Artificial Intelligence and Firm-Level Productivity: Early Evidence from a Small Open Economy [1]

Iulia Siedschlag & Juan Duran
Economic and Social Research Institute (ESRI) and Trinity College Dublin

ESCoE Conference on Economic Measurement 2026
19 May 2026
King's Business School, King's College London

[1] This research is part of the EFFEct project funded from the European Union's Horizon Europe Programme (Grant No. 101129146). Views and opinions expressed are however those of the authors only and do not necessarily reflect those of the European Union or the granting authority. Neither the European Union nor the granting authority can be held responsible for them.

Research results are based on analysis of strictly controlled Research Microdata Files provided by the Central Statistics Office (CSO) of Ireland. The CSO does not take any responsibility for the views expressed or the outputs generated from this research.

AN INSTITIÚID UM THAIGHDE EACNAMAÍOCHTA AGUS SÓISIALTA
ESRI ECONOMIC & SOCIAL RESEARCH INSTITUTE

o Background

- Artificial Intelligence (AI) is a general-purpose technology (GPT) with economy-wide potential.
- Limited firm-level evidence on AI productivity effects due to its intangible nature and the wide range of its applications (da Silva Marioni et al., 2024).
- Early firm-level evidence shows modest and uneven productivity gains (Acemoglu et al., 2022b; Calvino and Fontanelli, 2023a; da Silva Marioni et al., 2024).
- Existing research highlights two important features:
  - **Self-selection bias**: productivity gains partly reflect self-selection into AI adoption of initially more productive firms (Calvino and Fontanelli, 2023a,b).
  - **Time dynamics**: gains may take time to materialise as they require complementary investments in other knowledge-based assets such as skills and organisational capital (Brynjolfsson et al. 2021)
- Beyond whether AI raises productivity on average, a policy-relevant question is: **does it matter what firms use AI for?**

This Paper

Estimates dynamic causal effects of AI adoption on **labour productivity** (turnover per employee) and uncovers **heterogeneous** productivity effects driven by specific **AI technologies** adopted and the different **business purposes** for which AI is used.

Data: representative panel of Irish enterprises, 2013–2024

Methods:

- Propensity Score Matching (PSM) combined with a Least Absolute Shrinkage and Selection Operator (LASSO) model
- Local Projection Difference-in-Differences

Key Findings Preview

What AI is used for matters

- **Broad-use AI tools** (marketing, admin,ICT security, RPA, data mining): +7.9–8.8% labour productivity.
- **Technical / sector-specific AI** (production optimisation, logistics, image and language processing): No significant short-run gains.

Skills enable AI adoption

- Strongest predictors of adoption: availability of ICT specialists and ICT training.
- Points to **skills and training** as key policy levers (Fontanelli et al., 2025).

o Related Literature

- **Effects of investment in intangible assets and ICT on firm productivity**
  Cardona et al., 2013; Bertschek & Kaiser (2004); Black & Lynch (2001); Bloom et al. (2012); Brynjolfsson & Hitt (2003, 2000); and O'Mahony & Vecchi (2005); Di Ubaldo & Siedschlag (2021); Borowiecki et al. (2021)

- **Digitalisation and firm productivity**
  Cette et al. (2022); Erjavec et al. (2023); Coyle et al. (2022)

- **AI and firm productivity**
  Agrawal et al., (2018); Brynjolfsson et al., (2018, 2021); Acemoglu et al., (2022a); Yang, (2022); Czarnitzki et al. (2023); Calvino and Fontanelli (2023a,b), Nucci et al. (2023); Babina et al. (2024); da Silva Marioni et al. (2024).

o Data

- Micro-data sets from the Survey on e-commerce and ICT between 2013-2024 available from Ireland's Central Statistics Office (CSO).
- Survey size is a representative sample of approximately 4,000 firms in the business sector (manufacturing, utilities, construction, and selected services) excluding largest firms.
- AI adoption measurement: reported in waves 2021, 2023, and 2024, proxied with use of machine learning, natural language processing, natural language generation, or speech recognition for big data analysis in 2019.
- Sample size: 7,307 firms, observed in at least two years.

Artificial Intelligence Technology	Description
Data mining	Technologies performing analysis of written language
Speech recognition	Technologies converting spoken language into machine-readable format
Natural language generation	Technologies generating written or spoken language
Image recognition, image processing	Technologies identifying objects or persons based on images
Machine learning	Machine learning (e.g. deep learning) for data analysis
Artificial Intelligence based software robotic process automation	Technologies automating workflows or assisting decision-making
Autonomous robots, self-driving vehicles, autonomous drones	Physical movement of machines via autonomous decisions

Source: Survey on e-Commerce and ICT 2021-2024 and Business Register RMFs 2013-2022, Central Statistics Office of Ireland.

Artificial Intelligence Technology	Description
Production or service processes	Predictive maintenance, defect detection, autonomous robots
Business administration or management	Assistants, forecasting, decision support via machine learning
Logistics	Robots for packing, route and delivery optimization
ICT security	Face recognition, cyber-attack detection using AI
Accounting, controlling, or finance	Financial decisions, invoice and document automation
Research and development (R&D)	Data analysis to improve products or solve problems

Source: Survey on e-Commerce and ICT 2021-2024 and Business Register RMFs 2013-2022, Central Statistics Office of Ireland.

0 Methods (1/2)

LP-DiD

$$\underbrace{\ln Y_{i,t+h} - \ln Y_{i,t-1}}_{\text{Turnover/employee growth over horizon } h} = \beta_h^{LP-DiD} \underbrace{\Delta AI_{i,t}}_{\text{AI adoption indicator}} + \Gamma X_{i,t} + \underbrace{\sum_{j=-1}^{1} \theta_j^h \Delta AI_{i,t+j}}_{\text{Leads and lags}} + \underbrace{\delta_t^h}_{\text{Year effects}} + e_{i,t}^h \quad (1)$$

$$\begin{cases} \text{Treated (adopters):} & \Delta AI_{i,t} \\ \text{Clean controls:} & AI_{i,t+h} = 0 \end{cases}$$

- $h = 2, 3$ years. Effects relative to pre-adoption mean-differerenced productivity.
- $X_{i,t}$: employment and age.
- Absorbing treatment: first year of adoption.
- Assumptions: parallel trends and no-anticipation effects.

o Methods (2/2)

PSM

$$\underbrace{AI_i}_{\text{AI adoption post 2019}} = \theta_o + \underbrace{X_{i,t_o}}_{\text{Baseline charact. 2018}} + \underbrace{\mu_j}_{\text{Industry FE}} + \epsilon_i \quad (2)$$

- X_{i,t_o}: selected using LASSO over a rich set of observables (employment, age, labour productivity, adoption of other digital technologies, ultra-fast broadband (UFB), ICT specialists, ICT training, and electronic sales and purchases).
- Ten nearest neighbors within a caliper set to one-fourth of the standard deviation of the estimated propensity score (Stuart and Rubin, 2008).

Heterogeneity

- Treatment re-defined as the adoption of AI for a given business purpose or technology.
- LP-DiD estimates comparing firms that adopted AI for that business purpose/technology to PSM-matched firms that never adopted AI.
- Interpretation: marginal effects for business purpose/technology-specific use conditional on AI adoption.

0 Summary Stats (1/2)

Firm Characteristics Pre-treatment (2013-2018)

	Adopters		Non-Adopters		Matched	
	Mean	Variance	Mean	Variance	Std-difference	Variance ratio
Before matching						
Log employment	4.958	1.64	3.895	1.329	0.873	1.234
Log turnover/emp	11.866	1.484	11.774	1.222	0.08	1.214
Log age	2.981	0.451	2.772	0.518	0.302	0.87
ERP dummy	0.624	0.235	0.358	0.23	0.552	1.021
ICT specialists dummy	0.696	0.212	0.421	0.244	0.574	0.87
ICT traning dummy	0.475	0.25	0.193	0.156	0.625	1.601
UFB dummy	0.36	0.231	0.192	0.155	0.383	1.486
After matching						
Log employment	4.958	1.63	5.009	1.925	-0.038	0.847
Log turnover/emp	11.868	1.486	11.816	1.638	0.042	0.907
Log age	2.982	0.449	2.95	0.463	0.047	0.97
ERP dummy	0.625	0.235	0.613	0.237	0.024	0.99
ICT specialists dummy	0.696	0.212	0.7	0.21	-0.008	1.008
ICT traning dummy	0.475	0.25	0.478	0.25	-0.007	1
UFB dummy	0.36	0.231	0.346	0.226	0.03	1.02

Source: Authors' calculations/estimates based on Research Microdata Files (RMFs) from the Survey on e-commerce and ICT 2013-2024 and Business Register RMFs 2013-2022, provided by the Central Statistics Office (CSO) of Ireland.

o Summary Stats (2/2)

AI Adoption by Business Purpose/Technology

	Adopters	Non-Adopters	Matched
Purpose: marketing	0.48		
Purpose: production	0.38		
Purpose: management	0.36		
Purpose: logistics	0.31		
Purpose: ICT security	0.5		
Purpose accounting	0.03		
Purpose research	0.14		
Technology: datamining	0.43		
Technology: speech recognition	0.36		
Technology: language generation	0.52		
Technology: image generation	0.32		
Technology: deep-learning	0.09		
Technology: RPA	0.57		
Technology: auton. robots	0.23		

Notes: All estimates weighted with weights that represent the employment share of each type of firm in the Business Register industry-size bins.
Source: Authors' calculations/estimates based on Research Microdata Files (RMFs) from the Survey on e-commerce and ICT 2013-2024 and Business Register RMFs 2013-2022, provided by the Central Statistics Office (CSO) of Ireland.

Estimation Results - PSM (1/2)

Probit Estimates of AI Adoption

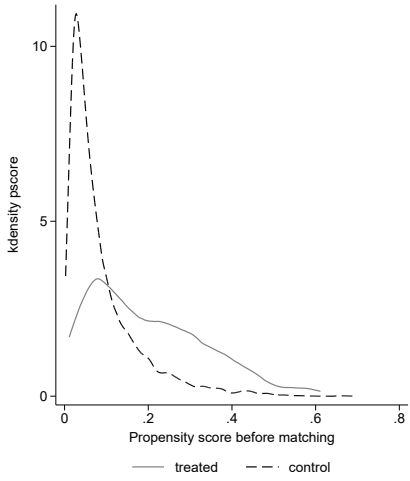
	(1)	(2)	(3)	(4)
Employment	0.043***	0.040***	0.043***	0.040***
	(0.003)	(0.003)	(0.003)	(0.003)
Turnover/employee	0.007**	0.006*	0.009***	0.007**
	(0.003)	(0.003)	(0.003)	(0.003)
Age	0.021***	0.023***	0.023***	0.024***
	(0.005)	(0.005)	(0.005)	(0.005)
ERP	0.034***	0.030***	0.032***	0.028***
	(0.007)	(0.007)	(0.007)	(0.007)
ICT Specialists	0.032***	0.013	0.028***	0.011
	(0.007)	(0.009)	(0.007)	(0.009)
UFB	0.034***	0.029***	0.032***	0.029***
	(0.007)	(0.007)	(0.008)	(0.008)
ICT Traning		0.039***		0.038***
		(0.009)		(0.009)
Obs.	7,307	7,307	7,307	7,307
Pseudo R2	0.127	0.131	0.138	0.142
Industry FE			Yes	Yes

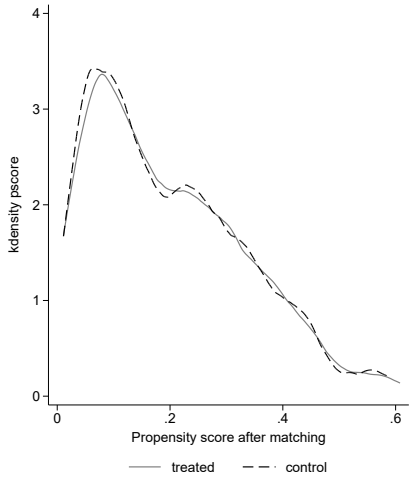
Notes: *p<0.1, **p<0.05,***p<0.01. Standard errors clustered at the firm level in parentheses.

Source: Authors' estimates based on Research Microdata Files (RMFs) from the Survey on e-commerce and ICT 2013-2024 and Business Register RMFs 2013-2022, provided by the Central Statistics Office (CSO) of Ireland.

o Estimation Results - PSM (2/2)

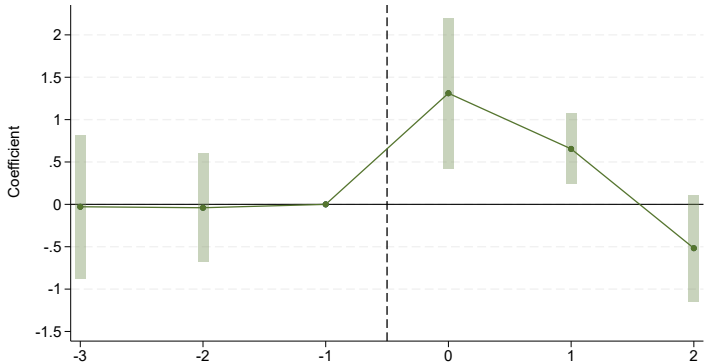
PS Density Distributions





o LP-DiD Labour Productivity Effects

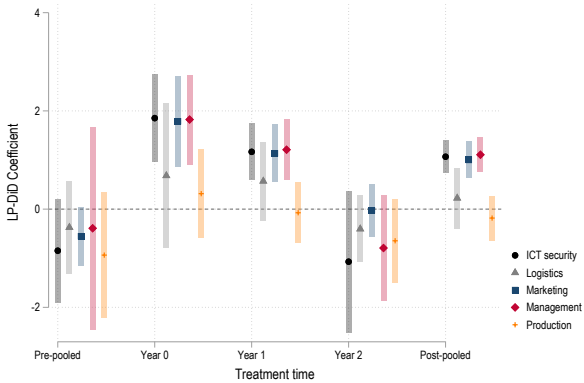
Pre-adoption pooled coef. = -0.204 (SE 0.4328)
Post-adoption pooled coef. = 0.355 (SE 0.1814) ≈ 2.87% increase compared to mean matched control group



Source: Authors' estimates based on Research Microdata Files (RMFs) from the Survey on e-commerce and ICT 2013-2024 and Business Register RMFs 2013-2022, provided by the Central Statistics Office (CSO) of Ireland.

o Heterogeneity by Business Purposes

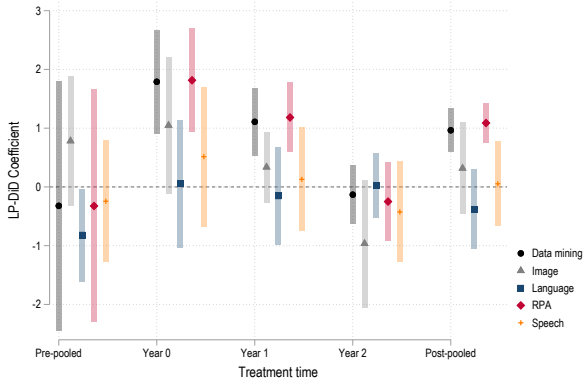
Post-adoption pooled coef. ≈ 7%-8.8% when benchmarking to the average labour productivity of never-treated matched units.



Source: Authors' estimates based on Research Microdata Files (RMFs) from the Survey on e-commerce and ICT 2013-2024 and Business Register RMFs 2013-2022, provided by the Central Statistics Office (CSO) of Ireland.

o Heterogeneity by Technology

Post-adoption pooled coef. ≈ 7%-8% when benchmarking to the average labour productivity of never-treated matched units.



Source: Authors' estimates based on Research Microdata Files (RMFs) from the Survey on e-commerce and ICT 2013-2024 and Business Register RMFs 2013-2022, provided by the Central Statistics Office (CSO) of Ireland.

Robustness Analysis

- Baseline: results
  - Never treated units
  - Entropy balancing algorithm (first 3 data moments)
  - Non-absorbing treatment
- Heterogeneity: Entropy balancing algorithm results

Findings

- We examine the effect of AI adoption on firm-level productivity using data from Irish enterprises between 2013 and 2024 leveraging a Local Projection Difference-in-Differences framework complemented with Propensity Score Matching.
- We find that, at this early stage of adoption, on average, the productivity gains from AI adoption are small and short-lived in time.
- However, the heterogeneity analysis reveals more substantial marginal effects conditional on adoption for firms that use AI for specific business purposes and AI technologies:
  1. Adopting AI for marketing or sales, organisation of business administration processes or management, and ICT security purposes (7-9%).
  2. Adopting technologies automating different workflows or assisting in decision making (data mining and software robotic process automation - RPA) (7-8%).
- Overall, the findings point to increased efficiency and marketing improvements as the main channels through which AI currently boosts productivity growth at the firm level.

Thank you

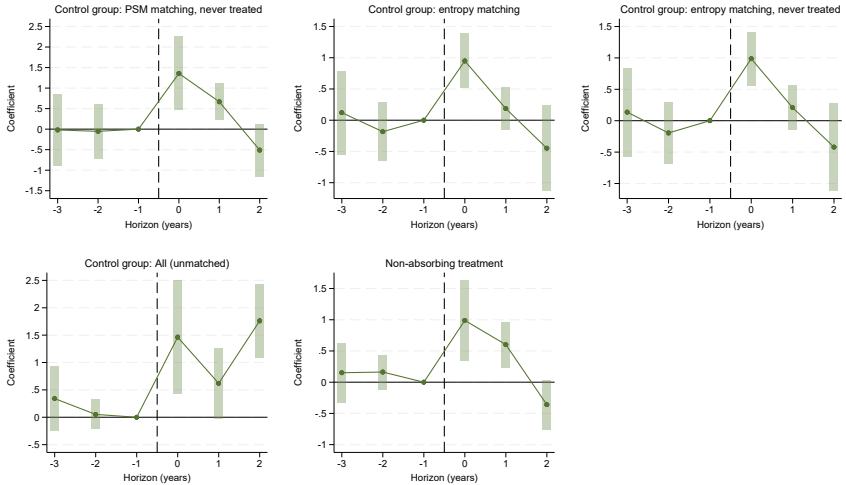
Iulia Siedschlag **iulia.siedschlag@esri.ie**

Sign up to our newsletter

ESRI.ie
Economic and Social Research Institute (ESRI)
Economic and Social Research Institute (ESRI)
@ESRIDublin

AN INSTITIÚID UM THAIGHDE EACNAMAÍOCHTA AGUS SÓISIALTA
ESRI ECONOMIC & SOCIAL RESEARCH INSTITUTE

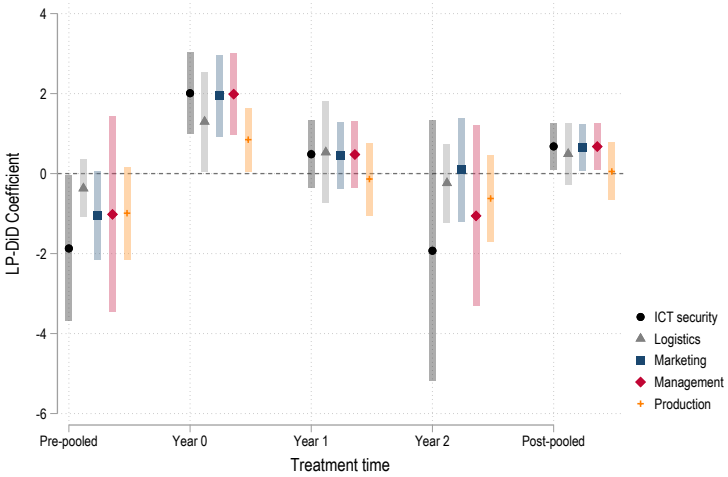
o Robustness Analysis - LP-DiD - Baseline back



Source: Authors' estimates based on Research Microdata Files (RMFs) from the Survey on e-commerce and ICT 2013-2024 and Business Register RMFs 2013-2022, provided by the Central Statistics Office (CSO) of Ireland.

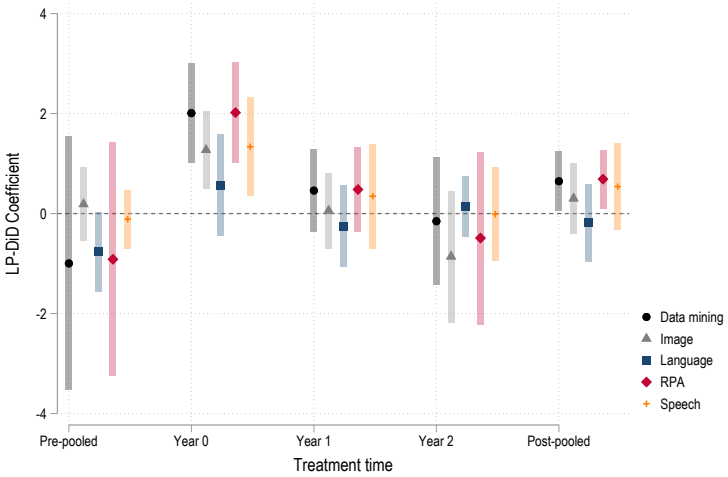
o Robustness Analysis - LP-DiD - Heterogeneity Business Purposes

back



Source: Authors' estimates based on Research Microdata Files (RMFs) from the Survey on e-commerce and ICT 2013-2024 and Business Register RMFs 2013-2022, provided by the Central Statistics Office (CSO) of Ireland.

o Robustness Analysis - LP-DiD - AI Technologies back



Source: Authors' estimates based on Research Microdata Files (RMFs) from the Survey on e-commerce and ICT 2013-2024 and Business Register RMFs 2013-2022, provided by the Central Statistics Office (CSO) of Ireland.