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Artificial Intelligence Adoption and Labor Productivity Growth Volatility: Evidence from Romanian Firms

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Collegium Talentum

Presentation outline

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Introduction

- Artificial intelligence is widely regarded as a general purpose technology with the potential to foster innovation and drive productivity growth (Kopka and Fornahl, 2024);

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Motivation

- Limited firm-level evidence on AI and productivity (data constraints) (Czarnitzki et al., 2023)
- Existing studies focus either on specific AI technologies or on firms developing and patenting AI (e.g. Yang (2022), Zhai and Liu (2023))
- Firms that adopt externally developed or unpatented AI technologies are overlooked.
- Productivity dynamics (volatility) remain unexplored (e.g. Fontanelli et al. (2025)).
- No firm-level evidence for Romania.

Objectives

- Analyze the effect of AI adoption on productivity growth volatility.
- Evidence from Romanian firms.
- Examine whether the relationship remains robust across comparable firms and firm characteristics.

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- Analyze the effect of AI adoption on productivity growth volatility.
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Research Questions

- RQ1: Does AI adoption correspond to differences in firms' labor productivity growth volatility in Romania?
- RQ2: Is this relationship robust when comparing similar firms?
- RQ3: Does the relationship vary across firm size and digital intensity?

Presentation outline

Literature Review

Productivity effects

- AI adoption is associated with higher firm-level productivity in China between 2006-2020 and 2011-2020 (Zhai and Liu, 2023; Wang et al., 2023).
- Positive effects of AI on firm productivity are also found in Germany and globally between 2000-2016 (Czarnitzki et al., 2023; Damioli et al., 2021);

Measurement approaches

- However, existing studies focus on specific AI technologies or rely on patent-based measures (e.g. Yang (2022)).

Productivity dynamics

- Firm-level evidence on productivity dynamics remains scarce, with only limited evidence on volatility (in case of France) (Fontanelli et al., 2025).

Presentation outline

Methodology

- Baseline OLS estimates of the relationship between AI adoption (AI_i) and labor productivity growth volatility ($\ln \sigma_i$).
- Controls for firm characteristics (FGP_{i,t_0}) and digital intensity (ICT_i), including sector fixed effects (δ_s).

$$\ln \sigma_i = \alpha + \beta\, AI_i + \gamma_1 \ln FGP_{i,t_0} + \gamma_2 ICT_i + \delta_s + \varepsilon_i. \tag{1}$$

- Coarsened Exact Matching (CEM) applied to compare otherwise similar AI adopters and non-adopters.
- Weighted OLS on the matched sample.

Presentation outline

Data and Sample (1)

- Firm-level data from the Eurostat Community Survey on ICT Usage and E-commerce in Enterprises for Romania (Eurostat, 2025).
- The survey is implemented by the National Institute of Statistics.
- Period: 2013-2022.
- In 2022, when AI use was measured, the survey included 9 807 firms operating in 13 sectors and was restricted to enterprises with at least 10 employees.

Data and Sample (2)

Variable	**Notation**	**Description**
Productivity volatility	$\ln \sigma_i$	Log labor productivity growth volatility (2017–2022).
AI adoption	AI_i	Dummy equal to 1 if the firm uses AI in 2022.
Firm size	$Size_i$	Log number of employees in baseline year.
Baseline productivity	$Prod_i$	Log labor productivity in baseline year.
ICT intensity	ICT_i^{tech}	Number of non-AI digital technologies used.
Fast broadband	$FastBroadband_i$	Dummy for broadband speed $\geq$ 30 Mbit/s.
Sector FE	δ_s	Two-digit NACE fixed effects.

Presentation outline

Results (1)

Table1: Comparison of AI users and non-users (2017–2022)

	Full sample	Non-users	AI users
Size	351.07	326.61	1044.16***
Productivity	403002.15	388427.81	816022.55**
Fast Broadband	0.98	0.98	0.99
# other digital technologies	2.49	2.39	5.14***
Volatility of prod. growth rates (σ_i)	0.19	0.19	0.15***
Obs.	5281	5101	180

Notes: Mean differences between AI users and non-users are tested using Welch's two-sample t-tests.
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.
Source: Authors' calculations based on Eurostat ICT survey data for Romania.

Results (2) - OLS

Table 2: OLS Results for Eq. 1.

	σ_i (2017–2022)			σ_i (2018–2022)	σ_i (2013–2022)	σ_i (2013–2017)
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
AI	-0.124**	-0.081	-0.080	-0.072	0.004	0.019
	(0.055)	(0.058)	(0.058)	(0.058)	(0.058)	(0.066)
log Productivity (2013)					-0.119***	-0.203***
					(0.042)	(0.030)
log Productivity (2017)		0.037	0.072			0.218***
		(0.026)	(0.050)			(0.049)
log Productivity (2018)				0.069		
				(0.059)		
log Productivity (2022)			-0.039	-0.029	0.105*	
			(0.057)	(0.065)	(0.058)	
log Size (2013)					-0.030*	-0.075***
					(0.017)	(0.019)
log Size (2017)		-0.046***	-0.045***			
		(0.016)	(0.016)			
log Size (2018)				-0.067***		
				(0.018)		
Fast Broadband		0.041	0.041	0.156*	0.038	0.041
		(0.087)	(0.086)	(0.085)	(0.074)	(0.098)

Results (3) - OLS

Table 2: OLS Results for Eq. 1.

	σ_i (2017–2022)			σ_i (2018–2022)	σ_i (2013–2022)	σ_i (2013–2017)
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Non-AI Digital Tech. = 1		-0.052*	-0.052*	-0.068**	-0.067**	-0.060*
		(0.029)	(0.029)	(0.031)	(0.034)	(0.035)
Non-AI Digital Tech. = 2		-0.061	-0.059	-0.052	-0.073*	-0.046
		(0.044)	(0.042)	(0.044)	(0.041)	(0.044)
Non-AI Digital Tech. = 3		-0.066	-0.065	-0.053	-0.079*	-0.051
		(0.047)	(0.047)	(0.044)	(0.046)	(0.046)
Non-AI Digital Tech. = 4		-0.034	-0.032	-0.045	-0.066	-0.117**
		(0.041)	(0.040)	(0.047)	(0.042)	(0.052)
Non-AI Digital Tech. = 5		-0.044	-0.042	-0.053	-0.071	-0.043
		(0.046)	(0.046)	(0.049)	(0.053)	(0.060)
Non-AI Digital Tech. = 6		-0.030	-0.028	0.001	-0.061	-0.158**
		(0.040)	(0.040)	(0.048)	(0.049)	(0.065)
Non-AI Digital Tech. = 7		-0.089	-0.086	-0.101	-0.139**	-0.157***
		(0.055)	(0.055)	(0.063)	(0.062)	(0.050)
Non-AI Digital Tech. = 8		-0.077	-0.073	-0.073	-0.116**	-0.086
		(0.053)	(0.052)	(0.080)	(0.053)	(0.070)
Non-AI Digital Tech. = 9		-0.203**	-0.199**	-0.203**	-0.199**	-0.056
		(0.087)	(0.088)	(0.086)	(0.085)	(0.114)
Non-AI Digital Tech. = 10		-0.189	-0.178	-0.141	-0.249*	0.051
		(0.215)	(0.219)	(0.201)	(0.129)	(0.147)

Results (4) - OLS

Table 2: OLS Results for Eq. 1.

	σ_i (2017–2022)			σ_i (2018–2022)	σ_i (2013–2022)	σ_i (2013–2017)
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	-2.214***	-2.431***	-2.364***	-2.461***	-1.821***	-2.290***
	(0.001)	(0.279)	(0.325)	(0.292)	(0.407)	(0.388)
Controls X_{i,t_0}	No	Yes	Yes	Yes	Yes	Yes
Controls ICT_i	No	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5281	5281	5281	5783	3757	4049
Adj. R^2	0.217	0.222	0.222	0.197	0.274	0.238
Clustered SE	Industry	Industry	Industry	Industry	Industry	Industry

Notes: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Source: Authors' calculations based on Eurostat ICT survey data for Romania.

Results (3) - CEM

Table 3: Comparison of AI users and non-users (2017-2022, CEM-weighted)

	Full sample	Non-users	AI users
log Size	5.86	5.85	5.98
log Productivity	12.73	12.73	12.73
Fast Broadband	0.99	0.99	0.99
# other digital technologies	3.47	3.35	5.12***
log Volatility of prod. growth rates (σ_i)	-2.01	-2.00	-2.16***
Obs.	2608	2429	179

Notes: Means are computed using CEM weights.
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.
Source: Authors' calculations based on Eurostat ICT survey data for Romania.

Results (4) - Weighted OLS after CEM balancing

Table 4: Weighted OLS Results of Eq. 1 after CEM balancing.

	σ_i (2017–2022) Model 1	σ_i (2018–2022) Model 2	σ_i (2013–2022) Model 3	σ_i (2013–2017) Model 4
AI	-0.069	-0.055	-0.053	-0.020
	(0.058)	(0.058)	(0.059)	(0.076)
log Productivity (2013)			0.058	0.227*
			(0.065)	(0.133)
log Productivity (2017)	0.057			-0.189
	(0.091)			(0.124)
log Productivity (2018)		0.143		
		(0.088)		
log Productivity (2022)	-0.005	-0.038	-0.021	
	(0.100)	(0.102)	(0.064)	
log Size (2013)			-0.103***	-0.131***
			(0.026)	(0.029)
log Size (2017)	-0.095***			
	(0.024)			
log Size (2018)		-0.130***		
		(0.025)		
Fast Broadband	0.085	0.179	-0.083	-0.329
	(0.182)	(0.147)	(0.227)	(0.255)

Results (5) - Weighted OLS after CEM balancing

Table 4: Weighted OLS Results of Eq. 1 after CEM balancing.

	σ_i (2017–2022) Model 1	σ_i (2018–2022) Model 2	σ_i (2013–2022) Model 3	σ_i (2013–2017) Model 4
Non-AI Digital Tech. = 1	-0.087	-0.049	-0.206**	-0.184
	(0.088)	(0.059)	(0.096)	(0.128)
Non-AI Digital Tech. = 2	-0.074	-0.133*	-0.162	-0.240*
	(0.103)	(0.068)	(0.101)	(0.136)
Non-AI Digital Tech. = 3	-0.181**	-0.123	-0.158*	-0.129
	(0.092)	(0.080)	(0.095)	(0.116)
Non-AI Digital Tech. = 4	0.046	0.002	-0.002	-0.152
	(0.108)	(0.095)	(0.090)	(0.106)
Non-AI Digital Tech. = 5	-0.041	-0.031	-0.080	-0.173
	(0.099)	(0.104)	(0.104)	(0.134)
Non-AI Digital Tech. = 6	0.040	0.033	-0.067	-0.287***
	(0.097)	(0.077)	(0.079)	(0.094)
Non-AI Digital Tech. = 7	-0.022	-0.073	-0.077	-0.196*
	(0.117)	(0.119)	(0.104)	(0.118)
Non-AI Digital Tech. = 8	-0.192	-0.128	-0.172	-0.163
	(0.124)	(0.112)	(0.135)	(0.157)
Non-AI Digital Tech. = 9	-0.148	-0.177**	-0.247**	-0.257*
	(0.092)	(0.078)	(0.118)	(0.149)
Non-AI Digital Tech. = 10	-0.120	-0.205	-0.196	-0.049
	(0.199)	(0.161)	(0.185)	(0.142)

Results (5) - Weighted OLS after CEM balancing

Table 4: Weighted OLS Results of Eq. 1 after CEM balancing.

	σ_i (2017–2022) Model 1	σ_i (2018–2022) Model 2	σ_i (2013–2022) Model 3	σ_i (2013–2017) Model 4
Constant	-2.356***	-2.957***	-1.797***	-1.756***
	(0.706)	(0.560)	(0.514)	(0.560)
Controls X_{i,t_0}	Yes	Yes	Yes	Yes
Controls ICT_i	Yes	Yes	Yes	Yes
Ind. FE	Yes	Yes	Yes	Yes
Observations	2608	3201	1475	1639
Adj. R^2	0.191	0.212	0.306	0.298
Starting Imbalance	0.603	0.578	0.673	0.672
Ending Imbalance	0.000	0.000	0.000	0.000
Number Strata	296	297	281	284
Number Matched Strata	100	112	68	74
Clustered SE	CEM bin	CEM bin	CEM bin	CEM bin

Notes: $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Source: Authors' calculations based on Eurostat ICT survey data for Romania.

Presentation outline

Conclusions and Policy Recommendations

Conclusions

- No significant relationship between AI adoption and productivity volatility.
- Results remain robust across specifications and matched samples.
- Broader digitalization is associated with more stable productivity dynamics.
- Larger firms exhibit lower productivity volatility.

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Policy Recommendations

- AI adoption alone may not be sufficient to improve productivity stability.
- Organizational capabilities and workforce skills remain important.
- Policies supporting digital readiness may strengthen longer-term productivity performance.

Presentation outline

Limitations and Further Research

Limitations

- AI adoption observed in 2022.
- Binary measure does not capture AI intensity or type.
- The effects of AI adoption may not yet be fully observable in the short-run.

Further Research

- Long-term effects of AI adoption.
- Differences across AI technologies and use cases.
- Role of organizational and human capital factors.

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