Automation Adoption and the Margins of Export Performance: Evidence from French firms

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Intangible Assets, Digitalisation and
Asymmetries in European Value Chains

PRIN Project Workshop, 23 January 2026, Rome, Italy

Previous literature

Automation increases firm performance

Automation adoption → Firm performance

- *Employment and wages*
  Studies on the firm level impact of automation generally show an increase in employment and wages
  (Acemoglu, Lelarge, and Restrepo, 2020; Dixon, Hong, and Wu, 2019; Domini et al., 2021, 2022; Humlum, 2021; Koch, Manuylov, and Smolka, 2021)

- *Competition effect*
  Automation can then be viewed as a source of firm competitiveness leading to increases in market share at the expense of non-adopting firms
  (Bajgar et al., 2019; Acemoglu and Restrepo, 2020; Babiana et al., 2020; Firooz et al., 2022; Bisio et al., 2025)

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Trade data can help identifying the sources of this competitiveness

Previous literature

Export effects documented but limited understanding

- Robots increase export participation and sales (Artuc et al. 2023; Lin et al. 2022)
- 3D printing: +80% hearing aid exports via customization (Freund et al. 2022)
- **Gap**: Little evidence on *how* product scope shapes these effects

Our premise: Scope economies as the key driver—automation investments often exhibit low scope economies, creating different strategic responses

Our contribution

We study whether and how automation adoption affects firms' export performance.

What:

- Beyond single-technology focus (robots) to a broad array of automation technologies
- From aggregate export outcomes to composition (products vs. destinations
- Role of firm heterogeneity: single- vs. multi-product, size, and resource allocation between product vs. process innovation
  - **Product scope**, not size alone, governs whether automation induces **substitution** (process focus) or **complementarity** (product + process)

How:

- We exploit transaction-level customs data from France
- We execute a staggered diff-in-diff analysis, resorting to state-of-the-art methodologies in the field (Callaway and Sant'Anna, 2021)

Data and Measurement

Data Sources:

- **French Customs (DGDDI):** Transaction-level trade data, 8-digit product codes
- **Fiscal Data (FICUS/FARE):** Balance sheet, revenue accounts
- **Employment Data (DADS):** Wages, employment

Measuring Automation Adoption:

- **Imports** of capital goods embedding automation technologies
- Identified via HS6 codes: robots, 3D printers, CNC machines, automated tools, etc.
- **Automation spike** = firm's largest automation adoption event

Sample: 22,386 manufacturing firms that import automation goods (2002-2019)

Empirical Strategy
Staggered Difference-in-Differences

Challenge:
Multiple treatment periods with staggered adoption ⇒ Traditional TWFE can be biased

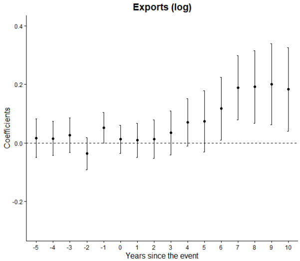
Solution: Staggered did-in dif methods
(Borusyak et al., 2021; Callaway and Sant'Anna, 2021; de Chaisemartin and D'Haultfoeuille, 2020; Sun and Abraham, 2021)

We use the Callaway-Sant'Anna (2021) estimator

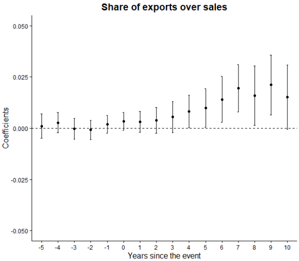
- Compares each cohort to never-treated firms
- Controls for parallel trends using firm characteristics
- Averages treatment effects across cohorts and time periods

Outcomes: Log exports, log # countries, log # products, export share

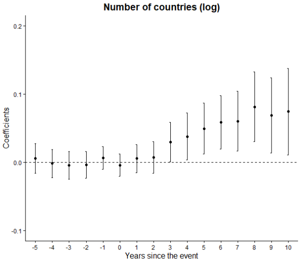
Main results - Event study



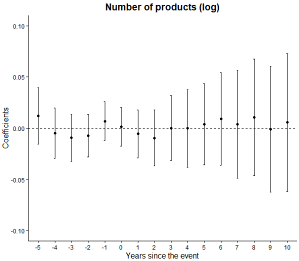
$ATT_{aggte} = 0.149\ (0.032)^{**}$



$ATT_{aggte} = 0.014\ (0.003)^{**}$



$ATT_{aggte} = 0.070\ (0.014)^{**}$



$ATT_{aggte} = 0.018\ (0.016)$

Heterogeneity: technology, size, and product scope

Three dimensions

- **Technology type:** 3D printers vs. robots
- **Firm size:** very small, small, medium, large
- **Product scope (key):** single-product (SPF) vs. multi-product (MPF)

Findings

- 3D printing: export gains; robots: no clear export effects
- Effects concentrated in SMEs (small/medium); null for very small and large
- **Scope trade-off:** SPFs expand products & markets; MPFs expand markets, prune products

Mechanisms: Why do SPFs and MPFs respond differently?

Having established that product scope drives heterogeneous automation effects, we examine two key mechanisms that explain the divergent responses:

Two channels:

- **Export destination channel:** Do firms target high-income vs. low-income markets differently?
- **Product complexity channel:** Do firms upgrade or streamline their product offerings?

Mechanism 1: Export destination channel

Which markets do automating firms enter? High-income vs. low-income destinations reveal different strategies.

Mechanism — Destinations

Dep var:	Exports HI (log)	Exports LI (log)	Nb countries HI (log)	Nb countries LI (log)	Nb products HI (log)	Nb products LI (log)
Panel A. All firms						
ATT_{aggte}	0.134**	0.142**	0.042**	0.040**	0.009	0.010
	(0.035)	(0.047)	(0.015)	(0.018)	(0.019)	(0.021)
Nb of obs	282,559	184,535	282,564	184,543	278,872	157,899
Panel B. Only single-product firms						
ATT_{aggte}	0.797**		0.265**		0.455**	
	(0.115)		(0.032)		(0.03)	
Nb of obs	59,968		59,972		58,980	
Panel C. Only multi-product firms						
ATT_{aggte}	0.046	0.111**	0.090**	0.043**	0.009	0.004
	(0.037)	(0.050)	(0.018)	(0.021)	(0.017)	(0.025)
Nb of obs	213,143	155,629	213,143	155,635	210,627	132,211

Notes: HI = High-income, LI = Low-income countries. CS estimates; firm-clustered SEs. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Mechanism 2: Product complexity channel

Does automation change the sophistication of what firms produce? We examine the complexity of firms' most advanced products.

Mechanism — Product complexity

Dep var:	Top complexity
Panel A. All firms	
ATT_{aggte}	-0.102**
	(0.045)
Nb of obs	303,398
Panel B. Only single-product firms	
ATT_{aggte}	0.335**
	(0.038)
Nb of obs	72,287
Panel C. Only multi-product firms	
ATT_{aggte}	-0.119**
	(0.052)
Nb of obs	220,725

Notes: Top complexity = maximum complexity in firm's product portfolio. CS estimates; firm-clustered SEs. * p<0.1, ** p<0.05, *** p<0.01.

Robustness checks

We perform extensive robustness checks to ensure our findings are not driven by specific methodological choices or confounding factors:

Four categories of checks:

- **Alternative methodology:** IV estimation using different identification assumptions
- **Alternative spike definitions:** Relative thresholds, late adopters only
- **Sample restrictions:** Exclude re-exporters, focus on continuous exporters
- **Technical checks:** Anticipation effects, additional covariates

All robustness checks confirm our main findings. Results are qualitatively identical, with some checks revealing additional significant effects on product scope.

Conclusion

Main findings:

- Automation adoption increases export performance
- Effects driven by market expansion rather than product diversification
- **Key insight:** Product scope, not firm size, determines automation's impact

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Single-product firms (SPFs):

- Target high-income markets (quality-focused strategy), increase product complexity and scope
- Use automation to enhance capabilities and expand offerings
- Leverage automation for complementarity between product and market expansion

Multi-product firms (MPFs):

- Expand primarily in low-income markets (cost-focused strategy), reduce product complexity and consolidate portfolio
- Use automation to become "leaner and meaner"
- Face substitution between product innovation and market expansion

Thank you

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Appendix

Automation Technologies (HS6 Codes)

Table 1: HS 2012 codes for automation capital goods (Table ??)

	HS-2012 codes
1. Industrial robots	847950
2. Dedicated machinery	847989
3. Automatic machine tools	845600-846699, 846820-846899, 851511-851519
4. Automatic welding machines	851521, 851531, 851580, 851590
5. Weaving and knitting machines	844600-844699, 844700-844799
6. Other textile machinery	844400-844590
7. Automatic conveyors	842831-842839
8. Automatic regulating instruments	903200-903299
9. 3-D printers	847780

Measurement challenges

1. Overestimating automation adoption

Some importing firms may not actually use imported automation goods as they can resell them in the domestic or international markets:

- We focus on manufacturing firms, excluding intermediaries
- We conduct robustness checks excluding re-exporters

2. Underestimating automation adoption

Firms may adopt automation through other channels, either through domestic market purchases or via intermediaries rather than direct imports

- France has a comparative disadvantage in producing automation goods (see Domini et al. 2021)
- We restrict our analysis to firms active in international trade, comparing adopters with non-adopters
- Complex automation goods typically bypass intermediaries (Bernard et al., 2015)