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# The impact of digitalization on the use of AI and productivity – the case of Romania

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**7<sup>th</sup> International Conference on Economics and Business Management**  
**Section Economics**

14 November 2025, Cluj – Napoca, Romania

# Agenda



**1.** Introduction and context



**2.** Literature review and research questions



**3.** Sample and methodology



**4.** Results



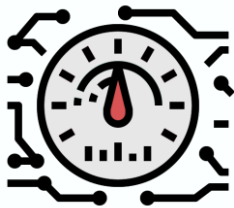
**5.** Discussion

# Introduction and context

Digital transformation is reaching new levels with the emergence of Artificial Intelligence (AI).



Firm-level experiences and the performance implications of their (AI and other digital technologies) usage. Digital readiness models (Hizam et al., 2020) predicts that implementing an additional digital technology could be easier if a company already has experience with digital technologies.



Conditions of introducing AI, such as the availability of rich data or a high-speed internet connection



We investigate how AI adoption is related to the use of other digital technologies.

# Literature review and research questions

We have plenty of positive evidence about the influence of AI on business performance, there are also studies expressing doubts.

## *Relationship of AI to other digital technologies.*

companies pair traditional and new technologies

some technological prerequisites are required before implementing AI, such as big data and cloud computing, high-speed and scalable computational power, and rich data (Enholm et al., 2022; Wamba-Taguimdje et al., 2020).

works usually approach the technological solutions as bundled together and do not scrutinize their potential influence on each other.

## *Performance implications of digital technologies and AI.*

the latest technologies to increase operational and business performance (e.g., Vu et al., 2024). AI has similar positive promises regarding business performance improvements (Chowdhury et al., 2022).

there are less optimistic works (Rana et al., 2021; Filippucci et al., 2024), and even negative influence is detected

*RQ1: What types of digital technologies influence the adoption of AI?*

*RQ2: To what extent do digital technologies and AI justify higher productivity?*

# Sample

We used the ‘ICT usage in enterprises’ (i.e., ICT survey) firm-level data from Eurostat in 2023 for Romania (Eurostat, 2024a). Romania is an extreme case of digitalisation within Europe since the country is the least developed in the EU27.

Economic Activity (NACE Rev. 2 Section)	Population	% of Total	Sample	% of Total	Ratio Diff	Included	AI users	%	no AI users	%
A Agriculture, Forestry and Fishing	0	0.00%	3	0.03%	-0.03%	NO	0	0%	3	0.03%
B Mining And Quarrying	350	0.64%	4	0.04%	0.60%	NO	0	0%	4	0.04%
<b>C Manufacturing</b>	<b>11324</b>	<b>20.85%</b>	<b>3494</b>	<b>35.63%</b>	<b>-14.78%</b>	<b>YES</b>	<b>73</b>	<b>23.62%</b>	<b>3418</b>	<b>36.06%</b>
D Electricity, Gas, Steam and Air Conditioning Supply	166	0.31%	94	0.96%	-0.65%	YES	9	2.91%	85	0.90%
E Water Supply;Sewerage, Waste Management and Remediation Activities	698	1.29%	280	2.86%	-1.57%	YES	4	1.29%	276	2.91%
F Construction	9167	16.88%	1039	10.59%	6.28%	YES	9	2.91%	1027	10.84%
<b>G Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles</b>	<b>12309</b>	<b>22.66%</b>	<b>1774</b>	<b>18.09%</b>	<b>4.58%</b>	<b>YES</b>	<b>52</b>	<b>16.83%</b>	<b>1719</b>	<b>18.14%</b>
H Transportation and Storage	4646	8.55%	750	7.65%	0.91%	YES	14	4.53%	732	7.72%
I Accommodation and Food Service Activities	4103	7.55%	359	3.66%	3.89%	YES	2	0.65%	356	3.76%
<b>J Information and Communication</b>	<b>2030</b>	<b>3.74%</b>	<b>606</b>	<b>6.18%</b>	<b>-2.44%</b>	<b>YES</b>	<b>75</b>	<b>24.27%</b>	<b>530</b>	<b>5.59%</b>
K Financial and Insurance Activities	602	1.11%	0	0.00%	1.11%	NO	0	0%	0	0%
L Real Estate Activities	571	1.05%	66	0.67%	0.38%	NO	0	0%	66	0.70%
<b>M Professional, Scientific and Technical Activities</b>	<b>2535</b>	<b>4.67%</b>	<b>500</b>	<b>5.10%</b>	<b>-0.43%</b>	<b>YES</b>	<b>50</b>	<b>16.18%</b>	<b>450</b>	<b>4.75%</b>
N Administrative and Support Service Activities	3356	6.18%	796	8.12%	-1.94%	YES	21	6.80%	770	8.12%
O Public Administration and Defence; Compulsory Social Security	0	0.00%	0	0.00%	0.00%	NO	0	0%	0	0%
P Education	262	0.48%	0	0.00%	0.48%	NO	0	0%	0	0%
Q Human Health and Social Work Activities	1294	2.38%	0	0.00%	2.38%	NO	0	0%	0	0%
R Arts, Entertainment and Recreation	433	0.80%	3	0.03%	0.77%	NO	0	0%	3	0.03%
S Other Service Activities	464	0.85%	39	0.40%	0.46%	NO	0	0%	39	0.41%
T Activities of Households as Employers; Undifferentiated Goods-And Services-Producing Activities of Households for Own Use	0	0.00%	0	0.00%	0.00%	NO	0	0%	0	0%
U Activities of Extraterritorial Organisations and Bodies	0	0.00%	0	0.00%	0.00%	NO	0	0%	0	0%
<b>Total</b>	<b>54,310</b>	<b>100%</b>	<b>9,807</b>	<b>100%</b>			<b>309</b>	<b>100%</b>	<b>9,478</b>	<b>100%</b>

# Operationalisation

Variable name		Scale	Items / Questions
<b>DEPENDENT</b>			
Productivity (RON)		= (Total turnover – costs of goods sold) / number of employees	
AI	AI_tech	0 = None; 7 = All technologies	Does your enterprise use any of the following Artificial Intelligence (AI) technologies?
			a) AI technologies performing analysis of written language (e.g. text mining)
b) AI Technologies converting spoken language into a machine-readable format (speech recognition)			
c) AI Technologies generating written or spoken language (natural language generation, speech synthesis)			
d) AI Technologies identifying objects or persons based on images or videos (image recognition, image processing)			
e) Machine learning (e.g. deep learning) for data analysis			
f) AI Technologies automating different workflows or assisting in decision making (e.g. AI-based software robotic process automation)			
g) AI Technologies enabling physical movement of machines via autonomous decisions based on observation of surroundings (autonomous robots, self-driving vehicles, autonomous drones)			
	UseAI	0 = No use of AI; 1 = At least 1 AI technology is used)	

Digital technologies	Internet_speed	1-5
	Website	0 = None; All features - 8
	Mobile_app	0 = No; 1 = Yes
	socialmedia	0 = None; 3 = All platforms)
	Sales_web	0 = NO; 1 = YES
	Sales_marketplace	0 = NO; 1 = YES
	Sales_edi	0 = NO; 1 = YES
	ERP	0 = NO; 1 = YES
	CRM	0 = NO; 1 = YES
	Business_Intelligence	0 = NO; 1 = YES
	Datasharing_supplychain	0 = NO; 1 = YES
	Dataanalytics_sources	0 = None; 8 = All sources
Cloud_services	0 = None; 10 = All services	
Datasharing_invoice	0 = No; 1 = YES	

Control variables	Firm-size	= ln (Avg. number of employees in 2022)	Average number of employees and self-employed persons (persons employed), during 2022
	Industry	NACE_X 0-1	Main economic activity of the enterprise, during 2022 (See Table 1)

# Sample filtering and variables used

We excluded industries with no AI usage, insufficient responses, or missing key data. After filtering, we retained 9064 companies, of which 292 use AI. The analysis includes variables related to digital technologies and firm characteristics.

	Descriptive statistic								
Number of AI technologies used	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	
	8772	73	63	52	55	15	11	23	
AI usage (yes / no)	<b>0</b>	<b>1</b>							
	8772	292							
Internet speed	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>				
	113	1194	4022	2422	1313				
Website	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>
	3622	1533	1478	959	533	333	194	115	297
Mobile application	<b>0</b>	<b>1</b>							
	8234	830							
Number of social media platforms	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>					
	4849	2500	1029	686					
Online sales on own website	<b>0</b>	<b>1</b>							
	7862	1202							
Online sales via marketplaces	<b>0</b>	<b>1</b>							
	8552	512							
EDI usage	<b>0</b>	<b>1</b>							
	8479	585							
ERP system	<b>0</b>	<b>1</b>							
	6005	3059							

CRM system	<b>0</b>	<b>1</b>							
	7527	1537							
Business Intelligence tools	<b>0</b>	<b>1</b>							
	7736	1328							
Supply chain data sharing	<b>0</b>	<b>1</b>							
	7731	1333							
Number of data sources for analytics	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>
	6503	414	566	484	415	267	175	95	145
Number of cloud services used	<b>0</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>
	6675	273	255	351	284	250	264	180	170
Electronic invoicing	<b>0</b>	<b>1</b>							
	5463	3601							
Firm size	<b>N</b>	<b>MEAN</b>	<b>SD</b>	<b>MIN</b>	<b>MAX</b>				
	9064	4.565	1.068	2.303	10.089				
Productivity	<b>N</b>	<b>MEAN</b>	<b>SD</b>	<b>MIN</b>	<b>MAX</b>				
	9064	163684.7872	612088.7749	63.27272727	23047376.78				

Most companies in the sample do not use AI technologies, with only 292 firms identified as AI users. Basic digital tools such as websites and social media are widely adopted, while more advanced systems (CRM, BI, supply-chain data sharing, cloud services) are less common across the sample.

# Research methodology / Modeling procedure

Model building steps and progressive inclusion of explanatory variables

**RQ1: What types of digital technologies influence the adoption of AI?**

MODEL 01  
Baseline logistic regression model:  
Dependent variable: useAI (yes/no)  
Independent variables: **Digital technologies** (website, mobile app, social media, ERP, CRM, BI, data sharing, cloud services etc)

Stepwise model selection (AIC-based)  
Less relevant predictors removed  
The model retains the most influential digital technology drivers

MODEL 02  
Model extension with control variables: firm size included as a control

MODEL 03  
Industry-specific effects controlled for (NACE rev.2)

**RQ2: To what extent do digital technologies and AI justify higher productivity?**

Data preparation and 1–99% winsorization  
Productivity measures contain extreme outliers  
Winsorization reduces distortion without losing observations  
Productivity variable log-transformed

MODEL 01  
Linear regression with **digital technologies**  
Stepwise model selection (AIC-based)

MODEL 02  
Model extension with AI usage

MODEL 03 – MODEL 04  
Firm size and industry fixed to ensure robust interpretation

# RQ1: What types of digital technologies influence the adoption of AI?

Logistic Regression models were used to explore the influence of independent variables such as digital technologies and control variables (e.g. firm size, industry) on the intensity of AI technology use.

Variable	Model 01		Model 02		Model 03	
	Est.	Odds	Est.	Odds	Est.	Odds
Internet_speed	0.313***	1.368	0.287***	1.333	0.162**	1.176
Website	-0.065**	0.937	-0.066**	0.936	-0.061*	0.941
Mobile_app						
Socialmedia	0.514***	1.671	0.516***	1.676	0.421***	1.523
Sales_web					0.253	1.288
Sales_marketplace						
Sales_edi					0.321	1.379
ERP						
CRM						
Business_Intelligence	0.786***	2.196	0.686***	1.986	0.589***	1.802
Datasharing_supplychain	0.390***	1.477	0.346**	1.413	0.316**	1.372
Dataanalytics_sources						
Cloud_services	0.203***	1.225	0.197***	1.218	0.173***	1.189
Datasharing_einvoice	0.281**	1.324	0.267**	1.306	0.315**	1.371
Firmsize			0.212***	1.236	0.281***	1.325
NACE_D						
NACE_E						
NACE_F					-0.495	0.610
NACE_G						
NACE_H						
NACE_I					-1.492**	0.225
NACE_J					1.042***	2.835
NACE_M					1.397***	4.044
NACE_N						
McFadden	21.91%		22.55%		25.62%	
Hosmer Lemeshow	<i>p value</i> = 0.1187		<i>p value</i> = 0.0573		<i>p value</i> = 0.0894	
N	9064		9064		9064	

Regarding digital solutions, 6 items have a positive and significant influence on AI usage at the  $p < 0.05$  level in all models:

- Internet speed (increases the probability of the company's AI usage by 17.6% in Model 3),
- Social media (52.3%),
- Business Intelligence (80,2%),
- Supply chain data sharing (37,2%)
- Cloud services (18,9%), and
- Electronic invoicing (37,1%)

*Our model has moderate explanatory power.*

Note: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

# RQ2: To what extent do digital technologies and AI justify higher productivity?

Firm-level business performance is measured by productivity ((Total turnover in 2022 - Total expenses for goods and services in 2022) / Average number of occupied positions in 2022), and we used a winsorized (99/1) value in the OLS models.

	Model01	Model02	Model03	Model04
Variable	Est.	Est.	Est.	Est.
Intercept	11.097***	11.101***	11.211***	11.085***
Internet_speed	0.059***	0.0577***	0.060***	0.034***
Website	0.030***	0.030***	0.031***	0.022***
Mobile_app				
Socialmedia	0.024**	0.022**	0.022**	
Sales_web				-0.093***
Sales_marketplace				
Sales_edi	0.133***	0.132**	0.137***	0.175***
ERP	0.172***	0.174***	0.183***	0.162***
CRM	0.073**	0.072**	0.072**	0.062**
Business_Intelligence	0.154***	0.149***	0.158***	0.118***
Datasharing_supplychain				
Dataanalytics_sources				
Cloud_services	0.034***	0.033**	0.033***	0.028***
Datasharing_einvoice	-0.036**	-0.036**	-0.035**	-0.023*
AI_tech		0.029**	0.032**	0.019
Firmsize			-0.027***	
NACE_D				0.7368***
NACE_E				
NACE_F				0.069***
NACE_G				0.424***
NACE_H				0.248***
NACE_I				
NACE_J				0.539***
NACE_M				0.364***
NACE_N				-0.275***
Adjusted R-squared	9.98%	10.11%	10.12%	17.87%
RMSE	0.762	0.762	0.761	0.727
AIC	20812.58	20809.89	20799.83	19989.01951
BP-test	p value = 0.704	p value = 0.667	p value = 0.286	p value = 0
N	9064	9064	9064	9064

## Main results (stable across Model 01–04):

+ Internet speed, website, EDI-type sales, ERP, CRM, Business Intelligence, and Cloud services

*consistently associated with higher productivity*

– web sales

– E-invoicing

*small negative effect (implementation and transition costs may temporarily lower efficiency)*

## AI effect:

+ Positive and significant in Model 03

Not significant in Model 04 when industry controls are added

*AI's productivity impact is industry-dependent, not automatic*

## Industry effects (Benchmark = Manufacturing, NACE C)

## Model fit:

Adjusted R<sup>2</sup> ≈ 18%

*Productivity is influenced by technology and managerial, organizational, and market factors*

# Conclusion

Our paper offers guidelines for companies and policymakers in their AI deployment efforts.

**RQ1: The assumption that digital readiness positively influences AI usage is supported. We have defined a limited set of digital technologies boosting AI adoption**

AI remains a sector-dependent technology.

**RQ2: Our results also suggest that firms do not benefit from AI in terms of firm productivity**

Our results suggest that differences in productivity across firms are better explained by sectoral affiliation and digital adoption than by firm size.

One can define a core set of digital technologies contributing to AI usage and productivity simultaneously

To examine the impact of context on the results, in our future research, we aim to incorporate **Denmark**, the leading country in digitalisation in the EU27



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# Thank you for your attention!

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## 7<sup>th</sup> International Conference on Economics and Business Management

### Section Economics

14 November 2025, Cluj – Napoca, Romania



# Appendix

**INDEPENDENT**

Digital technologies	Internet_speed	1-5	What is the maximum contracted download speed of the fastest fixed internet connection of your enterprise?
	Website	0 = None; All features - 8	Does the website have any of the following? a) Description of goods or services, price information b) Online ordering or reservation or booking, e.g. shopping cart c) Possibility for visitors to customise or design online goods or services d) Tracking or status of orders placed e) Personalised content on the website for regular/recurrent visitors f) A chat service for customer support (a chatbot, virtual agent or a person replying to customers) g) Advertisement of open job positions or online job application h) Content available in at least two languages
	Mobile_app	0 = No; 1 = Yes	Does your enterprise have a mobile app for clients (e.g. for loyalty program, e-commerce, customer support)?
	socialmedia	0 = None; 3 = All platforms)	Does your enterprise use any of the following social media? a) Social networks (e.g. Facebook, LinkedIn, Xing, Viadeo, Yammer) b) Enterprise's blog or microblogs (e.g. Twitter) c) Multimedia content sharing websites or apps (e.g. YouTube, Flickr, SlideShare, Instagram, Pinterest, Snapchat)
	Sales_web	0 = NO; 1 = YES	During 2022, did your enterprise have web sales of goods or services on your enterprise's websites or apps?
	Sales_marketplace	0 = NO; 1 = YES	During 2022, did your enterprise have web sales of goods or services on e-commerce marketplace websites or apps used by several enterprises for trading goods or services?
	Sales_edi	0 = NO; 1 = YES	During 2022, did your enterprise have EDI-type sales of goods or services?
	ERP	0 = NO; 1 = YES	Does your enterprise use the following business software? a) Enterprise Resource Planning (ERP) software
	CRM	0 = NO; 1 = YES	Does your enterprise use the following business software? b) Customer Relationship Management (CRM) software
	Business_Intelligence	0 = NO; 1 = YES	Does your enterprise use the following business software? Business Intelligence (BI) software
	Datasharing_supplychain	0 = NO; 1 = YES	Does your enterprise share data electronically with suppliers or customers within the supply chain (e.g. via websites or apps, EDI systems, real-time sensors or tracking)?
	Dataanalytics_sources	0 = None; 8 = All sources	Does your enterprise perform data analytics on data from the following sources? a) transaction records such as sale details, payments records b) customer purchasing information, location, preferences, customer reviews, searches c) social media, incl. from your enterprise's own social media profiles d) web data (e.g. search engine trends, web scraping* data) e) location data from the use of portable devices or vehicles f) smart devices or sensors (e.g. Machine to Machine (M2M) communications, sensors installed in machinery) g) government authorities' open data h) satellite data
	Cloud_services	0 = None; 10 = All services	Does your enterprise buy any of the following cloud computing services used over the internet? a) E-mail b) Office software c) Finance or accounting software applications d) Enterprise Resource Planning (ERP) software applications e) Customer Relationship Management (CRM) software applications f) Security software applications g) Hosting the enterprise's database(s) h) Storage of files i) Computing power to run the enterprise's own software j) Computing platform providing a hosted environment for application development, testing or deployment
	Datasharing_einvoice	0 = No; 1 = YES	In 2022, did your enterprise send any of the following types of invoices: a) Invoices in electronic form, in a standard structure suitable for automated processing (e-invoices)?