THE IMPACT OF DIGITALIZATION AND EDUCATION ON TOURISM REVENUE IN CENTRAL AND EASTERN EUROPE: AN ARDL APPROACH

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Abstract

Purpose – The study investigates the impact of digitalization and education on international tourism revenue in Central and Eastern European (CEE) countries. Given the increasing reliance on digital platforms in the tourism industry, understanding the role of broadband infrastructure, internet penetration, and educational factors is essential for policymakers and industry stakeholders.
Methodology – An Autoregressive Distributed Lag (ARDL) model examined the short- and long-term relationships between tourism revenue and independent variables (broadband subscriptions, internet use, education expenditure, tertiary enrollment) using 2003-2021 data from World Bank. The study also includes a trend variable to capture long-term structural changes in tourism revenue.
Findings – Internet usage has a positive long-term impact, while broadband shows no clear effect, suggesting that infrastructure alone is not sufficient without industry adaptation. Education indicators negatively affect tourism revenue, due to workforce shifts. In the short run, both broadband and internet usage have negative effects, reflecting delays in digital adoption and changing consumer behaviour. The overall negative trend in tourism revenue points to structural challenges that call for targeted policy responses.
Contribution – This study provides an in-depth analysis of the relationship between digitalization, education, and tourism in CEE economies, contributing to both academic discussions and policy development. The findings challenge the assumption that digitalization inherently boosts tourism growth, demonstrating that strategic adaptation is necessary for digital infrastructure to generate positive economic effects.
Keywords Digitalization, Tourism Revenue, Education, ARDL Model

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INTRODUCTION

The impact of digitalization and education on tourism revenue is increasingly recognized as a critical factor for economic growth, especially in Central and Eastern European (CEE) countries. As the tourism industry evolves, the integration of digital platforms has transformed how services are marketed and delivered, significantly influencing consumer behavior and destination engagement. Improvements in broadband infrastructure and internet penetration play pivotal roles in enhancing the competitiveness of tourism sectors, ultimately affecting a country's economic development and attractiveness as a tourist destination. Moreover, education shapes human capital, ensuring that the workforce is equipped with the necessary skills to adapt to the digital economy, thereby contributing to overall tourism performance.

This article presents a comprehensive analysis of the relationship between digitalization, education, and international tourism revenue in selected CEE economies. It begins with a literature review that contextualizes the role of digitalization and education in tourism development. Following this, the data analysis section elaborates on the methodologies used, including tests for panel unit root and cointegration analysis. The study employs an Autoregressive Distributed Lag (ARDL) model to examine both short-term and long-term dynamics between tourism revenue and key independent variables such as broadband subscriptions, internet penetration, government education expenditure, and tertiary education enrollment. The results section discusses the variations in how these factors influence tourism revenue across the selected countries. The article concludes with a discussion of the implications of these findings and offers policy recommendations.

1. LITERATURE REVIEW

The research by Palazzo et al refers to digital platforms, in connection with the tourism industry, as a trend towards its recovery. It benefits from facilities such as contactless payment, services automation, and virtual experiences. Digital and virtual reality technologies are bound to change the industry and enable various types of cross-border collaboration, at a global level. Glocal tourism, as a combination of global and local tourism, creates the premises for a more efficient sustainable regional tourism,

that includes leveraging digital technologies. Investments by policy makers in global tourism refer to digital technologies and virtual reality, to help tourist managers create the proper content for visitors (Palazzo et al., 2022). However, Gavurova (Gavurova, 2020) analyzed various Central and Eastern European countries and noted that there is a need for more research on the effect between determinants in tourism and development and economic indicators, and education, technology, digitalization and other means are at the forefront.

Kallou and Kikilia (2021) argue that digital platforms in the tourism industry, connected to an educational environment, lead to innovation, enhanced experiences, and even changes in tourist behavior. In the future, tourism employees will have to be technology oriented and skilled to address the demands of a competitive tourism environment. The authors suggest the use of Learning Management Systems (LMS), web conferencing technologies, and Massive Open Online Courses (MOOCs). These tools could be used in tourism management. The modern digital tools and technologies can be incorporated into educational settings, that transform the learning process through the development of digital skills (Kallou & Kikilia, 2021). Research also seeks out various potential risks, such as of Deb (Deb, 2024), who analyzed the risk of digital marketing as having a negative effect on business performance, however, the research found no support for this hypothesis. Sokhanvar argues that education is a relevant factor for tourism, but in the sense that highly educated people might spend less on travel, possibly because of access to better information, which leads to better informed decisions (Sokhanvar et al., 2018). Zalukhu and Agustina argue, however, that because domestic tourists with higher education level, tend to spend above average, it leads to the conclusion that a higher number of citizens with higher education will have more tourism related expenditures (Zalukhu & Agustina, 2023). Better tourism education seems to be an important element in Mekinc et al. where it leads to an increase in competitiveness and employability. Better education develops better working skills, that future employees integrate in their daily operations, leading to better client care. It seems that soft skills, such as hospitality, working with people, cooperation, and emotional intelligence are the most important for students. Higher education institutions could integrate such skill development, coupled with better technological skills, that would allow the soft skills to develop as well. Digital literacy does not seem to be as important as human-related skills, but this shows that students see tourism as an industry based on human contact (Mekinc et al., 2023). Adeyinka-Ojo et al. presents education as facing new challenges. These are needed to navigate the digital environment of the tourism industry. However, end-user applications, industry specific applications, strategy focused applications, and disruptive technologies, are important for the advancement of tourism industry, since they are coupled with employability skills and soft skills. The former are divided into operational, strategic, and basic, while digital technologies range from internet browsing and social media, to property management systems, global distribution systems, data planning, customer relationship management, and AI, VR/AR. The range of applications and technological innovations that are trainable through higher education, highlights the strengths and weaknesses of the development of the tourism industry (Adeyinka-Ojo et al., 2020). On a general note, Jiang (Jiang, 2023) provides evidence for the positive economic impact of digitalization in tourism, with various direct benefits for local economic tourism, which generates economic growth.

Balula et al. focus on how digital technology is influencing the advancement of society, in all fields, tourism being one of them. Digital technology is a driver of innovation in the tourism industry, by increasing the reliance on digital platforms. From an educational standpoint, both teachers and students need to develop skills specifically for this environment. Higher education needs to be in tune with digital transformations, being able to prepare the staff and the students in how to use them efficiently. Digitalization is integrated into tourism education, that has an enduring impact on the tourism industry, by preparing a highly skilled workforce (Balula et al., 2019). Phan (Phan, 2021) mentions that applying regression analysis and forecasting methods to forecast tourism, implies that tourism revenue follows trends that can be modeled over time, which is a consequence of well-trained students, who enter the workforce. If well-trained staff enter the workforce, they will be able to use various methodologies for the promotion of the tourism industry. Nunkoo (Nunkoo, 2019) manages to prove that depending on the methodology used to study the results on the tourism-led growth, can vary from one country to another. It also implies that the magnitude and direction of effects vary depending on context and method used. Also, Yu et al. (2024), examine how the digital economy empowers the development of high-quality tourism through digital innovation, providing insights that can be extrapolated to CEE contexts. As particular application, Musah (2023) investigates the impact of information and communication technology, on tourism development, at a national level in Ghana, and found that digitalization had a significant impact on tourism development.

Wang et al. argue that there are contexts where inadequate public service support, coupled with a lack of digital culture and tourism service platforms, create a severe problem for the tourism industry, by halting its progress, that would benefit a larger population. Broadband infrastructure is a necessity for development and the utilization of digital platforms and services, that work best through the integration of disparate information and the establishing of comprehensive platforms. The result would be an enhanced tourist experience and an increase in revenues (Wang et al., 2023). Hafidh argues that internet penetration, digitalization, and education are elements that positively influence international tourism revenue. Technology drives the revenue element in transitioning economies or in developed economies. The development of tourism, based on basic infrastructure and natural attractions, is developing at a slower speed (Hafidh & Rashid, 2021). A potential positive tourism benefit might come from students. Bento (Bento, 2014) defines and investigates the determinants of international academic tourism, which considers student mobility as a type of tourism, and concludes that the higher education sector (proxied by the number of higher education students) is an important determinant and finds evidence of a positive and highly significant dynamic effect where past demand positively influences current demand.

Recent studies have increasingly acknowledged the significant role of digitalization and education in shaping the performance and competitiveness of the tourism sector, particularly regarding tourism revenue. Advances in digital infrastructure, such as broadband connectivity and internet penetration, have transformed how tourism services are marketed, accessed, and delivered. The ability of destinations to reach global audiences and streamline operations has been greatly enhanced through digital platforms, allowing for improved visitor experiences (Luo et al., 2022; Schönherr et al., 2023). The evolution of digital platforms facilitates a more efficient and personalized service to consumers, signifying a shift in how tourism businesses operate in the digital age (Tang, 2023; Zhang, 2023). The contribution of education to tourism development has been increasingly recognized. Education significantly improves human capital, service quality, and managerial capacity within the sector (Istiqomah et al., 2022; Lucia et al., 2021). Studies indicate that higher levels of educational attainment and investment in skills development correlate with greater adaptability to digital tools and innovation (Menon et al., 2022). A well-educated workforce enhances customer service in tourism-related businesses, leading to sustained improvement in overall service standards and competitiveness (Liburd et al., 2018). Husein (Husein, 2022) argues that there is a connection between educational tourism and dynamic demand effects, pointing towards evidence of a dynamic effect where past demand influences current demand, and demonstrating that university quality, specifically world university rankings, has a positive and significant impact on this demand in both the short and long term. The integration of a humanistic approach in tourism education—focusing on ethics and values—further promotes responsible management practices, aligning educational outcomes with industry demands (Kuščer & Mihalič, 2019). Digital tourism not only streamline operations but also necessitates ongoing education and training in digital competencies for employees (Schönherr et al., 2023; Tang, 2023; Zhang, 2023). Of particular interest might be the informal educational environment. Machado (Machado, 2022) examines the role and outcomes of informal environmental education activities offered within tourism settings, investigating how these influence tourist outcomes such as knowledge, attitude, awareness, satisfaction, identification, and intention to travel with the hosting tour operator again in the future, and suggesting that these activities can be advantageous for tourism stakeholders in terms of customer loyalty. A set of hypotheses has been formulated to evaluate the potential effects of digital and educational factors on tourism revenue, distinguishing between short-term fluctuations and long-term development trajectories.

H1a: Digitalization has a positive and significant long-term effect on tourism revenue.
H1b: Digitalization has a negative and significant short-term effect on tourism revenue.
H2a: Education has a positive and significant long-term effect on tourism revenue.
H2b: Education has a positive and significant short-term effect on tourism revenue.
H3: The effects of digitalization and education on tourism revenue vary significantly across Central and Eastern European countries due to structural, institutional, and socio-economic differences.
H4: There is a positive and significant trend effect on tourism revenue, reflecting long-term structural changes such as technological progress, international mobility, and global tourism demand.

2. DATA ANALYSIS AND METHODOLOGY

This study applies an Autoregressive Distributed Lag (ARDL) model to examine both short-term and long-term relationships between international tourism revenue (TOUR) and key explanatory variables, namely broadband subscriptions (BROAD), internet penetration (INTERNET), government expenditure on education (EDU), and tertiary education enrollment (HEDU). The analysis uses annual data for the period 2003–2021, covering a balanced panel of nine Central and Eastern European (CEE) countries: Bulgaria (BG), Croatia (HR), Czechia (CZ), Estonia (EST), Hungary (HU), Poland (PL), Romania (RO), Slovenia (SLV), and Slovakia (SK). The dataset was compiled from the World Bank, and the econometric analysis was conducted using EViews 12.0. A time trend variable was included to capture long-term structural changes in tourism revenue. A detailed description of all variables, including their measurements and corresponding data sources, is presented in Table 1.

Table 1: **Variables and source information**

Abbreviations	Variable (measurement)	Source	Period
	Tourism		
TOUR	International tourism revenue (current US$)	World Bank	2003-2021
	Digitalization		
INTERNET	Individuals using the Internet (% of population)	World Bank	2003-2021
BROAD	Fixed broadband subscriptions (per 100 people)	World Bank	2003-2021
	Education		
EDU	Government expenditure on education, total (% of GDP)	World Bank	2003-2021
HEDU	School enrollment, tertiary (gross), gender parity index (GPI)	World Bank	2003-2021

Source: Developed by the authors

The descriptive statistics, based on 171 observations per variable from the World Bank, summarize key indicators for the 9 CEE countries. The mean of international tourism revenue is 5.09 billion US$ (Std. Dev. = 3.51 billion US$), with a positive skewness (0.84), indicating higher values in a few countries. Internet usage averages 62.04% and is negatively skewed (–0.70), showing broad digital penetration with some laggards. Government expenditure on education (EDU) is 4.49% of GDP (Std. Dev. = 0.70; skewness = –0.08), and tertiary enrollment (GPI) has a mean of 1.27, suggesting general gender parity. Broadband subscriptions mean 19.57 per 100 people (skewness = –0.42), reflecting uneven digital infrastructure. These patterns underscore regional disparities and justify the investigation of how digital and educational factors shape tourism revenue.

Table 2: **Descriptive statistics**

	TOUR	INTERNET	EDU	HEDU	BROAD
Mean	5093644220	62.04417	4.488689	1.274984	19.5706
Median	4009000000	66.5987	4.52116	1.28364	21.0013
Std. Dev.	3510632318	19.27886	0.702046	0.069531	9.826973
Kurtosis	-0.15749227	-0.30275	-0.70431	-0.40042	-0.77334
Skewness	0.84231690	-0.70282	-0.08679	-0.21819	-0.42795
Count	171	171	171	171	171

Source: Developed by the authors

The next step involves testing the stationarity of the variables using panel unit root tests. The ARDL approach requires that all variables be integrated of order zero, I(0), order one I(1), or a combination of both, but not integrated of order two, I(2). To ensure this prerequisite is satisfied, several panel unit root tests were applied. These include the Levin, Lin & Chu (LLC) test, which assumes homogeneous autoregressive parameters across cross-sections (Levin et al., 2002); the ADF-Fisher test, which allows for heterogeneous adjustment dynamics (Maddala & Wu, 1999); and the PP-Fisher test, which adjusts for potential autocorrelation and heteroscedasticity in the residuals (Phillips & Perron, 1988). The results of these tests confirm the appropriate integration order for implementing the ARDL model. The results are presented in Table 3.

Table 3: **Panel unit root test results**

Variables		Levin, Lin & Chu t	ADF - Fisher Chi-square	PP - Fisher Chi-square
		t-statistics (Prob.)	t-statistics (Prob.)	t-statistics (Prob.)
TOUR	I(0)	-2.689 (0.003)	40.07 (0.002)	46.6 (0.000)
	I(1)	-	-	-
BROAD	I(0)	1.246 (0.893)	4.838 (0.991)	3.772 (0.990)
	I(1)	-14.87 (0.000)	159.64 (0.000)	129.97 (0.000)
INTERNET	I(0)	4.650 (0.990)	0.745 (0.990)	0.140 (0.990)
	I(1)	-8.588 (0.000)	88.41 (0.000)	129.56 (0.000)
EDU	I(0)	-0.908 (0.181)	9.850 (0.936)	17.581 (0.483
	I(1)	-11.07 (0.000)	124.90 (0.000)	164.69 (0.000)
HEDU	I(0)	-0.417 (0.338)	10.515 (0.913)	8.926 (0.961)
	I(1)	-5.831 (0.000)	63.46 (0.000)	88.85 (0.000)

Note: I – the order of integration.
Source: Developed by the authors

The panel unit root test results (Table 3) indicate that the variable TOUR is stationary at level I(0), as all three tests reject the null hypothesis of a unit root. In contrast, the variables BROAD, INTERNET, EDU and HEDU are non-stationary at level but become stationary after first differencing, as shown by highly significant test statistics across all three methods at I(1) (e.g., for BROAD: LLC = –14.87, p = 0.000; ADF-Fisher = 159.64, p = 0.000; PP-Fisher = 129.97, p = 0.000). These findings confirm that the dataset includes a mix of I(0) and I(1) variables, validating the use of the ARDL approach, which is appropriate for this type of integration structure.

After establishing the order of integration, the next step is to examine the presence of a long-term equilibrium relationship among the variables through cointegration analysis.

Table 4: **Data cointegration analysis**

Test	Statistic	Probability	Interpretation
Pedroni (Panel PP-Statistic)	-2.3104	0.0104	Significant - Cointegration confirmed
Pedroni (Panel ADF-Statistic)	-2.8269	0.0024	Significant - Cointegration confirmed
Pedroni (Group PP-Statistic)	-4.0429	0.0000	Significant - Cointegration confirmed
Pedroni (Group ADF-Statistic)	-3.0344	0.0012	Significant - Cointegration confirmed
Kao (ADF-Statistic)	-4.8694	0.0000	Significant - Cointegration confirmed
ADF Test on Residuals (RESID-1)	-0.811	0.0000	Significant - Residuals are stationary, confirming cointegration

Source: Developed by the authors

In the context of panel data, the Pedroni (1999, 2004) and Kao (1999) cointegration tests are commonly used due to their ability to account for cross-sectional heterogeneity. In this study, both tests were applied to examine the existence of a stable long-term relationship between tourism revenue, broadband penetration, internet access, and educational investment. The Pedroni test confirmed cointegration through statistically significant values of the Panel PP-Statistic, Panel ADF-Statistic, Group PP-Statistic, and Group ADF-Statistic ($p < 0.05$). The Kao test reinforced these findings, with an ADF statistic of –4.8694 ($p = 0.0000$), rejecting the null hypothesis of no cointegration. Additionally, the ADF test on the residuals indicated stationarity, further validating the long-term relationship. These results suggest that digitalization and education investments are linked to long-term tourism performance, although adjustment speeds may differ across countries.

3. ARDL ESTIMATION AND CROSS-COUNTRY ANALYSIS

The Pooled Mean Group (PMG) estimator within the ARDL framework is appropriate for panel data where variables are integrated of order zero [I(0)] and one [I(1)], and a long-run equilibrium relationship is expected (Pesaran et al., 1999). This approach allows for the joint estimation of long-term relationships and short-term dynamics. In this study, an ARDL (1,1,1,1,1) model is specified with international tourism revenue (TOUR) as the dependent variable, and broadband subscriptions (BROAD), internet penetration (INTERNET), government education expenditure (EDU), and tertiary enrollment (HEDU) as explanatory variables, capturing the influence of digitalization and education on tourism revenue.

$$\Delta TOUR_{it} = \phi_i\left(TOUR_{i,t-1} - \beta_{1i} \cdot BROAD_{i,t-1} - \beta_{2i} \cdot INTERNET_{i,t-1} - \beta_{3i} \cdot EDU_{i,t-1} - \beta_{4i} \cdot HEDU_{i,t-1}\right) + \alpha_{1i} \cdot \Delta BROAD_{it} - \alpha_{2i} \cdot \Delta INTERNET_{it} - \alpha_{3i} \cdot \Delta EDU_{it} - \alpha_{4i} \cdot \Delta HEDU_{it} + \gamma \cdot t + \mu_i + \varepsilon_{it}$$

where:

$\Delta TOUR_{it}$ – change in international tourism revenue for country *i* at time *t*
Φ – the speed of adjustment coefficient (ECM)
β_{1i}, β_{2i}, β_{3i}, β_{4i} – long-term coefficients associated with the digitalization and education
α_{1i}, α_{2i}, α_{3i}, α_{4i} – short-term coefficients associated with the digitalization and education
$\gamma \cdot t$ – time trend
μ_i – country-specific fixed effects
ε_{it} – error term.

The following section presents the long-term and short-term relationships between international tourism revenue and the selected indicators of digitalization and education across the nine Central and Eastern European countries analyzed. The analysis examines the speed of adjustment toward long-term equilibrium, offering insights into how quickly tourism revenue responds to structural changes in digital and educational investment across countries with varying levels of economic and institutional development.

Table 5: **Long-term and short-term estimation results using the PMG-ARDL**

Variable	**Long-term Estimates**	
	Coefficient	Prob.
BROAD	0.1084	0.3926
INTERNET	1.0672	0.0186
EDU	-0.8062	0.0004
HEDU	-6.4003	0.0001
	Short-term Estimates	
Variable	Coefficient	Prob.
COINTEQ01	-0.6845	0.0002
D(BROAD)	-0.2097	0.0177
D(INTERNET)	-0.7238	0.0045
D(EDU)	-0.2496	0.5238
D(HEDU)	1.8145	0.1513
C	14.5312	0.0002
@TREND	-0.0601	0.0000

Source: Developed by the authors

The PMG-ARDL (1,1,1,1,1) estimation results presented in Table 5 highlight significant short-run and long-run relationships between international tourism revenue (TOUR) and key explanatory variables associated with digitalization and education. In the long-term, internet penetration (INTERNET) has a positive and statistically significant effect on tourism revenue (coefficient = 1.0672, p = 0.0186), suggesting that better internet access contributes to higher tourism performance, likely by improving online visibility, booking systems, and customer experience. This confirms Hypothesis H1a, which expected a positive and significant long-run impact of digitalization on tourism revenue. In contrast, education indicators show negative long-term effects: EDU (government expenditure on education) has a coefficient of –0.8062 (p = 0.0004) and HEDU (tertiary enrollment) has a stronger negative effect of –6.4003 (p = 0.0001). These results contradict Hypothesis H2a, which expected a positive long-run relationship, and may reflect a reallocation of resources or labor away from tourism toward other education-intensive sectors. The long-term effect of broadband subscriptions (BROAD) is positive but not statistically significant (0.1084, p = 0.3926), indicating limited long-term influence when controlling other variables. The error correction coefficient (COINTEQ01) is –0.6845 (p = 0.0002), significant and with the expected negative sign, showing that approximately 68% of short-term deviations from long-term equilibrium are corrected within one year—a fast speed of adjustment. Among the short-term coefficients, D(BROAD) and D(INTERNET) have statistically significant negative effects (–0.2097, p = 0.0177 and –0.7238, p = 0.0045, respectively), suggesting that while digital infrastructure supports tourism in the long-term, its short-term expansion may disrupt traditional operations or require time for adaptation. These findings support Hypothesis H1b, which expected a negative short-term effect of digitalization on tourism revenue. The short-term effects of D(EDU) and D(HEDU) are not statistically significant (p = 0.5238 and p = 0.1513), implying that education does not have an immediate measurable impact on tourism revenues, and therefore Hypothesis H2b is not confirmed. The trend variable is negative and highly significant (–0.0601, p = 0.0000), suggesting a gradual long-term decline in tourism revenue. This result does not confirm Hypothesis H4, which anticipated a positive trend effect, and instead points to structural or demographic challenges affecting tourism revenue.

Table 6: **Cross-country comparison of short-term effects on tourism revenue**

Country	COINTEQ01	D(BROAD)	D(INTERNET)	D(EDU)	D(HEDU)	C	@TREND
BG	-1.4385 (0.0001)	-0.5049 (0.0216)	-0.9707 (0.3091)	0.5348 (0.2835)	8.9041 (0.7468)	30.2123 (0.3161)	-0.1358 (0.0000)
HR	-1.6597 (0.0001)	-0.0307 (0.6949)	-0.3051 (0.5983)	0.7595 (0.0103)	0.0159 (0.9988)	35.2953 (0.2244)	-0.0611 (0.0000)
CZ	-0.4499 (0.0022)	-0.2189 (0.0055)	-0.0963 (0.8311)	-0.0438 (0.5986)	-6.4844 (0.7672)	9.7823 (0.6644)	-0.0467 (0.0000)
ES	-0.6083 (0.0040)	-0.6297 (0.3494)	-0.1462 (0.9690)	0.3344 (0.3534)	-3.7677 (0.9336)	12.4617 (0.7228)	-0.0542 (0.0000)
HU	-0.5086 (0.0143)	0.1481 (0.7106)	-0.6682 (0.8271)	0.2647 (0.8644)	4.1939 (0.9699)	11.0229 (0.8205)	-0.0604 (0.0000)
PLN	-0.2644 (0.1030)	-0.1930 (0.0156)	0.1387 (0.9246)	-2.2508 (0.6115)	1.8772 (0.9480)	5.9422 (0.9212)	-0.0245 (0.0000)
RO	-0.6889 (0.0003)	-0.0943 (0.5757)	-1.2894 (0.1579)	0.9923 (0.3145)	5.8091 (0.8199)	14.3753 (0.4216)	-0.0872 (0.0000)
SK	0.0269 (0.5959)	0.0487 (0.7982)	-2.2796 (0.2332)	-1.8660 (0.0495)	3.5250 (0.8165)	-0.2415 (0.9905)	-0.0206 (0.0000)
SLN	-0.5694 (0.0015)	-0.4129 (0.1300)	-0.8976 (0.4819)	-0.9714 (0.4337)	2.2571 (0.6065)	11.9303 (0.6302)	-0.0506 (0.0000)

Source: Developed by the authors

The ARDL model results for Central and Eastern European countries highlight a complex relationship between digitalization, education, and tourism revenues, with notable cross-country differences. The error correction term (COINTEQ01) is negative and statistically significant in most cases, confirming the presence of a long-term cointegrated relationship between the explanatory variables and tourism revenues. Countries like Bulgaria (–1.4385, p = 0.0001), Croatia (–1.6597, p = 0.0001), and Romania (–0.6889, p = 0.0003) show the fastest adjustment speeds toward long-term equilibrium after a shock. By contrast, Slovakia (0.0269, p = 0.5959) shows no evidence of cointegration, indicating that the model may not fully capture tourism dynamics there. The Czech Republic (–0.4499, p = 0.0022) and Estonia (–0.6083, p = 0.0040) display moderate speeds of adjustment. These findings support Hypothesis H3, confirming that the effects of digitalization and education on tourism revenue vary significantly across countries, depending on their structural, institutional, and socio-economic characteristics. In the short term, broadband has a negative and significant effect in Bulgaria (–0.5049, p = 0.0216), the Czech Republic (–0.2189, p = 0.0055), and Poland (–0.1930, p = 0.0156), suggesting that improvements in infrastructure do not immediately boost tourism revenues—possibly due to shifts in consumer behaviour toward digital experiences rather than physical travel. No significant broadband effects are found in Hungary, Slovakia, or Slovenia. Internet usage is not statistically significant in any country, though Romania and Slovakia report large negative coefficients, pointing to potential short-term disruptions. Regarding education, government spending on education is significant only in Croatia (positive) and Slovakia (negative), highlighting country-specific dynamics in how education affects tourism. Finally, the long-term trend (@TREND) is negative and highly significant across all countries, indicating a structural decline in tourism revenues. This may reflect rising global competition, demographic change, or inadequate adaptation to evolving market demands.

CONCLUSIONS

The analysis confirms that digitalization, particularly internet penetration, plays a positive and significant role in enhancing tourism revenue over the long term. This underscores the importance of continued investment in digital infrastructure and online service platforms within the tourism industry. However, the short-term negative effects of both broadband and internet usage suggest that digital transitions require time and sectoral adaptation. For digitalization to yield immediate benefits, tourism stakeholders must improve their digital capabilities and integrate technology effectively into their operational models. Contrary to expectations, both public spending on education and tertiary enrollment exhibit significant negative effects on tourism revenue in the long run. These findings may reflect a structural shift in labor allocation away from the tourism sector toward more education-intensive industries. In the short term, education does not appear to influence tourism performance significantly. Therefore, aligning educational policies with tourism sector needs, particularly through vocational training, digital skills development, and service-oriented programs, should be a strategic priority for policymakers aiming to strengthen the tourism workforce.

This study is limited by its focus on a specific set of variables related to digitalization and education, which may not fully capture the broader forces influencing tourism revenue. It does not account for external factors such as global travel demand, labor market dynamics, or national tourism policies. Future research should explore these additional explanatory factors and examine how policy interventions and structural shifts influence the long-term relationship between digital and educational investments and tourism revenue.

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