significantly contributed to the depth and relevance of this study.

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APPENDIX

Survey Questionnaire – *Customer Satisfaction and Loyalty in the Mobile Telecommunication Industry*

Dear Respondent, the purpose of this questionnaire is to measure and analyze customer satisfaction levels and brand loyalty towards mobile telecommunication providers in the Republic of North Macedonia. Your responses are strictly confidential and will be utilized solely for academic research purposes. Thank you for your time and contribution

Section A: Demographic Information

Please select the option that best describes you.

1. Please choose your age category
- Less than 18
- 19-25
- 26-35
- 36-45
- 45-55
- 56-65
- More than 65

2. Select your Gender
- Male
- Female

3. What is your current occupation?

_____

4. In which category does your monthly income belong?
- Less - minimal income in MKD 20.200
- 20.200 - 30.000 MKD
- 30.000 - 40.000 MKD
- 40.000 - 50.000 MKD
- 50.000 - 60.000 MKD
- Above 60.000 MKD

Section B: Baseline Usage Profiles

Please provide information regarding your baseline usage behavior.

5. Who is your current primary mobile telecommunication service provider?
- T - Mobile (Македонски телеком)
- A1
- M Tel
- Neotel
- Telekabel
- Lyka Mobile

6. For how long do you use the services from your current service provider?

_____

7. Type of customer category
- Prepaid
- Postpaid

8. Have you ever noticed your average monthly mobile usage in minutes?
(How long are you on the phone while speaking)

_____

9. Also, average monthly data usage (in GB)?

_____

Section C: Core Construct Evaluation Scales

10. Please rate your overall satisfaction with your telecommunication service provider
(From 1 to 5 - where 1 represents Very Dissatisfied and 5 represents Very Satisfied)

11. How satisfied are you with your network coverage?
(From 1 to 5 - where 1 represents Very Dissatisfied and 5 represents Very Satisfied)

12. How satisfied are you with the call quality? (Clarity, connection, etc.)
(From 1 to 5 - where 1 represents Very Dissatisfied and 5 represents Very Satisfied)

13. How satisfied are you with the data services? (Internet speed, reliability, etc.)
(From 1 to 5 - where 1 represents Very Dissatisfied and 5 represents Very Satisfied)

14. How satisfied are you with the customer service (response time, problem resolution, etc.) provided by your telecom service provider?
(from 1 to 5 - where 1 represents Very Dissatisfied and 5 represents Very Satisfied)

15. How satisfied are you with the pricing and value for money offered by your mobile service provider?
(From 1 to 5 - where 1 represents Very Dissatisfied and 5 represents Very Satisfied)

16. How satisfied are you with the range of mobile devices offered by your mobile service provider?
(From 1 to 5 - where 1 represents Very Dissatisfied and 5 represents Very Satisfied)

Section D: Brand Loyalty & Switching Intentions

17. Would you recommend your telecommunication provider to other customers?
- *Yes
- *No
- *Maybe

18. On a scale of 1-5, how likely are you to switch to another telecommunication provider in the near future?

19. What are the main reasons you choose to remain loyal to your current mobile service provider?

- Network coverage
- Pricing and value for money
- Variety of products and service options
- Customer care
- Overall service quality
- *Other

20. What factors would make you consider switching to a different mobile service provider?

- Network coverage
- Service reliability
- Customer service quality
- Pricing and affordability
- Exclusive offers and promotions
- Mobile device offerings and availability

21. Have you had any negative experiences with your current mobile service provider that made you consider switching?

_____
_____
_____

22. Are there any additional feedback or suggestions you would like to provide regarding your experience with your current mobile service provider?

_____
_____
_____

23. Thank you for your time. You can add suggestions for improvement of the overall satisfaction below.

_____
_____
_____
_____
_____
_____
_____

Balkans JETSS (2026) 1: 38-50
DOI: https://doi.org/10.31410/Balkans.JETSS.2026.9.1.38-50

Original Scientific Article

Between Efficiency and Emotion: Exploring Intelligent Automation in Restaurants Through Owner and Customer Perspectives

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Received: August 30, 2025 / Revised: June 3, 2026
Accepted: June 13, 2026 / Published: June 30, 2026
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Abstract: *Hospitality businesses are increasingly adopting intelligent automation (IA), including service robots and AI, to mitigate labor shortages and enhance efficiency. However, its influence on guest experience and human interaction remains contested. This study employs a triangulated qualitative approach: an in-depth interview with a restaurant owner analyzed through grounded-theory-informed coding, netnographic analysis of 21 online reviews, and academic literature. Findings indicate that automation reduces staff strain and improves efficiency, while employees continue to provide emotional service. The restaurant's robot not only streamlined operations but also contributed to its brand identity. Customer perceptions were mixed—many valued novelty and efficiency, whereas others highlighted delays, reduced warmth, or fears of job loss. Consistent with prior research, results suggest that IA is most effective in hybrid models, where technology supports routine tasks and humans deliver empathy-driven interactions. The study concludes that IA enhances efficiency and branding when integrated thoughtfully, complementing rather than replacing human labor.*

Keywords: *Intelligent automation, Robots, Waiters, Restaurant, Netnography*

JEL Classification: L83, O33, M15

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1. INTRODUCTION

In recent years, the restaurant industry has undergone a notable shift in service delivery and operations, driven largely by intelligent automation (IA) and artificial intelligence (AI) (Blöcher & Alt, 2021; Yoon, 2023). IA has led this transition, representing nearly 70% of technological adoption through tools designed to streamline tasks, accelerate service, and reduce staff strain (Batat, 2021; Harpanahalli et al., 2020). AI complements these changes by shaping strategy and enhancing customer experience, forming part of a broader response to labor shortages, rising costs, and consumer expectations for speed and digital engagement (Arora et al., 2021; Tan & Netessine, 2020). The urgency to adopt intensified during COVID-19, when contactless service became critical (Tuomi et al., 2021; Yoon, 2023).

Adoption, however, has been uneven. While IA and AI improve efficiency, they also raise challenges. Customers may find robots or AR features novel yet impersonal, undermining the warmth traditionally associated with hospitality (Batat, 2021; Li et al., 2025). Employees often welcome relief from repetitive tasks but worry about job security, reduced responsibilities, and declining interpersonal aspects of service (Tuomi et al., 2020; Yoon, 2023). Owners thus face complex trade-offs: beyond efficiency and financial return, they must weigh impacts on business identity, staff morale, and customer trust (Arora et al., 2021; Tan & Netessine, 2020). Despite this, research continues to prioritize customer and employee perspectives, with quantitative studies on performance and consumer behavior dominating the field (Li et al., 2025; Yoon, 2023). Consequently, little is known about how owners themselves interpret and manage adoption decisions (Blöcher & Alt, 2021; Tuomi et al., 2021).

This study addresses that gap by exploring the perspective of a restaurant owner who has implemented both IA and AI. Specifically, the study addresses two research questions: (RQ1) How does a restaurant owner perceive and manage the benefits, trade-offs, and evolving staff–technology relationship associated with intelligent automation? (RQ2) How do customers, as expressed through online reviews, perceive the novelty, efficiency, and emotional dimensions of automated restaurant service? Through an in-depth interview using a Grounded Theory approach, the study investigates how the owner perceives these benefits, trade-offs, and the evolving staff–technology relationship (Tuomi et al., 2020). To enrich this view, a netnographic analysis of online reviews captures customer perceptions of novelty, efficiency, and emotional disconnect. Taken together, the findings show that while automation promises efficiency and competitive appeal, concerns about costs, employee adaptation, and the loss of human warmth remain central (Arora et al., 2021; Blöcher & Alt, 2021; Tuomi et al., 2021; Yoon, 2023). Rather than offering prescriptive solutions, the study provides grounded insights into what is gained and what may be lost as restaurants automate.

2. LITERATURE REVIEW

In restaurant contexts, IA and AI are often discussed as if they are interchangeable, though they serve quite different functions. IA typically refers to technologies that take over routine, task-based activities. These include self-order kiosks, service robots, QR menu systems, and, in some cases, augmented reality (AR) tools that guide guests through ordering (Batat, 2021; Harpanahalli et al., 2020; Yoon, 2023). These systems are usually introduced to speed up service, relieve pressure on staff, and help address ongoing labor shortages. AI, by contrast, tends to operate less visibly. Rather than interacting directly with guests, it runs in the background—analyzing data, recognizing trends, and supporting decision-making at the managerial level. In practical terms,

this might involve chatbots responding to customer queries, predictive tools that adjust inventory planning, or software designed to extract insights from customer reviews (Blöcher & Alt, 2021; Lee et al., 2021). The application of these tools often varies according to restaurant type. Fast-food and quick-service venues, where throughput is a priority, rely heavily on kiosks and QR codes to move customers through quickly (Arora et al., 2021; Yoon, 2023). By contrast, higher-end restaurants may use technologies like AR or interactive tables less for efficiency and more to shape ambiance or create a distinctive experience (Batat, 2021; Tan & Netessine, 2020). In either case - whether aimed at speeding up a process or elevating an experience - technology has begun to reshape how restaurants operate and how service is delivered.

To date, academic literature has centered more on how these technologies affect customers or frontline employees, with many studies relying on large-scale surveys or econometric models. While useful, this leaves out an important piece: the perspective of the people making the investment decisions. Restaurant owners are ultimately the ones who decide whether, when, and how to adopt these tools, yet their views remain largely absent from the discussion (Tan & Netessine, 2020; Tuomi et al., 2020). This gap is especially noticeable in qualitative research, where richer, more contextual insights into owner reasoning could offer a more grounded understanding of what technology adoption looks like in practice. Moreover, existing studies rarely interrogate how owners weigh conflicting priorities, such as short-term efficiency gains against longer-term risks to brand identity and staff morale, leaving open questions about the underlying decision logic that this study seeks to unpack.

2.1. Benefits of Intelligent Automation and Artificial Intelligence in Restaurants

2.1.1. Customers

Restaurants increasingly deploy IA to improve service efficiency and customer control. Self-order kiosks and QR menus shorten queues, reduce errors, and proved particularly attractive during COVID-19 due to hygiene concerns (Arora et al., 2021; Harpanahalli et al., 2020; Yoon, 2023). In fine dining, IA has also enhanced immersion; for instance, Le Petit Chef uses AR to turn meals into sensory experiences linked with greater enjoyment and well-being (Batat, 2021; Batat et al., 2019; Velasco et al., 2018). AI complements these tools through recommendation systems, chatbots, and review analytics, helping customers navigate options while offering managers operational insights (Berezina et al., 2019; Blöcher & Alt, 2021; Lee et al., 2021; Li et al., 2025). Robots and interactive displays often appeal to younger, digitally oriented diners (Li et al., 2025; Zhu, 2022). Other customers, however, perceive kiosks and robots as impersonal or disruptive (Batat, 2021; Li et al., 2025). Successful adoption thus depends on aligning technology with service models, as misalignment risks undermining both function and experience (Joo et al., 2023; Yoon, 2023).

2.1.2. Employees

For staff, IA reduces routine tasks, allowing greater focus on guest service. Robots delivering food or clearing tables are often described as “helpers” that ease physical strain in high-volume settings (Tuomi et al., 2020; Wirtz et al., 2018). Tools such as RFID (Radio Frequency Identification) systems further reduce bottlenecks and stress during peak periods (Ahmed et al., 2019; Harpanahalli et al., 2020). When paired with clear role division, these efficiencies can improve job satisfaction. AI also supports inventory forecasting and scheduling, easing workload and enabling more guest interaction (Blöcher & Alt, 2021; Ivanov & Webster, 2019; Joo et al., 2023).

However, concerns persist: in many contexts, staff view automation as a threat to job security and purpose (Tuomi et al., 2020; Tussyadiah, 2020). Adaptation is smoother when owners are transparent, provide training, and preserve meaningful roles (Tuomi et al., 2021). Yet most studies examine employee reactions rather than how owners manage these transitions (Blöcher & Alt, 2021; Li et al., 2025).

2.1.3. Owners

For owners, IA and AI deliver clear economic and strategic gains. Self-service kiosks and QR systems reduce labor costs, streamline processes, and increase sales—digital menus, for example, often boost order size (Arora et al., 2021; Tan & Netessine, 2020; Yoon, 2023). Table-ordering devices and upselling functions further enhance profitability, particularly in low-margin segments (Susskind & Curry, 2016). IA also facilitates scaling by standardizing service and reducing reliance on staff during peak hours. RFID and forecasting tools further help optimize inventory and staffing (Harpanahalli et al., 2020; Ivanov & Webster, 2019; Joo et al., 2023; Kumar et al., 2016; Li et al., 2025; Ma et al., 2023). Strategically, AR dining concepts and robot restaurants attract novelty-seeking customers and differentiate brands (Batat, 2021; Li et al., 2025; Romano et al., 2020; Zhu, 2022). Moreover, data-driven insights support targeted marketing and loyalty programs (Lee et al., 2021; Tan & Netessine, 2020).

Despite these benefits, most research remains rooted in quantitative analyses, leaving the owners' perspective underexplored (Blöcher & Alt, 2021; Joo et al., 2023; Tuomi et al., 2021; Yoon, 2023). Critically, much of this literature treats efficiency and emotional authenticity as separate outcomes rather than examining how owners actively negotiate the tension between them—a conceptual gap this study aims to address. Questions about balancing short-term gains with long-term investments, or about impacts on employees and customer experience, remain largely unanswered. This study addresses that gap by adopting a qualitative lens, centering on how owners interpret and implement IA and AI in practice.

2.2. Operational Dynamics and Strategic Implications of Intelligent Automation and Artificial Intelligence in Restaurants

2.2.1. Efficiency of IA and AI

IA improves speed, accuracy, and consistency in restaurants. Self-service kiosks and QR systems can cut waiting times by up to 40% (Arora et al., 2021), while robots sustain performance during peak hours (Li et al., 2025; Tuomi et al., 2021). Table devices reduce dining time, increasing turnover and sales (Tan & Netessine, 2020). AI enhances efficiency through predictive analytics for inventory and staffing, reducing waste and optimizing resources (Blöcher & Alt, 2021; Joo et al., 2023). Although experimental and SEM-based studies confirm these gains, results vary by restaurant type and size (Tan & Netessine, 2020; Yoon, 2023). Owners' views on efficiency, however, remain underexplored (Blöcher & Alt, 2021).

2.2.2. Human–Technology Division of Labor

IA reshapes labor distribution: machines handle repetitive tasks, while humans provide personal service and manage exceptions (Tuomi et al., 2020; Yoon, 2023). Robots deliver food, QR codes automate ordering, and AR enhances dining experiences, with staff ensuring warmth and emotional connection (Arora et al., 2021; Batat, 2021; Li et al., 2025; Tuncer, 2020). AI provides

analytical insights, but humans remain responsible for strategic decisions (Blöcher & Alt, 2021). Cultural differences shape collaboration patterns, yet owners' perceptions of these dynamics are seldom addressed (Li et al., 2025; Tuomi et al., 2020). Successful integration depends on training and clear role definitions (Tuomi et al., 2021).

2.2.3. Challenges and Drawbacks

Despite clear benefits, IA and AI adoption faces barriers. High costs hinder smaller businesses, while technical malfunctions disrupt service (Harpanahalli et al., 2020; Li et al., 2025; Yoon, 2023). Some customers perceive kiosks and robots as impersonal, particularly in venues emphasizing human connection (Batat, 2021; Tan & Netessine, 2020). Employees fear job loss and reduced meaning in their roles (Tuomi et al., 2020; Wirtz et al., 2018). AI personalization also raises privacy concerns regarding data collection and transparency (Lee et al., 2021; Tan & Netessine, 2020). Quantitative research has outlined these issues, but owners' perspectives on risks and ethical trade-offs remain underrepresented (Li et al., 2025; Tuomi et al., 2021). Overall, studies highlight efficiency gains, higher satisfaction, and profitability. Yet adoption is still constrained by costs, resistance, and ethical challenges (Blöcher & Alt, 2021; Yoon, 2023). Crucially, owners' voices are missing: little is known about the trade-offs they weigh, the risks they accept, or how they interpret automation in practice (Li et al., 2025; Tuomi et al., 2020).

3. METHODOLOGY

3.1. Research Design

Grounded Theory is a qualitative methodology suited to underexplored phenomena, such as how restaurant owners perceive and navigate the adoption of intelligent automation, as it enables theory to be developed inductively from empirical data rather than tested against a pre-existing framework (Glaser & Strauss, 1967; Tuomi et al., 2020). While much of the existing research relies on quantitative approaches, such as difference-in-differences or structural equation modeling (Joo et al., 2023; Yoon, 2023), Grounded Theory was selected because it affords richer, context-sensitive insight into decision-making processes that remain largely undocumented in the literature (Tuomi et al., 2020). A single, in-depth case was considered appropriate given the exploratory aim of the study and the depth of access secured with the participant, consistent with guidance that case-based designs are well suited to research questions requiring detailed, context-rich understanding (Batat, 2021; Saunders et al., 2012). To strengthen the credibility and contextual depth of this single-case design, the interview was complemented by a netnographic analysis (Kozinets, 2020), a method well established in tourism and hospitality research (Marine-Roig & Anton Clavé, 2015). This triangulation of interview and netnographic data allowed the analysis to capture not only the owner's internal decision-making process but also independently expressed customer perceptions, addressing concerns about the evidentiary limits of relying on a single data source. Precedent for applying Grounded Theory methods to a single, in-depth interview exists in the qualitative literature (Rich, 2015), which similarly acknowledges the resulting constraints on transferability; the triangulation of interview data with a complementary qualitative source—company documents and archival material in Reed's (2017) single-case study of Cummins Inc., or netnographic reviews in the present study—further supports the credibility of single-case Grounded Theory designs. Consistent with this exploratory aim, the study does not claim theoretical saturation or generalizable theory in the strict Grounded Theory sense; rather, it offers a single-case exploratory analysis that surfaces context-rich patterns intended to inform, rather than conclusively establish, theoretical understanding of owner-level automation adoption.

3.2. Data Collection and Analysis

Data were gathered through a semi-structured, in-depth interview with the owner of a mid-sized casual dining restaurant in Tenerife, Spain. The restaurant employs 12 staff, serves an average of 80–100 guests daily, and introduced intelligent automation in 2023, including a robotic waiter and an AI-powered ordering system, following high staff turnover. The owner, who directly oversaw the integration, was purposively selected for his lived experience with both operational and strategic decision-making. The interview lasted two hours, was audio-recorded, and produced a verbatim transcript of over 11,000 words. An interview guide with 14 open-ended questions explored motivations for automation, staff adaptation, customer response, costs, and brand identity. Data analysis followed Charmaz's (2006) Grounded Theory principles. Open coding was first applied to identify key concepts, which were then organized into broader axial categories such as drivers of adoption, implementation challenges, and impacts on staff roles. Through selective coding, these categories were integrated into a core concept explaining how smart technologies influence managerial decision-making and reshape restaurant operations. NVivo software supported the process by enabling systematic coding, categorization, and memoing (Welsh, 2002). Trustworthiness was addressed through triangulation of interview and netnographic data, a detailed audit trail of coding decisions maintained in NVivo, and reflexive memoing throughout analysis; while transferability is necessarily limited by the single-case design, the rich, context-specific description provided here is intended to allow readers to judge the applicability of findings to comparable hospitality settings.

The netnographic dataset was built from TripAdvisor, Google Reviews, and Facebook, using the search term 'robot'. Out of 345 reviews, 21 directly referring to robot waiters were extracted, anonymized, and imported into NVivo for coding. An initial coding cycle was conducted using NVivo's node creation functionality, where key phrases and recurring ideas were tagged under open codes such as "novelty," "fun experience," "efficiency," "impersonal service," and "frustration". In the second cycle of coding, related codes were merged into broader parent nodes, representing major emergent themes: (a) Technological novelty and entertainment, (b) Service efficiency and limitations, and (c) Emotional disconnect and techno-skepticism. NVivo's query tools, such as the word frequency and text search features, helped validate the thematic relevance and frequency of certain keywords like "robot," "waiter," "friendly," "slow," and "impersonal". To mitigate the risk of selection bias associated with keyword-based sampling, the remaining reviews from the initial pool of 345 were subsequently checked manually for alternative references to automation (e.g., mentions of "machine," "kiosk," or "automated service") that did not include the term "robot." This manual check did not identify additional reviews meeting the inclusion criteria, supporting the adequacy of the keyword-based sample for capturing customer perceptions of the automation experience.

4. RESULTS

4.1. Results of the Interview

The analysis of the restaurant owner's account revealed three major categories: (a) Determinants of automation, (b) Human–technology interaction, and (c) Strategic repositioning of labor. These categories converged around a central theme of balancing efficiency with human value in intelligent restaurant work (see Table 1).

Table 1. Coding Summary for the Owner Interview

Theme	Representative Open Codes	Illustrative Quote	Source
Determinants of Automation	labor shortage; efficiency need	"We simply couldn't find reliable staff anymore. They are no longer interested in working in the hospitality industry. Moreover, machines don't call in sick — and that matters when you're open seven days a week."	Owner interview (translated from recording)
		"Before, for a table of six, my husband had to make three trips by hand carrying trays. Now it brings everything in one go — it has four shelves, and each one holds two large trays."	Owner interview (translated from recording)
Human–Technology Interaction	task delegation; service boundary	"The robot brings the food, but it's our people who bring the warmth. Guests still need to feel cared for."	Owner interview (translated from recording)
		"I explained to her: it's not a robot, it's a transporter. It doesn't serve you itself — we still do that. It just comes to the table and stops."	Owner interview (translated from recording)
Strategic Repositioning of Labor	role redefinition; future automation plans	"We didn't fire anyone — we changed what their job meant. Now they monitor the tech and make sure the service feels human."	Owner interview (translated from recording)
		"What my husband wants next is for it to follow him around, so at the end of the night it can help clear the tables too, once it's done bringing food."	Owner interview (translated from recording)

Source: Own research

4.1.1. Determinants of Automation

The owner highlighted that the choice to implement intelligent automation started from ongoing labor shortages and rising wage pressures. Automation was regarded as a strategic long-term response to these operational challenges: "We simply couldn't find reliable staff anymore. They are no longer interested in working in the hospitality industry. Moreover, machines don't call in sick — and that matters when you're open seven days a week". This reasoning aligns with prior studies identifying labor shortages as a primary driver of automation in hospitality, with kiosks, robots, and QR menus adopted to alleviate workforce gaps and reduce operational risks (Arora et al., 2021; Yoon, 2023). Moreover, the owner described automation as a competitive differentiator, enhancing a "tech-forward" appeal—echoing literature that stresses how novelty and innovation attract younger, digitally curious customers and create brand distinction (Batat, 2021; Li et al., 2025).

4.1.2. Human–Technology Interaction

The owner emphasized a strategic focus on human–machine collaboration instead of complete staff replacement. Automated systems were assigned procedural and repetitive tasks, such as order taking and billing, enabling staff to concentrate on high-touch, relational aspects of service: "The robot brings the food, but it's our people who bring the warmth. Guests still need to feel cared for." This reflects findings that IA reshapes the division of labor, with machines delivering efficiency and humans ensuring personalization and emotional connection (Li et al., 2025). In addition to operational efficiency, the owner observed that customers were highly curious and

amused by the robot, often interacting with it playfully. This novelty created memorable experiences (Zhu, 2022) and contributed to a distinctive, tech-forward brand image: "Some guests even film the robot or ask for selfies with it - it becomes part of the dining experience."

4.1.3. Strategic Repositioning of Labor

Automation led to a redefinition of roles. Existing staff were upskilled and repositioned as "guest experience agents" or "system overseers." The owner noted: "We didn't fire anyone — we changed what their job meant. Now, they monitor [sic] the tech and make sure the service feels human". He also referred to training employees on artificial intelligence in the workplace: "The automation system occasionally required manual overrides or technical maintenance, and staff had to learn to monitor, support, and troubleshoot the technology". This resonates with research noting that automation not only redistributes tasks but also requires staff training and hybrid role development to manage both service and technology (Tuomi et al., 2021). While some studies emphasize fears of job loss (Tussyadiah, 2020), the owner's perspective highlights a more constructive integration where staff retain employment but evolve into tech-fluent hospitality roles.

4.2. Results of the Netnography

The netnographic analysis revealed three main themes: (a) technological novelty and entertainment, (b) service efficiency and technical limitations, and (c) emotional disconnect and techno-skepticism. Out of the 21 reviews, 11 expressed positive attitudes, 6 were negative, and 4 were ambivalent. Customers valued robots as amusing novelties, yet some criticized delays, inefficiency, or the lack of human warmth (see Table 2).

Table 2. Coding Summary for the Netnographic Analysis

Theme	Representative Open Codes	Illustrative Quote	Source
Technological Novelty and Entertainment	novelty; fun experience	"The robot waiters are a brilliant touch."	Facebook, Lee Maggs, Aug 7, 2024
		"Absolutely loved the robot, bringing drinks and food to table."	Facebook, Arthur Davies, Jun 26, 2024
		"Highlight is the robot waiter … great touch."	TripAdvisor, Sep 2024
		"He [the robot] does get a bit lost most of the time—bit funny."	Google, AntiMagicDragon, ca. Nov 2024
Service Efficiency and Limitations	efficiency; frustration	"The delight of the service are the very polite and friendly waiters and their robots that bring the food and drinks to the tables."	Google, Andreea T., ca. May 2025
		"The robot… is the slowest, most pointless thing I've ever seen."	TripAdvisor, Oct 2024
		"We had to wait 45 minutes for our mains … Perhaps the delivery robot's fault!"	TripAdvisor, Mar 2025
		"The robot, whilst amusing once, is a bit of an unnecessary gimmick."	TripAdvisor, Nov 2024

Theme	Representative Open Codes	Illustrative Quote	Source
Emotional Disconnect and Techno-Skepticism	impersonal service	"Personally, I don't like the service/waitress robot. In my opinion, it feels impersonal and a bit out of place in a nice restaurant like this."	Google, Lotte Corijn, ca. Mar 2025
		"Just the fact they substitute the People for robots—I will never be there! … I like traditional service with empathetic people, not ROBOTS!"	Facebook, Miguel Martins, Nov 2024
	warmth attribution (inverse case)	"The staff weren't very friendly or welcoming. The robot waiters were more friendly."	Google, Jonny Smith, ca. May 2025

Source: Own research

4.2.1. Technological Novelty and Entertainment

Many reviewers perceived the robot waiters as an appealing and innovative feature that enhanced the dining experience. Comments frequently described the robots as a "great touch" or a "brilliant touch" (TripAdvisor, Sep 2024; Facebook, August 7, 2024), indicating their function as a novelty that added value to the customer experience. This finding aligns with Batat's (2021) study. One Google user highlighted the entertainment value by stating, "He [the robot] does get a bit lost most of the time—bit funny," illustrating how malfunctions were sometimes interpreted playfully (Google, AntiMagicDragon, Nov 2024).

The robots were often seen as initial attractions that differentiated the restaurant from others. A TripAdvisor reviewer noted, "They were the initial draw but the food and service eclipsed the robots very quickly," indicating that while the technology attracted attention, traditional service components still defined satisfaction (TripAdvisor, Jul 2024), which confirms earlier arguments that while technological innovation attracts attention, traditional hospitality factors such as taste and relational service ultimately drive overall evaluations (Tan & Netessine, 2020).

4.2.2.Service Efficiency and Limitations

A second theme focused on the functional dimension of robotic service. Some customers appreciated the integration of robots in improving logistics and speed of delivery. For instance, one Google reviewer emphasized, "The delight of the service are the very polite and friendly waiters and their robots that bring the food and drinks to the tables" (Google, Andreea T., May 2025). Similarly, TripAdvisor users described the service as "different" and "efficient," praising how robots were seamlessly integrated into the dining routine (TripAdvisor, Aug 2024). This corresponds with literature that describes robots and IA tools as "helpers" reducing workload and enhancing logistical flow during peak hours (Harpanahalli et al., 2020; Tuomi et al., 2020). However, not all experiences with robots were positive in this regard. Several reviewers criticized the slow pace and limited responsiveness of robot waiters. One noted, "The robot… is the slowest most pointless thing I've ever seen," expressing frustration with the robot's inefficiency (TripAdvisor, Oct 2024). Another reviewer blamed delayed and incorrect orders on the delivery robot: "We had to wait 45 minutes for our mains… perhaps the delivery robot's fault!" (TripAdvisor, Mar 2025). These reviews underscore the gap between technological promise and operational reliability and also confirm that while robots can contribute to efficiency, their limitations often highlight the continued importance of human adaptability and oversight (Blöcher & Alt, 2021; Joo et al., 2023).

4.2.3. Emotional Disconnect and Techno-Skepticism

The third theme identified was a concern over the loss of human interaction and a perceived lack of emotional connection. A Google reviewer remarked, "Personally I don't like the service/waitress robot. In my opinion, it feels impersonal and a bit out of place in a nice restaurant like this" (Google, Lotte Corijn, Mar 2025). This sentiment was echoed by others who valued the emotional warmth typically associated with hospitality. On Facebook, critiques took a more ideological turn, raising concerns about automation and job displacement. One user wrote, "Just the fact they substitute the People for robots—I will never be there! That scares me… I like traditional service with empathetic people, not ROBOTS!" (Facebook, Miguel Martins, Nov 2024). Such perspectives echo broader debates about the cultural and ethical implications of automation, particularly the tension between efficiency-driven innovation and the preservation of empathy, authenticity, and meaningful human work (Li et al., 2025; Tuomi et al., 2020; Wirtz et al., 2018).

5. CONCLUSION

This study provides a nuanced understanding of how intelligent automation (IA) and artificial intelligence (AI) are reshaping restaurant work, combining both the lived experience of a restaurant owner and the perceptions of customers expressed in online reviews. By integrating these perspectives, the study addresses a significant gap in the literature, which has often emphasized customers or employees through large-scale quantitative approaches (Li et al., 2025; Yoon, 2023) while overlooking the strategic voice of owners (Blöcher & Alt, 2021; Tuomi et al., 2021). The owner's account illustrates that automation was primarily implemented as a response to labor shortages and rising costs, reflecting broader industry trends (Tan & Netessine, 2020; Yoon, 2023). However, instead of replacing staff, the technology was integrated in a hybrid way: machines were assigned repetitive, procedural tasks, while human employees focused on relational and supervisory responsibilities. This transition from substitution to collaboration (Tuomi et al., 2020) shows how owners act as strategic integrators, balancing efficiency with the preservation of hospitality's emotional essence. Employee roles were redefined as "guest experience agents" or "system overseers," underlining the principle of decent work through automation. At the same time, the owner recognized automation as a branding asset but remained cautious about excessive reliance on robots that might undermine authenticity.

Findings from the reviews mirror the owner's account: robots were perceived as attractive and entertaining, yet their limited performance and lack of empathy often generated frustration. This reflects prior studies emphasizing that while novelty and innovation can differentiate restaurants and create memorable experiences (Batat, 2021; Romano et al., 2020; Zhu, 2022), such effects are short-lived if food quality or emotional service is compromised (Tan & Netessine, 2020; Yoon, 2023). The mixed reactions also reinforce arguments for hybrid service models, where robots handle routine logistics and humans deliver warmth and personalization (Chi et al., 2023; Li et al., 2025; Tuomi et al., 2020). Netnographic evidence complements the owner's narrative by highlighting a balance of curiosity and criticism: customers enjoy the novelty but express techno-skeptic concerns when efficiency falters or human empathy seems displaced. This confirms earlier findings that automation is best received when it enhances rather than replaces human labor (Blöcher & Alt, 2021; Tussyadiah, 2020; Wirtz et al., 2018). From a managerial standpoint, this underlines the owner's role not only as a technology adopter but also as a mediator of change—aligning operational efficiency with employee well-being, customer trust, and brand authenticity (Ivanov & Webster, 2019; Joo et al., 2023). Theoretically, this study makes an original methodological contribution by combining Grounded Theory with netnography to examine intelligent automation simultaneously from the owner's strategic

perspective and the customer's experiential perspective—a dual-lens design that remains rare in the hospitality technology literature, which has tended to study these actors separately and predominantly through quantitative methods (Blöcher & Alt, 2021; Tuomi et al., 2021; Yoon, 2023). Compared with prior work, which has typically examined either owner-level strategic decisions or customer-level acceptance in isolation, this study is among the first to analyze both simultaneously within a single hospitality setting, offering an integrated account of how automation is enacted and experienced across both sides of the service encounter. This triangulated design extends established models of technology adoption, such as the Technology Acceptance Model (Davis, 1989) and the Service Robot Acceptance Model (Wirtz et al., 2018), which explain adoption primarily through rational, individual-level constructs such as perceived usefulness and ease of use. By situating customer techno-skepticism and owner decision-making within the broader, threefold tension between novelty, efficiency, and emotional authenticity, the findings suggest that acceptance of automation in hospitality settings is also shaped by relational and affective factors—such as perceived warmth and authenticity—that are not fully captured by existing acceptance models (Li et al., 2025; Tuomi et al., 2021). Practically, the results suggest positioning automation as an enabler rather than a disruptor. Clear communication that robots support staff, investment in training for hybrid roles, and systematic monitoring of customer feedback through social media can foster stronger acceptance. Emotional authenticity remains the cornerstone of hospitality and should guide technological integration (Batat, 2021; Tussyadiah, 2020).

By combining interview data with netnographic insights, the study achieves methodological triangulation. This dual perspective shows that while robots can enrich dining through novelty and efficiency, emotional authenticity remains the cornerstone of hospitality. While the study draws on a single-owner case, the addition of netnographic data enhances its contextual depth. Nevertheless, the findings are not intended as broad generalizations. Accordingly, the study is best understood as an exploratory, single-case investigation rather than a fully saturated Grounded Theory account, and its contribution lies in generating context-specific insight rather than in producing generalizable theory. It is also worth noting that the restaurant is located in Tenerife, Spain, a Mediterranean, tourism-driven market with a longstanding tradition of personalized, relationship-based hospitality service; owner and customer attitudes toward automation observed here may not directly generalize to markets with different service cultures or a lower reliance on tourism. Future research should build on this foundation by conducting comparative case studies or cross-cultural analyses, exploring how different ownership types and cultural contexts influence the adoption and adaptation of automation.

In conclusion, intelligent automation in restaurants offers more than cost reduction or labor substitution: it represents a strategic tool for shaping customer experiences, empowering employees, and redefining brand identity. The challenge for owners is to reconcile technological efficiency with the human essence of hospitality, ensuring that innovation supports, rather than undermines, the values that define the dining experience.

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Balkans JETSS (2026) 1: 51-61
DOI: https://doi.org/10.31410/Balkans.JETSS.2026.9.1.51-61

Original Scientific Article

Data Dreams vs. Reality: Bridging the Data Culture Gap in Small Cultural Destinations

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Received: August 30, 2025 / Accepted: June 6, 2026 /
Revised: June 16, 2026 / Published: June 30, 2026
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Abstract: *Small cultural destinations face significant challenges in tourism data collection and analysis. This study aims to examine the data culture in smaller cultural destinations across selected countries using a triangulated methodology combining qualitative workshops, quantitative surveys, and content analysis. Data were collected from 99 DMOs and municipalities in Slovakia, the Czech Republic, Albania, Poland, and Hungary between 2022 and 2024. Results reveal an underdeveloped data culture characterised by limited financial resources, reliance on basic data sources (own questionnaires, social networks, and tourist information centres). The research revealed the existence of "aspirational data culture" and the "aspiration-reality gap". This consists mainly of technology aspiration versus real opportunities. While organisations desire advanced data collection methods, such as mobile/GSM data, most employ only basic analytical techniques, with some storing data without any analysis. Key barriers include insufficient funding, lack of institutional cooperation, and limited technical expertise. The study recommends standardised methodological frameworks, collaborative purchasing models, and centralised data-sharing platforms to bridge the data culture gap and enhance sustainable tourism management in cultural destinations.*

Keywords: *Data Culture, Cultural destinations, Tourism, DMOs*

JEL Classification: Z31, M15, M14

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1. INTRODUCTION

Small cultural destinations constitute a unique segment of the tourism sector, characterised by limited geographic size, lower visitor volumes, and strong reliance on local cultural assets that play a vital role in preserving cultural heritage, traditions, and community identity (Richards, 2018; Timothy & Nyaupane, 2009). Unlike major urban centres, these destinations offer intimate, authentic experiences tied to local stakeholder participation and heritage safeguarding (UNWTO, 2018). In times when digital transformation, smart tourism destinations, and data-driven governance are discussed, small destinations might be "left behind" in these aspects.

Effective management and sustainable development depend heavily on tourism data availability and quality. For DMOs and municipal offices, systematic data collection is fundamental for understanding visitors´ profiles, monitoring flows, assessing economic impacts, and evaluating marketing initiatives (Baggio & Klobas, 2017; Morrison, 2013). Reliable data enables informed decisions, optimised resource allocation, and tailored tourism products (Gretzel et al., 2015). In resource-limited small destinations, data-driven management is crucial for allocating scarce resources, maximising investment effectiveness and supporting external funding applications (Dredge & Jenkins, 2016).

Transparent, evidence-based reporting fosters trust among communities, institutions, and businesses, providing foundations for participatory planning (Bramwell & Lane, 2011). This is essential where tourism impacts are felt more directly by residents and stakeholders. Data culture encompasses three interconnected dimensions: (1) technical capabilities (infrastructure, tools, skills), (2) organisational practices (data governance, processes, roles), and (3) cultural attributes (data literacy, trust in data, data-driven mindset) (Kiron et al., 2014). In small cultural destinations, these dimensions are constrained by resource limitations.

The theoretical gap this study addresses is the data culture concepts in resource-constrained tourism organisations, particularly in small cultural destinations, where traditional enterprise-focused frameworks may not be applied directly (Chen et al., 2012). The research question is formulated as follows:

RQ: "What is the situation with data collection in smaller cultural destinations in selected countries through the lenses of data culture?"

Based on the definition of data culture, the following sub-questions are formulated:
(1) What are the methods used,
(2) What are the methods desired,
(3) What barriers are encountered,
(4) What data analysis is employed, and
(5) What is the potential usage of the data?

The answers have been brought through a triangulation of qualitative analysis of focus groups (workshops), quantitative analysis, and content analysis. The main innovation of this paper is the application of the data culture framework to small cultural destinations, which are lacking in the literature. The results are not only an insight into the practice but also offer a significant theoretical contribution to this topic.

2. CHALLENGES AND NEEDS IN DATA COLLECTION FOR SMALL DESTINATIONS

Small cultural destinations face a unique constellation of challenges in the collection, management, and utilisation of tourism data. A primary obstacle is the limited financial and human capacity of small destinations, which makes it difficult to invest in advanced data- collection systems or conduct regular, large-scale surveys (Borowiecki et al., 2024). The costs associated with these technologies are often prohibitive, resulting in a reliance on traditional, less granular methods such as manual visitor counts or occasional surveys (European Commission et al., 2022). Small staff teams may lack the time or specialised expertise to conduct comprehensive data gathering and analysis (Baggio & Klobas, 2017; Morrison, 2013). Nevertheless, the commitment to data-driven management remains strong, as DMOs and municipalities seek innovative solutions.

Tourism data is inherently diverse, encompassing sources ranging from visitor registrations and financial transactions to social media analytics and geolocation data, further complicating the situation. Integrating such heterogeneous data streams into a coherent information system requires not only technical infrastructure but also specialised competencies in data harmonisation and analysis. These resources are typically scarce in small destinations, where human factors also play a significant role (Borowiecki et al., 2024; European Commission, 2022). The lack of common standards and interoperability protocols at the local level exacerbates these challenges, limiting the potential for data-driven management and evidence-based policy-making (Eurostat, 2017). Significant investments are more easily justified and absorbed in larger destinations with higher visitor volumes and greater public funding (European Commission et al., 2022). Small destinations risk digital exclusion, as they may lack the resources to participate in national or European data-sharing platforms or to implement smart tourism solutions at scale.

Another salient challenge is data privacy and governance. Especially data from mobile devices raises concerns about compliance with data protection regulations, such as the General Data Protection Regulation (GDPR) in the European Union. Small destinations often lack the legal expertise and institutional frameworks necessary to navigate these requirements, which can deter the adoption of innovative data sources.

A critical gap in the academic literature compounds these practical challenges. Most tourism research and methodological innovation have historically focused on large, resource-rich destinations, which are better equipped to participate in pilot projects and to adopt advanced data analytics (Borowiecki et al., 2024; Li et al., 2018). As a result, best practices and policy recommendations are often tailored to the needs of larger destinations, overlooking the specific circumstances and constraints of small, rural, or culturally unique locations. This paper aims to bridge the gap in the literature.

3. DATA CULTURE

The emerging topic of data culture/s has been identified and discussed across a broad spectrum of academic disciplines. Oliver et al. (2023) define the data culture as social, technical, and cultural characteristics, values, and practices that determine the nature of data production, generation, acquisition, cultivation, use, curation, preservation, sharing, and reuse by individuals, organisations, governments, and societies. They may co-exist and compete at multiple levels and are dynamic and normative in nature. The theoretical foundation of data culture in tourism organisations is built upon several established frameworks. Drawing from organisational culture theory (Schein, 2010), data culture represents a deeper layer of shared assumptions about the value of data and usage patterns.

Davenport and Patil's (2012) data-driven decision-making framework provides the operational dimension, while the Technology-Organization-Environment (TOE) framework (Tornatzky & Fleischer, 1990) explains the contextual factors influencing data culture adoption in small organisations. The importance of exploring and optimising data culture is increasingly recognised as crucial for innovation. Firms require a suitable organisational cultural orientation to fully capitalise on the benefits of big data variety and related analytical technologies (Hussinki et al., 2025).

While data-driven decision-making (DDDM) is increasingly recognised, many organisations struggle to fully implement and benefit from it (Mikalef et al., 2018). For small tourism organisations, this means focusing on accessible and affordable data analytics tools. Brynjolfsson, et al.'s (2011) research indicates that the impact of data-driven decision-making on a company's performance is significant. Output and productivity can be 5-6% higher than what would be expected given the company´s other investments and information technology usage. The avenue from data analysis to higher performance is, however, not straight. It is influenced by many diverse factors (Maroufkhani et al., 2019). This means that simply investing in data analytics tools does not guarantee improved performance. It is also important to train staff to interpret basic data trends (e.g., website traffic, booking patterns, customer feedback). For small tourism organisations, this suggests a need to carefully consider their specific context and align their data analytics efforts accordingly. A tailored approach is critical rather than a one-size-fits-all implementation of data analytics. Neuhofer et al. (2015) discuss how smart technologies enable service co-creation in tourism. Chuang (2023) conceptualizes the smart tourism service platforms and their role in value co-creation. Both implicitly rely on data sharing between tourists and tourism providers. Creating a culture where data informs choices about marketing, service offerings, and resource allocation is therefore crucial.

Several established frameworks and models are relevant in this area. Statistical Framework for Measuring the Sustainability of Tourism (SF-MST) was developed and recommended by UNWTO (UNWTO, 2022). The DIAMOND model for sustainable tourism development and Social Exchange Theory (SET) are useful for understanding stakeholder perceptions and impacts. Destination Management Information System (DMIS) is a comprehensive system that manages and integrates data related to a tourist destination, supporting both pre-trip and post-arrival information, including availability and booking services. DMIS facilitates data-driven decision-making for DMOs. There are also other recommendations for tourism data collection and/or sustainability monitoring, e.g., ETIS, TOURMIS. As already mentioned, they are mostly suitable for larger destinations (countries, regions) but not so much for smaller destinations at the town level.

4. RESEARCH AIM AND METHODOLOGY

The research question "What is the situation with data collection in smaller cultural destinations in V4 countries plus Albania through the lenses of data culture?" was formulated and necessitates an approach that captures breadth and depth of current practices, needs, and challenges. This study adopts a pragmatic research philosophy, employing mixed-methods triangulation (Creswell & Plano Clark, 2011; Koc & Boz, 2014). The sequential explanatory design proceeds from qualitative exploration (workshops) to quantitative validation (survey) and qualitative expansion (content analysis):

- **Qualitative workshops** with DMO staff and municipal officials to explore in-depth perceptions, motivations, and barriers related to data collection.
- **Quantitative analysis** of closed-ended (choice) survey questions to provide measurable insights into the prevalence of specific methods, desired improvements, and perceived barriers.
- **Content analysis** of open-ended survey responses to identify recurring themes, contextual factors, and innovative practices.

The workshops identified the challenging areas, and based on them, quantitative research was conducted to see how important the issues are and what the data culture is. This approach enables a comprehensive assessment of the five main aspects respecting data culture theory of data collection in small cultural destinations: (1) methods used, (2) methods desired, (3) barriers encountered, (4) data analysis employed, and (5) planned usage of the data. Data were collected in two stages between February 2022 and May 2024; methodological triangulation was achieved through the integration of findings from workshops, quantitative survey results, and qualitative content analysis.

A series of workshops was conducted in cultural destinations Kutná Hora, Litomyšl, Poznaň, Bardejov, Banska Stiavnica and Hercegkút. The structure of the topics was: (1) Is there any sustainability monitoring going on?, (2) What data sources/methods do you currently use?, (3) What are the barriers to sustainability monitoring/education/implementation of monitoring, (4) How would you like to use the data (for what purposes)?

A structured questionnaire was developed based on workshop findings and validated through expert review (international project team, 10 persons) and pilot testing (5 respondents, one in each country). The questionnaire measured five dimensions of data culture: collection methods, desired methods, barriers, analysis capabilities, and usage patterns. The questionnaire included both closed-ended and open-ended questions. The closed-ended items were analysed using descriptive statistics. The qualitative data from open-ended responses were analysed using a multi-stage qualitative content analysis approach. This process began with open coding, followed by the development of initial categories and conceptual groupings.

To ensure analytical rigour, the coding process was conducted in an iterative manner, meaning that codes and categories were repeatedly reviewed, compared, and refined throughout the analysis. This cyclical process allowed for the continuous improvement of category definitions and ensured consistency across the dataset. The final coding framework was validated through repeated internal review within the research team, where interpretations and category definitions were discussed and aligned until conceptual consensus was reached. This process enhanced the trustworthiness, transparency, and reliability of the qualitative findings.

A purposive sampling strategy was employed to select small cultural destinations meeting specific criteria: (1) UNESCO World Heritage status or equivalent cultural designation, (2) not the capital, (3) active DMO or municipal tourism management, and (4) located within V4 countries plus Albania. The exact sampling frame was determined through cultural heritage databases, resulting in 99 completed responses from organisations meeting the study criteria in Slovakia (26), the Czech Republic (23), Albania (21), Poland (18), and Hungary (11).

5. RESULTS

The workshops first addressed whether tourism data monitoring is conducted. Most destinations rely on basic data, such as accommodation statistics and length of stay, mostly from national statistical offices, but generally lack information on same-day visitors, visitor spending, and other economic data. Specific sustainability indicators (e.g., water use, waste, seasonality) are rarely tracked. The data sources and methods currently used are more diverse. Some destinations depend solely on national statistics, while others conduct their own surveys. Information centres frequently provide ticket sales data, but these often lack details and may cover multiple sites in one ticket, limiting the ability to segment by visitor type or origin. Only a few destinations use specialised data (e.g., mobile phone data), and also social media is mentioned, but social listening tools are not employed. Barriers

to monitoring include limited staff capacity, high workloads, and insufficient funding for professional data collection, with rare mentions of missing analytical skills. Fragmentation and weak collaboration between institutions, along with inconsistent institutional support and a lack of standardised data practices, further hinder progress. Data are often only available in aggregate forms, limiting detailed analysis. Strategic planning and marketing are generally underdeveloped. Response rates to data collection are low, and while some consider using social media for surveys, this remains underexplored. Regarding data usage, participants highlighted its importance for evidence-based argumentation, countering public criticism, and demonstrating that infrastructure investments serve both tourists and locals. Data also supports dialogues with political opposition and justifies public expenditures.

Second, based on the workshops, a quantitative research was conducted to see how important the issues are and what the data culture is, bringing the answers to questions (1) data collection methods used, (2) methods desired, (3) barriers encountered, (4) data analysis employed, and (5) planned usage of the data.

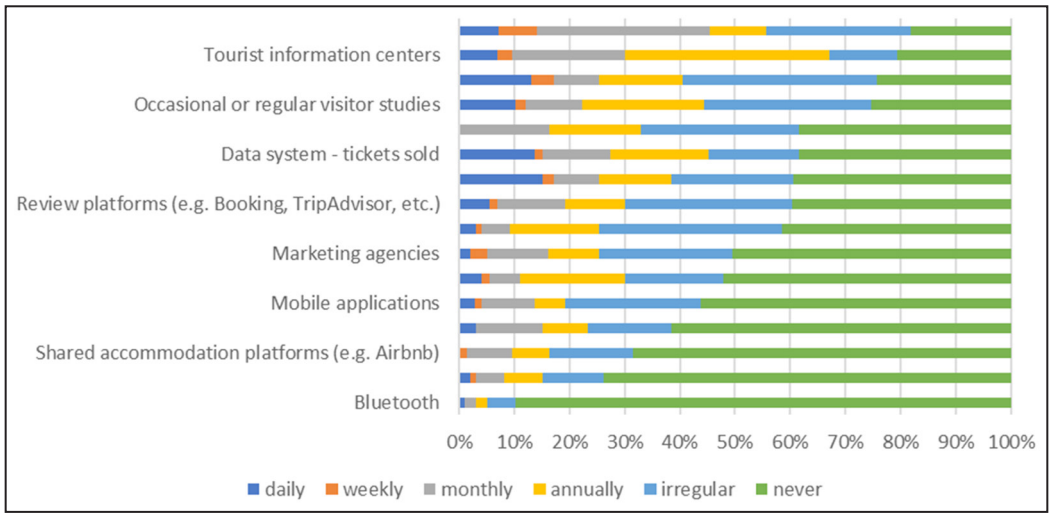

Figure 1. Data Sources for DMOs and Municipalities in Cultural Destinations
Source: Own calculations

The answer to the first question is presented on the graph, Figure 1: Data Sources for DMOs and Municipalities in Cultural Destinations. The graph presents the methods that the organisations (DMOs and municipalities) use. They actively use social networks and tourist information centres (more than 50% of them). More than 30% of the respondents use face-to-face questionnaires, visitor studies, data from businesses in the destination, ticketing systems, digital counters, review platforms, and mobile phone data tracking. The least used sources are Bluetooth connections and Wi-Fi access.

To answer question (2) on desired, we employed content analysis, resulting in the answers in 5 categories. The coding scheme is presented in Table 1: Categories from content analysis.

The results of content analysis are presented in Table 2: Content analysis, comprising category, sub-category, examples, and percentage of presence in the results. Each answer can mention none, one or more methods; in the rare cases where responses clearly combine categories, the mention is attributed to each mentioned category ("hybrid" is assigned if the answer is explicitly about combining, not just listing).

Table 1. Categories from content analysis

Category	Subcategory
Technology-Based	Mobile/GSM data, digital counters, cards, online/social media, payments
Direct Engagement	Surveys/questionnaires, interviews, enumerators
Institutional/Manual	TIC data, manual counts, business/ticket data
Aggregated/Secondary	Official statistics, external research studies
Hybrid/Combined	Multiple methods blended for comprehensive coverage

Source: Own processing

Table 2. Content analysis

Category	sub-category	examples	Percentage (%)	
Technology-based	Mobile/GSM/Telecom data	"mobile operators", "GSM data", "SIM card", "teleinformatics", real-time telecom, "data from mobile phones"	27	58
	Digital counters & Sensors	"digital counter", "traffic/people counter", "pedometer",	12	
	Digital visitor/ discount cards	"digital OravaCard", "digital visitor cards"	3	
	Online and social media	"online sources", "social networks", "review platforms", "online media"	9	
	Payment/ credit cards	"credit card", "payment card", "Visa/ Mastercard"	7	
Direct engagement	Surveys and questionnaires	"visitor survey", "questionnaire", "direct/ personal questions", "opinion surveys"	25	39
	Face-to-face interviews	"face-to-face interview", "oral interview", "focus groups"	10	
	Enumerators/ personal contact	"enumerators", "manual personal contact", "staff/volunteer collecting"	4	
Institutional/ manual	TIC data	"data from TIC", "Tourinform office"	8	30
	Manual data and records	"manual data collection", "manual counting", "records"	11	
	Business/ facility data	"accommodation facilities", "tax", "orders from websites", "event/business data", "ticket sales"	11	
Aggregated/ secondary	National or regional statistics	"Statistical office data", "CSO", "GUS", "DATACUBE", "NTAK", "state databases"	12	17
	Third-party/ external data	"marketing agency", "external research", "public database"	5	
Hybrid/ combined	Hybrid/ combined (explicit)	"ideal to combine methods", "combination of the above", "mixed-method", "triangulation"	7	7

Note: this was an open question, not compulsory; therefore the number of answers does not equal the number of respondents. In one answer, more methods can be mentioned.

Source: Own research (each category's percentage reflects how many of the 92 responses mention each method)

The most important key finding is the technology aspiration vs. reality gap in the practice of DMOs and municipalities. Organisations demonstrate strong interest in advanced data collection technologies, particularly mobile/GSM data, but cite financial constraints as the primary implementation barrier. Multiple responses indicate systemic challenges, including insufficient funding (for data collection in general), limited personnel capacity, and lack of technical expertise. These constraints drive reliance on traditional methods despite recognition of their limitations.

However, the organisations struggle to balance comprehensive quantitative data collection with detailed qualitative insights, often defaulting to methods that provide depth rather than breadth due to resource limitations.

The research question (3) barriers encountered is partially answered already in the content analysis as the "secondary" product, and it confirms the output from the workshops. However, the qualitative analysis is needed to see how important the barriers are. The results are presented in Figure 2. Barriers in data collection.

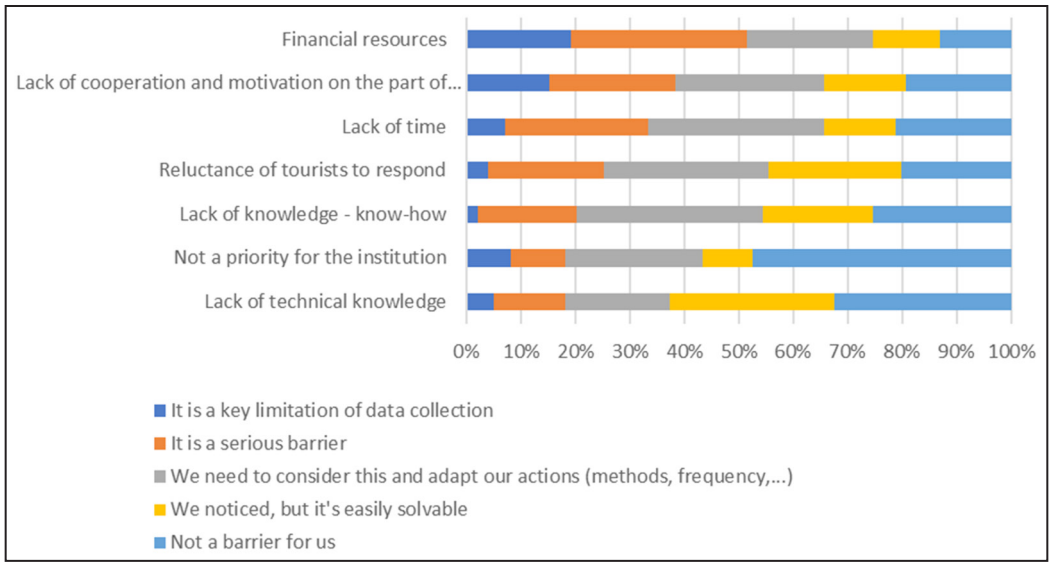

Figure 2. Barriers in data collection
Source: Own calculations

Figure 2 presents the key barriers in data collection. The most important obstacle is the lack of financial resources (51.5%). Surprisingly, the second reason is the lack of cooperation and motivation on the side of monuments and businesses. They don´t see any added value in data collection and sharing. Therefore, they are not motivated to do so. Lack of time is the third most important barrier.

The fourth question (4) about data analysis employed brought a significant gap between the data potential and real usage. The basic operations are employed by 53% and 45% of respondents (organising data into tables and graphs (using percentages, and using basic descriptive statistics (e.g., average), respectively). More complex analysis like performing statistical testing (e.g., examining correlations) (15%), time series analysis (21%), complex quantitative methods (e.g., cluster analysis, factor analysis, regression analysis) (5%), and selected qualitative methods based on text evaluation (e.g., sentiment analysis) (14%), are far behind leaving the most important insights into the data hidden. 11% of respondents only collect and store the data without any further usage or analysis. It is alarming that only 21% of respondents use time series, as the development is an important indicator of success and effectiveness.

And lastly, the fifth question will be answered regarding the usage of the data (5). The most important usage of data is seen in identifying needed improvements, developing partnerships, monitoring and influencing changes, and evaluating the results of actions.

Table 3. How would the participants like to use the data - for what purposes (number of mentions)

Usage	Mentions	%	Usage	Mentions	%
Identify needed improvements	82	82,8	Funding applications	46	46,5
Develop partnerships	71	71,7	To assure stakeholders that decisions are correct	44	44,4
Maintain and increase competitiveness	66	66,7	Respond to public concerns and criticism	42	42,4
Track and influence changes	64	64,6	Investment support	36	36,4
Evaluate the results of actions	59	59,6	It is easier to disprove some distorted information or interpretations	33	33,3
Arguments to partners, citizens	52	52,5	To start a dialogue	25	25,3
Finding partners for projects	49	49,5	Organization of seminars	20	20,2

Source: Own research

6. CONCLUSION

Based on research, we can conclude that the data culture in organisations in smaller cultural destinations is underdeveloped. This study advances data culture theory by demonstrating its context-dependent nature in resource-constrained environments. The "aspiration-reality gap" concept extends existing frameworks by showing how an organisation's intentions may not align with capabilities, particularly in public tourism organisations. There are many barriers in data collection, and the most important is funding (financial challenges), which is in accordance with Borowiecki et al. (2024). There is a significant gap between the potential data and the real analysis applied (Baggio & Klobas, 2017). As mentioned by Hussinki et al. (2025), developing the data culture is a task for the whole organisation and is a long-term challenge. The respondents understand the potential of the data and see a wide range of usage.

To summarize, considering the three dimensions, (1) technical capabilities (infrastructure, tools, skills), (2) organizational practices (data governance, processes, roles), and (3) cultural attributes (data literacy, trust in data, data-driven mindset) (Kiron et al., 2014), we can state that the actual data culture is on low level, especially in the first two dimensions. Technical capabilities are mainly limited due to financial resources; organisational practices are low due to personnel capacities. On the other hand, the respondents do not worry that they would not understand the data; and their intention towards a data-driven mindset is very high. The barriers "lack of know-how", "lack of technical knowledge" and "data not being a priority" are the least limiting obstacles. The cultural dimension is therefore considered as potentially being at a high level. However, this constellation creates the "aspirational data culture" – where organisations recognise data value but lack implementation capacity.

The difference in data culture reflects incomplete decentralisation, where local governments have responsibility for tourism but lack data capacities for decision-making. This suggests the need for multi-level governance solutions combining local autonomy with regional/national data support (Oates, 1999). First, the establishment of standardised methodological frameworks is essential to enhance data comparability across organisations while preserving necessary flexibility for localised adaptations. This entails defining minimum data standards and compatible protocols that can be widely adopted without impeding contextual relevance. The gap between ideal bespoke solutions and limited capacities and funding underscores the need for collaborative purchasing models. By pooling resources regionally or nationally, smaller organisations can access costly data

such as mobile operator or payment card information. Sustainable technology adoption also demands targeted technical and financial support – managers should fund training programs and equipment subsidies to shift from manual to digital data collection. Finally, centralised data-sharing platforms can reduce effort duplication and enable benchmarking through aggregated analyses, fostering collaboration and improving the effectiveness of tourism monitoring systems.

Comprehensive policy recommendations based on the results:
- Regional data cooperation mechanisms to achieve economies of scale,
- Conditional grants linking data capabilities to tourism funding,
- Public-private partnerships for data infrastructure sharing,
- Capacity building programs addressing the institutional coordination barrier.

The research suffers from several limitations. Considering the number of small cultural destinations in the countries, the number of respondents is relatively high; however, to be able to generalise the results, we might need a higher number. The sample's representativeness is still limited. Also, geographically limited data collection does not enable us to project the results to the whole of Europe. The respondents were chosen based on their willingness to answer; therefore, the answers might be biased by their interest in data collection. The institutional heterogeneity across participating countries, their data collection systems and current data accessibility may affect both data comparability and interpretative robustness.

The paper is of significance for both academic research and applied destination governance, particularly in the context of digital transformation and evidence-based tourism management. The concept of "aspiration-reality gap" is identified and explained in principle. Future research might focus on clearer conceptual boundaries, a clearer positioning within the existing literature, and potential framing as a mid-range theoretical construct in tourism data culture research.

Acknowledgment

This research was part of the project Nr. 22320140, "Data collection guidelines for tourism and sustainability monitoring in cultural destinations" supported by the International Visegrad Fund.

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Balkans JETSS (2026) 1: 62-76
DOI: https://doi.org/10.31410/Balkans.JETSS.2026.9.1.62-76

Original Scientific Article

Artificial Intelligence and Intellectual Property After the European AI Act

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Received: August 30, 2025 / Revised: June 7, 2026 /
Accepted: June 23, 2026 / Published: June 30, 2026
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Abstract: *This article seeks to examine the intersection between artificial intelligence and intellectual property, placing particular emphasis on recent legislative developments in Europe, most notably the AI Act, as well as other regulatory initiatives emerging in jurisdictions where the matter remains under active debate, such as the United Kingdom and the United States. The discussion includes an analysis of the latest judicial decisions, which delve into questions surrounding the authorship of AI-generated works, the use of copyrighted material for training AI models, and liability arising from the unauthorized use of protected content. Focusing on these issues, the paper explores the broader challenges AI presents to the existing intellectual property framework and considers potential regulatory or judicial responses that may help to reconcile technological advancement with the effective protection of copyright.*

Keywords: *Artificial Intelligence, Intellectual Property, Copyright, AI Act*

JEL Classification K11 · K24 · O34

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1. INTRODUCTION

Of all the open debates about intellectual property nowadays, it is undeniable that the question of how works generated by generative AI tools should be protected (if they should be protected) is central. It is a relatively new topic, since the appearance of the technology that allows works to be created in this way is recent, but the doctrinal and jurisdictional discussion is already extensive. This is due to the complexity of the issue, to the multitude of facets of intellectual property that can be affected by such a disruptive technology, and obviously because of the global economic impact that this new reality is already generating. We only need to remember the recent strike of screenwriters in the American film industry, who, among other demands, protested the imminent danger of losing their jobs to AI content generators (Chesterman, 2025, pp. 1–2).

The complexity of the subject can be introduced with the jurisdictional run that one of the first works created by AI has endured, "A Recent Entrance to Paradise", generated entirely by the "Creativity Machine", an AI model patented by Dr. Stephen Thaler in 2012. In August 2023, the U.S. Court of Appeals reiterated the requirement of human authorship in the protection of works under the current Copyright Law. The ruling clarifies that while AI can assist in the creative process, the fundamental criterion remains that a human must exercise significant creative control over the final product for it to be protected by copyright (Thaler v. Perlmutter, 2023).

This article addresses the following research question: does the European AI Act, read together with the text and data mining regime of Directive (EU) 2019/790, provide an effective copyright-compliance framework for general-purpose AI models, or does it merely impose procedural transparency obligations while leaving the core questions of authorization, remuneration, authorship and liability unresolved?

The thesis advanced here is that the AI Act represents a significant but incomplete shift in EU copyright governance. It does not alter the substantive rules of copyright protection, authorship or infringement, nor does it create a specific exception for AI training. Instead, it constitutionalises a compliance ground around AI models by requiring documentation, copyright policies and public summaries of training content. Hence, this starting ground can improve enforceability of copyright rules only if it is connected to clearer standards on lawful access, rights reservations, opt-out mechanisms, licensing and liability. Without such additional normative development, the AI Act risks producing formal transparency without effective copyright accountability.

The contribution of this article lies in connecting three debates that are often treated separately: the copyrightability of AI-generated outputs, the legality of AI training under the DSM Directive's text and data mining regime, and the new transparency and copyright-compliance obligations imposed by the AI Act on providers of general-purpose AI models. While existing literature has examined each of these issues individually, less attention has been paid to the way in which Article 53 of the AI Act transforms the Article 4(3) DSM Directive opt-out mechanism into a procedural compliance duty. The article therefore seeks to add value by arguing that the AI Act should be understood not as a new substantive copyright regime, but as a conditional transparency and accountability framework whose effectiveness depends on future standards on lawful access, rights reservations, licensing and evidentiary burdens.

2. IP LAWS ON AI-GENERATED WORKS

The resolution of the case reinforces the doctrinal and legal trend consisting of rejecting intellectual property protection for works generated exclusively by non-human figures. It is also relevant internationally, as various jurisdictions are currently discussing whether to expand IP protections to creations generated by AI autonomously, such as the European Union, the United Kingdom, and the United States, to name a few.

In the EU, both in terms of IP directives and in national regulations, it is established that protection is reserved exclusively for works created by human beings. Creations generated entirely autonomously by AI systems fall outside the classic protection regime, unless there is significant human intervention that justifies attribution of authorship. The recent entry into force of the so-called "Artificial Intelligence Law" (Regulation (EU) 2024/1689), although it does not provide a specific analysis of the issue, dedicates some points of its articles to the relationship between AI and IP. The regulation warns of the magnitude of the adverse consequences of an AI system for the fundamental rights protected by the EU Charter of Fundamental Rights, which is particularly important when classifying an AI system as high-risk (Barrio Andrés, 2024, p. 42; Council of Europe, 2024; European Parliament and Council, 2024).

Such rights, as is well known, include intellectual property rights. But the AI Act does not resolve the substantive copyright questions raised by generative AI. It does not determine whether AI-generated outputs are copyrightable, who should be regarded as their author, whether training a model on protected works constitutes infringement, or when an AI-generated output should be treated as a derivative work. Those questions remain governed by copyright law, particularly the acquis on originality, authorship, reproduction, communication to the public and exceptions and limitations. The Regulation's contribution is different: it introduces a procedural layer of transparency, documentation and copyright-compliance duties for providers of general-purpose AI models.

If we analyze the body of the AI Act, the copyright-relevant obligations for general-purpose AI models are located primarily in Article 53. Under Article 53(1), providers of general-purpose AI models must prepare and keep up to date technical documentation of the model, including information on the training and testing process; make relevant information and documentation available to downstream providers intending to integrate the model into their own AI systems; establish a policy to comply with Union law on copyright and related rights, in particular by identifying and respecting rights reservations made pursuant to Article 4(3) of Directive (EU) 2019/790; and prepare and make publicly available a sufficiently detailed summary of the content used for training the model.

These duties should not be confused with a new copyright exception or with a mechanism for ex ante authorization of training datasets. Article 53 does not legalize the use of protected works for AI training, nor does it create a general license for the benefit of AI developers. Rather, it presupposes the continued application of Union copyright law and seeks to make compliance more visible and auditable. Its function is therefore evidentiary and regulatory: it requires providers to document the development of the model, to inform downstream actors of its capabilities and limitations, to adopt internal policies capable of respecting copyright reservations, and to disclose, at least at a sufficiently general level, the categories and sources of content used for training.

The link with Directive (EU) 2019/790 is particularly important. Article 4 of that Directive permits reproductions and extractions for text and data mining, but it also allows right holders to

reserve their rights, including through machine-readable means in the case of online content. Article 53(1)(c) of the AI Act transforms that reservation mechanism into a compliance obligation for providers of general-purpose AI models. In other words, the AI Act does not replace the text and data mining regime of the DSM Directive; it builds an additional governance layer around it. Providers placing general-purpose AI models on the Union market must be able to show that they have adopted policies designed to detect and respect such reservations (Peukert, 2024, pp. 507–508; Ziaja, 2024, pp. 458–459).

The public summary required by Article 53(1)(d) has a similar function. It does not require full disclosure of every individual work included in a training dataset, and it must be reconciled with the protection of trade secrets and confidential business information. However, it should be sufficiently detailed to allow right holders and other interested parties to understand, in general terms, what types of content, datasets and sources were used to train the model. Its effectiveness will therefore depend on the level of granularity required by the AI Office template and by the codes of practice developed under Article 56. If the summary is too abstract, the obligation risks becoming a formal transparency exercise with little practical value for copyright enforcement. If it is sufficiently concrete, it may become one of the central mechanisms through which the AI Act contributes to copyright accountability in the generative AI sector.

It can therefore be argued that the most relevant contribution of the AI Act to copyright law is not the creation of a new substantive intellectual property right, but the imposition of procedural duties on providers of general-purpose AI models. Article 53 requires such providers to maintain technical documentation of the model, including information concerning the training and testing process; to provide sufficient information to downstream providers integrating the model into AI systems; to adopt a policy to comply with Union copyright law, including mechanisms to identify and respect reservations of rights under Article 4(3) of Directive (EU) 2019/790; and to make publicly available a sufficiently detailed summary of the content used for training. These obligations do not determine whether a specific act of training is lawful, nor whether a generated output infringes copyright. Their importance lies elsewhere: they create a traceability and accountability framework that may enable right holders, regulators and courts to test whether copyright exceptions, licenses and opt-outs have been respected. But it still raises doubts about how AI service providers should act when it comes to protecting IP rights and competition issues. Consequently, it seems that the text wants to imply that a specific legal development will be necessary for the matter, either at the level of European directives, or national regulations (Gutiérrez David, 2024, p. 680; Jiménez Serranía, 2024, p. 114).

The effects of the European “AI Law” are already beginning to appear in EU countries, such as the Benelux, or Germany, and especially France, where we find recent pronouncements on the issue (Assemblée Nationale, 2024; Bercimuelle-Chamot, 2024; Guadamuz, 2024; Jacobi, 2024).

The UK, on the other hand, has taken a more flexible stance on AI-generated works. Since 1988, section 9(3) of the Copyright, Designs and Patents Act (CDPA) has given protection for “computer-generated” works, attributing authorship to the person who makes the necessary arrangements for the creation of the work. This could include the programmer or the user setting up the AI system, even if human creative intervention is minimal. Also, in December 2024, the UK government launched a public consultation to gather views on how to apply copyright legislation to AI models trained outside the UK, how to incentivize AI companies to comply with UK law, and, in particular, to review their regulatory framework in relation to IP and AI under the CDPA (Instituto Autor, 2024).

In the U.S., the situation is also ambiguous for the time being. If, as we have seen, the courts have mostly opted for the "human" requirement to recognize the authorship of works generated by AI, this does not prevent the protection of AI-generated works from being recognized. The recently published Part 2 of the U.S. Copyright Office's Report on Copyright and Artificial Intelligence confirms that the use of AI tools to assist human creativity does not constitute an obstacle to copyright protection of the result, provided that there is sufficient human control over the expressive elements. Following these criteria, the registration of the AI-generated artwork "A Single Piece of American Cheese" was accepted by the Copyright Office (USCO) in January 2025. The work was registered due to the relevant human intervention consisting of the selection, coordination, and organization of elements generated by AI, in a process analogous to the creation of a collage. However, even from this case we cannot draw a single criterion within the American courts. As an example, the case of the work titled "Théâtre D'opéra Spatial" that was not accepted for registration, even though it was generated by introducing more than 624 prompts to the AI tool Midjourney, and after being modified with Photoshop. Despite that, the USCO determined that Allen could not claim protection because he was literally "unwilling to give up" the AI-generated material from the whole of his work (Copyright Review Board, 2023; Mazzi, 2024, p. 421; U.S. Copyright Office, 2025, p. 12).

The comparison between the European Union, the United Kingdom and the United States shows three different regulatory logics. The EU approach remains centred on human authorship and a closed catalog of copyright exceptions, but the AI Act adds a procedural layer of transparency, documentation and copyright-compliance obligations for general-purpose AI models. Its practical advantage is that it creates traceability duties for AI providers; its weakness is that it does not itself answer whether a given training act is lawful or whether right holders should be remunerated. The UK approach is more pragmatic regarding computer-generated works, since section 9(3) CDPA attributes authorship to the person making the necessary arrangements for the creation of the work, but recent litigation shows that the territorial and evidentiary limits of UK copyright law may make training-related claims difficult to prove. The US approach is more flexible because fair use allows courts to assess transformative use and market harm case by case, but this flexibility also produces uncertainty for right holders and AI developers. The practical implication is that the EU offers the clearest emerging compliance infrastructure, the UK offers a more explicit statutory solution for computer-generated outputs, and the US offers the most adaptable but least predictable litigation-based model.

3. IP RIGHTS AND THE RISE OF AI

The first relevant question in relation to AI-generated works is who (or what) can be recognized as an author. As we have seen, the answer in the vast majority of jurisdictions has been unequivocal: only human beings can hold the authorship. However, the advancement of AI techniques capable of generating content autonomously has called into question this traditional criterion. In modern generative AI systems, software is no longer a mere passive instrument and begins to make many of the creative decisions that lead to the work itself, without direct human intervention in each choice. This poses at least one first legal challenge: how to deal with the resulting machine-generated works? If the traditional requirements are strictly maintained, such results could be considered outside the protection of IP due to the lack of a human author, and thus they would enter directly into the public domain. But that would most likely create a disincentive for all companies that are currently devoting resources and research to the AI sector. In this sense, some authors warn that the lack of protection reduces investment in AI, slowing down its development, unless the savings in operating costs due to automation alone justify such projects (Bridy, 2016, p. 12; Guadamuz, 2017; Lacruz Mantecón, 2021, p. 163).

If we accept, as would seem more logical from a utilitarian point of view, that works generated by AI are sufficiently original to be protected, then a new question arises as to who should hold the authorship, and the exclusive rights derived. The options are multiple: should it be the programmer who created the algorithm? Or could it be the user who uses the AI to generate the work, at least when the inputs provided are relevant enough for the final result? It should be noted that no major jurisdiction has gone as far as to recognize AI as a subject of law. Perhaps, for this reason, a platform like ChatGPT has already stated that it will not claim copyright on any content generated by its technology, but that it would correspond to the person who has ordered the software to create the creation in question (Guadamuz, 2022; Lacruz Mantecón, 2021, p. 144; Xalabarder Plantada, 2020, p. 212).

But beyond these problems, equally fundamental questions remain unresolved, such as how moral rights would be applied in works generated by AI. If the work is produced by AI and the law designates a programmer as the author, does it make sense to talk about a personal link of this "legal author" with the work? Probably not, which indicates that these works depart from the traditional archetype on which many aspects of the copyright regime are based. Also, if IP does not offer protection to AI works, then companies will look for other legal frameworks such as competition law and trade secrets to protect their works, a position defended by part of the doctrine that does not admit IP protection for autonomous AI creations (Dornis, 2021, p. 11; Drexl et al., 2021).

As for the concrete solutions, none of them are completely satisfactory at the moment. The British model has the pragmatic advantage of providing legal certainty and legal protection, encouraging investment in AI. However, it moves away from the notion of authorship as a human creation. On the other hand, maintaining the requirement of human authorship preserves the traditional conception of IP, but it could require compensatory measures if, as is widely thought, it would discourage innovation. For example, alternative royalty systems for works generated by AI could be devised in favor of the creators of the program, or perhaps some sui generis system of limited IP protection, as already exists in some legislations such as the European in relation to databases (Navas Navarro, 2018, p. 286; Ramalho, 2017, p. 16).

4. BUILDING THE AI MODELS

A key question in the legal analysis of generative AI is how AI models collect, process and use the data that allows them to generate new content. The issue is technically complex because the process of compiling, selecting, cleaning and processing training data is generally not visible to the average user and, in many cases, is not fully disclosed by the providers of AI systems. In simplified terms, large language models are trained on substantial quantities of text in order to identify statistical relationships, linguistic structures, semantic patterns and probabilistic associations that allow them to generate apparently natural language. A similar logic can be applied to other generative systems trained on images, sounds, audiovisual materials or musical works (Quintais, 2025).

From a copyright perspective, it is useful to distinguish between two different moments: the input stage and the output stage. The input stage concerns the collection, reproduction, extraction, storage, cleaning and computational analysis of pre-existing materials used for training. The output stage concerns the content generated by the system and the possible reproduction, adaptation, transformation or communication to the public of protected expression in that output. This distinction is important because the legal questions are not identical. The input stage primarily raises issues of reproduction, extraction, text and data mining, lawful access and rights reservations. The output stage raises questions of substantial similarity, derivative works, attribution of liability and the possible application of exceptions such as quotation, parody or pastiche (Peukert, 2024, p. 501; Quintais, 2025).

4.1. The Relevance for Copyright of AI Training

The fact that an AI model does not operate by simply retrieving and displaying complete copies of the works used in training does not mean that copyright law is irrelevant. Training may involve several acts that are legally significant even if the final model does not contain a human-readable copy of the works. Depending on the architecture of the system and the training process, protected works may be copied, stored temporarily or permanently, extracted, transformed into machine-readable representations, tokenised, annotated or otherwise processed. The copyright analysis must therefore avoid two extremes. It would be inaccurate to assume that every use of protected material in AI training necessarily produces an infringing output. But it would also be inaccurate to treat AI training as legally neutral merely because the resulting model operates probabilistically.

The evidentiary problem is aggravated by the opacity of datasets. Generative AI systems are often trained on materials coming from heterogeneous sources: public-domain works, licensed materials, open web content, user-generated content, databases and, in some cases, unlawfully reproduced works. The presence of pirated material in training datasets has been documented in relation to large-scale language models, particularly in the debate surrounding datasets such as Books3. The legal significance of that fact is considerable. A copyright exception based on lawful access cannot easily justify the use of datasets built from pirated copies or from sources obtained in breach of technological, contractual or legal restrictions (Chesterman, 2025, pp. 1–3; Reisner, 2023; Schoppert, 2023).

The legal characterisation of training is nevertheless contested. A more permissive view argues that machine learning may be understood as a transformative use, especially when the purpose is not to substitute the original works but to extract information, patterns or statistical relationships from them. This argument has been particularly influential in the United States, where the fair use doctrine gives courts greater flexibility to consider the purpose of the use, market harm, and the transformative character of the activity. A more restrictive view, by contrast, stresses that generative AI training is not merely analytical in nature, because the training process may enable the system to generate expressive outputs that compete with, imitate, or partially reproduce protected works (Guadamuz, 2023, p. 9; Lemley, 2023, p. 23; Stober & Dornis, 2025).

EU law requires a different starting point. Unlike U.S. fair use, EU copyright law is structured around specific exclusive rights and a closed catalog of exceptions and limitations. The relevant question is therefore not whether AI training is generally “transformative”, but whether the acts of reproduction and extraction involved in training fall within an applicable exception, especially the text and data mining regime introduced by Directive (EU) 2019/790.

4.2. Text and Data Mining Exceptions and Article 53 AI Act

Article 4 of Directive (EU) 2019/790 introduced a general text and data mining exception or limitation applicable beyond the specific context of scientific research. Unlike Article 3, which is limited to research organisations and cultural heritage institutions, Article 4 is available to any beneficiary, including commercial actors, provided that the works or other subject matter have been lawfully accessed and that the right holder has not expressly reserved the use. This provision is especially relevant to generative AI because the development of large-scale models generally requires the computational analysis of vast quantities of text, images, sounds, audiovisual works and other digital materials. In that sense, AI training may fall within the functional logic of text and data mining, insofar as it involves automated analysis of large datasets to identify patterns,

correlations and statistical regularities (European Parliament and Council, 2019, Art. 4(1), 4(3); Margoni & Kretschmer, 2022, pp. 685–686).

However, Article 4 does not establish an unconditional freedom to train AI models on protected works. Its application is subject to two decisive limits. First, the works or other subject matter must be lawfully accessible. This requirement excludes, at least in principle, datasets built from pirated copies, unlawfully obtained databases or sources accessed in breach of technological or contractual restrictions. Secondly, the exception does not apply where right holders have expressly reserved the use of their works appropriately. In the case of content made publicly available online, the Directive specifically contemplates machine-readable means, including metadata or website terms, as appropriate mechanisms for such reservation. The practical effectiveness of this opt-out mechanism remains uncertain, since there is still no universally accepted technical standard for expressing, detecting and respecting machine-readable reservations of rights across the AI training ecosystem (European Parliament and Council, 2019, Art. 4(3), Recital 18; Margoni & Kretschmer, 2022, pp. 695–697; Ziaja, 2024, pp. 456–459).

This is the point at which the DSM Directive and the AI Act intersect. The AI Act does not create a new copyright exception for AI training, nor does it amend the substantive scope of Article 4 of Directive (EU) 2019/790. Instead, it converts the rights-reservation mechanism of Article 4(3) into a compliance obligation for providers of general-purpose AI models. Article 53(1)(c) of Regulation (EU) 2024/1689 requires such providers to put in place a policy to comply with Union law on copyright and related rights, and in particular to identify and comply with reservations of rights expressed pursuant to Article 4(3) of the DSM Directive. The AI Act therefore presupposes the continued application of copyright law and adds a procedural and evidentiary layer intended to make compliance more visible and auditable (European Parliament and Council, 2024, Art. 53(1)(c); Peukert, 2024, pp. 503–506; Quintais, 2025).

The obligation to publish a sufficiently detailed summary of the content used for training under Article 53(1)(d) reinforces this relationship. Such a summary does not require full disclosure of every individual work used in training, and it must be reconciled with trade secrets and confidential business information. Nevertheless, it must be sufficiently meaningful to allow authors, right holders and regulators to understand the main categories and sources of training materials. If implemented with sufficient granularity, this obligation may help right holders assess whether their works, catalogs or databases have plausibly been included in training datasets and whether their reservations of rights have been ignored. If implemented too abstractly, it risks becoming a formal transparency exercise with limited practical value for copyright enforcement (European Parliament and Council, 2024, Art. 53(1)(d), Recital 107; Peukert, 2024, pp. 507–509; Ziaja, 2024, p. 459).

The resulting framework is therefore hybrid. The DSM Directive remains the source of the copyright exception: it determines when reproductions and extractions for text and data mining are permitted and when authorization remains necessary. The AI Act, by contrast, does not itself authorise training. It imposes obligations of documentation, transparency and copyright governance on providers of general-purpose AI models. Its function is procedural and evidentiary rather than substantive. It may facilitate enforcement of copyright rules, but it does not answer all unresolved questions, such as what constitutes lawful access, how machine-readable opt-outs must be standardised, how detailed the training-data summary must be, or how liability should be allocated where a model has been trained outside the Union but is placed on the EU market (Lucchi, 2025; Peukert, 2024, pp. 507–509).

4.3. Litigation on Training Datasets and Model Development

The current litigation confirms that disputes over AI training are not merely theoretical. In the United Kingdom, Getty Images v Stability AI illustrates both the importance and the limits of litigation as a mechanism for clarifying the legality of AI training. Getty Images alleged that Stability AI had used millions of images from its repositories to train Stable Diffusion without authorization. However, by the end of the trial, the case had narrowed substantially. Getty abandoned its primary copyright claim concerning training and development, its outputs claim and its database-right claim, after accepting that there was no evidence that the training and development of Stable Diffusion had taken place in the United Kingdom. The High Court therefore did not decide whether the training of Stable Diffusion on protected images amounted to primary copyright infringement under UK law (Getty Images v. Stability AI, 2025; Guildea, 2025, p. 474).

The remaining copyright issue in Getty v Stability was one of secondary infringement: whether the Stable Diffusion model, or its weights, could be treated as an "infringing copy" imported, possessed or dealt with in the United Kingdom. The High Court rejected that argument, holding that an AI model such as Stable Diffusion, which does not store or reproduce the protected works, is not itself an infringing copy for sections 22, 23 and 27 of the Copyright, Designs and Patents Act 1988. The judgment was nevertheless not a complete victory for Stability AI, since Getty succeeded on limited trademark infringement claims relating to synthetic outputs bearing Getty or iStock watermarks. Moreover, Getty has been granted permission to appeal the dismissal of the secondary copyright infringement claim, because the construction of the expression "infringing copy" in the context of an AI model was considered a novel and important point of law (Getty Images v. Stability AI, 2025; Getty Images v. Stability AI (Re Form of Order), 2025, paras. 151–166).

The case therefore leaves the most important training question unresolved. It does not establish that AI training on protected works is lawful under UK copyright law. Nor does it establish the opposite. Its significance lies elsewhere: it shows the evidentiary and territorial difficulties faced by right holders when training takes place outside the forum, when datasets are opaque, and when the claimant cannot show where the relevant acts of reproduction or extraction occurred. This reinforces the importance of transparency obligations such as those introduced by Article 53 of the AI Act in the EU framework.

In the United States, Thomson Reuters v ROSS Intelligence shows a different doctrinal configuration. The dispute concerned the use of Westlaw headnotes to train an AI-powered legal research tool. In 2025, the District Court for the District of Delaware rejected ROSS's fair use defense at summary judgment, stressing that ROSS's use was commercial, not sufficiently transformative, and potentially harmful to the market for Westlaw's legal research materials and related licensing opportunities. As of July 2026, the case is before the Third Circuit on interlocutory appeal, with oral argument having taken place on 11 June 2026. The appeal is expected to address central fair use questions, especially transformative use and market harm in the context of AI training (Albert & Boyer, 2026; Thomson Reuters v. ROSS Intelligence, 2025).

In the EU, the pending preliminary reference in Like Company v Google Ireland may become especially significant. The Budapest Regional Court has asked the Court of Justice whether the display of protected press content by an LLM-based chatbot constitutes an act of communication to the public; whether the training of an LLM involves an act of reproduction; whether such training may fall within the Article 4 DSM Directive text and data mining exception; and whether outputs reproducing protected material should be attributed to the provider of the AI service. The reference therefore brings together the two dimensions that should be kept analytically distinct: input-stage training and output-stage reproduction (Case C-250/25, 2025; Zhang, 2026).

4.4. Outputs, Derivative Works and Liability

The output stage raises a different set of problems. An AI-generated output may be entirely remote from any protected work used in training, in which case copyright infringement will be difficult to establish. But an output may also reproduce protected expression, imitate distinctive expressive choices, or generate material sufficiently close to a pre-existing work to raise questions of reproduction, adaptation, or derivative work status. The legal assessment should not depend on the fact that the system operates through probabilistic prediction. What matters is whether the resulting output reproduces protected expression, whether the part reproduced is sufficiently original, and whether any exception or limitation applies.

This point is important because the debate is sometimes framed too broadly. It is not necessary to prove that every act of AI generation is infringing. Nor is it persuasive to argue that probabilistic generation always breaks the legal link with the works used as references. If the output contains protected expression from a pre-existing work, the ordinary copyright analysis should apply. In EU law, that means assessing whether there has been reproduction in whole or in part, communication to the public, adaptation where recognized by national law, or another act reserved to the right holder. The fact that the system produces the output through statistical processes should not by itself exclude infringement.

The classification of AI-generated outputs as derivative works is particularly difficult. In some cases, the relationship between the output and the pre-existing work may be too remote and should be characterised as mere inspiration. In other cases, the generated output may reproduce protected elements or transform a recognisable work in a way that would normally require authorization. Between these two poles, there will be cases in which the output evokes the style, genre or atmosphere of an author without reproducing protected expression. Such cases should be treated cautiously, since copyright does not protect style as such. The more precise question is whether the AI output appropriates protected expressive elements, not whether it merely resembles the aesthetic universe of a particular author (Al-Busaidi et al., 2024, p. 7).

The possible relevance of exceptions must also be considered. Certain AI-generated outputs could fall within quotation, parody, caricature or pastiche, depending on the legal system and the facts of the case. The CJEU's case law on exceptions requires a balance between the rights of authors and the freedom of expression and artistic freedom of users. However, these exceptions cannot become a general justification for the commercial exploitation of outputs that reproduce protected expression without authorization. They must be applied case by case and in accordance with the three-step test (Mezei et al., 2025).

Finally, output-stage infringement raises the question of liability. The user who enters a prompt may be responsible where the prompt intentionally asks the system to reproduce or imitate protected works, or where the user exploits the infringing output commercially. But exclusive focus on the user would be insufficient. Providers may also bear responsibility where infringing outputs are foreseeable, encouraged by the design of the system, insufficiently mitigated, or connected to training practices that systematically relied on protected works without authorization. The most convincing approach is therefore not an automatic rule of provider liability or user liability, but a control-based and foreseeability-based allocation of responsibility. The more control the provider exercises over the design, training, filtering, deployment and commercial exploitation of the system, the stronger the case for provider responsibility becomes (Rosati, 2025, p. 17).

4.5. Understanding the AI Act as a First Step

The preceding analysis shows that the legal treatment of AI model-building cannot be reduced to a single question. At the input stage, the key issues are reproduction, extraction, lawful access, text and data mining, rights reservations and transparency. At the output stage, the key issues are substantial reproduction, derivative works, exceptions and liability. The AI Act does not resolve these questions substantively. Its contribution is more limited but still important: it creates a compliance infrastructure through Article 53, requiring general-purpose AI model providers to adopt copyright policies and publish summaries of training content. That framework may improve accountability, but only if it is interpreted in a way that allows right holders and regulators to verify whether lawful access, opt-outs and licensing requirements have been respected.

For that reason, the relationship between Article 4 DSM Directive and Article 53 AI Act should not be understood as an expansion of the TDM exception in favor of AI developers. It is better characterised as a conditional compliance model. AI training may benefit from Article 4 where the relevant works were lawfully accessible, and no valid reservation of rights was made. Where right holders have opted out, authorization remains necessary. The AI Act strengthens this structure by requiring GPAI providers to organize their technical and legal processes around the detection and observance of such reservations. Its main contribution is therefore not to legalize AI training, but to make the legality of training more transparent, documentable and contestable (Peukert, 2024, pp. 507–509; Ziaja, 2024, pp. 458–459).

5. FUTURE RESEARCH DIRECTIONS

This article is subject to three main limitations. First, the regulatory framework analyzed is still evolving. The AI Act has only recently entered into force; its implementation will depend on technical standards, codes of practice and guidance from the AI Office, and several copyright-related questions remain pending before national courts and the Court of Justice of the European Union. Secondly, the analysis focuses primarily on copyright and related rights, although other areas of intellectual property law, such as trademarks, trade secrets, database rights and unfair competition, may also become relevant in disputes concerning generative AI. Thirdly, the comparative discussion is limited to the European Union, the United Kingdom and the United States, which are currently among the most relevant jurisdictions in this debate, but future research should also examine jurisdictions adopting different regulatory strategies.

Future research should therefore develop three lines of inquiry. The first concerns the practical implementation of Article 53 of the AI Act, especially the level of detail required in training-data summaries and the technical standards for identifying rights reservations. The second concerns the judicial treatment of AI training and AI-generated outputs, particularly once the Court of Justice rules on the pending preliminary references and appellate courts clarify the position in the United Kingdom and the United States. The third concerns possible licensing or remuneration mechanisms for large-scale commercial training, including collective licensing, statutory remuneration and rebuttable compliance presumptions for providers that can demonstrate lawful access, respect for opt-outs and adequate dataset governance.

It seems inevitable that current regulatory frameworks will have to evolve to find a balance, either by modifying domestic laws or through a much-desired international harmonization that balances the contribution of the AI designer, without detracting from the meaning of the traditional human author. And we are at the beginning of the road, where it is still possible in a certain way to

distinguish AI creations from human creations, probably because the former still present somewhat cold and mechanical results, surely the result of the little training (i.e., reference works) on which they work. But the day does not seem far off when determining what is what is no longer so obvious, and then, if the human author really wants to protect himself, we should have agreed on what and how to protect the creations of the machine (Guadamuz, 2017; Shields, 2025).

Perhaps the solution will end up coming from the same companies that own generative AIs, who, in search of offering greater legal certainty to their users, are already offering alternative solutions, announcing economic compensation to rights holders for the material used (Castillo Parrilla, 2024, p. 765).

At the same time, some authors raise an equally relevant question: understanding how AI-generated content is produced, and this is the determination of liability for possible copyright infringements. Could there be joint and several liability between the user who enters the prompt and the developer or provider of the AI model that provides the technological tools? (Rosati, 2025, p. 17).

6. CONCLUSION

The ideas presented in this paper show that the interaction between artificial intelligence and copyright represents one of the most innovative and complex legal challenges in the field of Intellectual Property in the last forty years. From the point of view of legal science, it forces us to rethink basic concepts of authorship and originality in the light of a technology capable of creating.

The challenges are several. At the level of international law, it threatens to fracture the normative harmony achieved after decades of treaties if countries adopt disparate responses. On a conceptual level, the treatment of generative AI implies that any interpretation will have costs and benefits: modifying our laws to protect AI works could encourage innovation but stresses the general principles of copyright, while not protecting them will slow down technological development and generate legal uncertainty in the international exploitation of works.

In any case, all these proposals encounter, in our opinion, two obstacles to overcome. The first is that for a lasting and stable implementation, it will be necessary for them to be accompanied by a legislative reinforcement that makes them mandatory for all generative AI operators operating in a territory. The second obstacle is more technical, as each protection system often ends up finding its match, understood as hackers who manage to bypass the protection measures incorporated in the works. And like the roadrunner and the coyote, the race never ends.

This paper takes the following normative position: in the near future, the proposal is twofold. First, EU law should resist the temptation to recognize autonomous AI systems as authors or to grant full copyright protection to machine-generated outputs without meaningful human creative control. Such a reform would weaken the anthropocentric foundations of European copyright without solving the economic problem of AI development.

Secondly, the EU should strengthen the regulatory architecture governing the input stage of generative AI. Article 53 of the AI Act should be implemented through binding or quasi-binding standards requiring meaningful training-data summaries, verifiable respect for Article 4(3) DSM rights reservations, and auditable copyright-compliance policies. At the same time, these duties

should be complemented by a harmonized opt-out infrastructure, collective licensing mechanisms for large-scale commercial training, and a rebuttable evidentiary framework that places the burden on providers who cannot demonstrate lawful access, rights-reservation compliance and adequate dataset governance. This would preserve innovation while transforming the AI Act's transparency model into an effective instrument of copyright accountability.

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ISSN: 2620-164X