

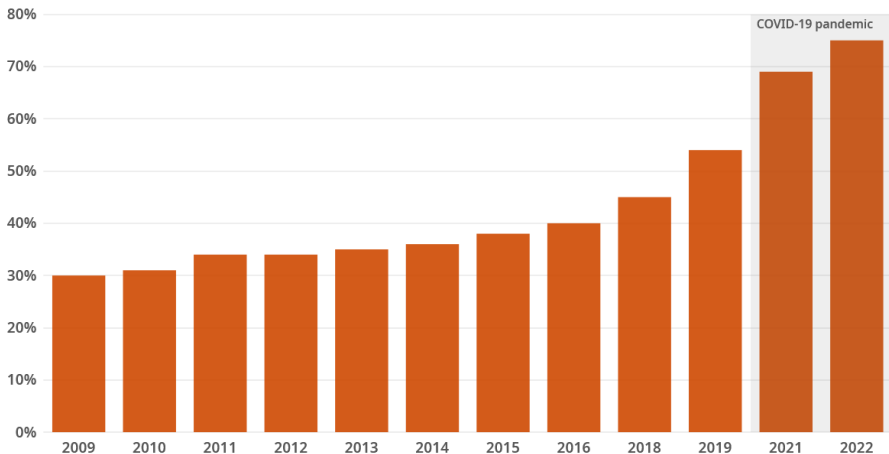
# No Kids, No Tech: How Shortages of Young Workers Hinder Firm Technology Adoption

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ZEW Mannheim, Utrecht University  
EEA Barcelona

August 29, 2023

# Enormous labor shortages in the OECD

Share of companies reporting talent shortages



Based on more than 40 000 employers across all industry sectors in 40 economies.  
OECD (2023), [Retaining Talent at All Ages, Ageing and Employment Policies, Figure 1.2, A](#).

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  - Slow-down in adoption of technologies that require worker skills

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  - Slow-down in adoption of technologies that require worker skills
- **Identification challenging:** labor scarcity endogenous to unobserved factors; simultaneous labor demand shock; slow diffusion

# This Paper

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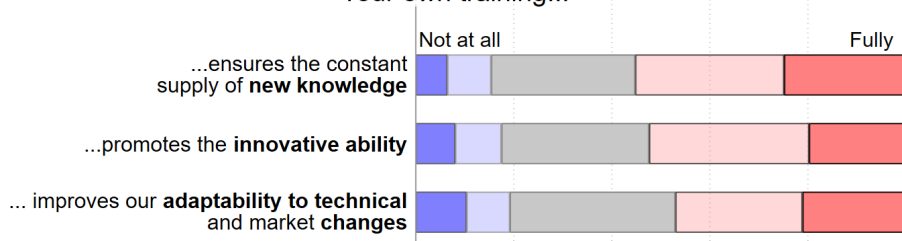
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  - ⇒ Evidence I: Investment drop driven by firms exposed to new skills
  - ⇒ Evidence II: Investment drop driven by firms retaining trainees

# Trainees relevant for supply of new tech skills

To what extent do the following statements apply to your company's training?  
Your own training...



Representative establishment survey on costs and benefits of vocational training in East Germany 2000, own calculations.

# Yearly Firm Panel Data

[▶ Sample Size](#)[▶ Imputation](#)

Representative firm panel survey (IAB Establishment Panel) + linked employer-employee data (LIAB)

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# Vocational Training (VT) in Germany

- Central in German educ. system and labor market (60% of workers)
- Dual system: vocational schooling (1/2 days/week)+ on-the-job training at firm (3/4 days/week)

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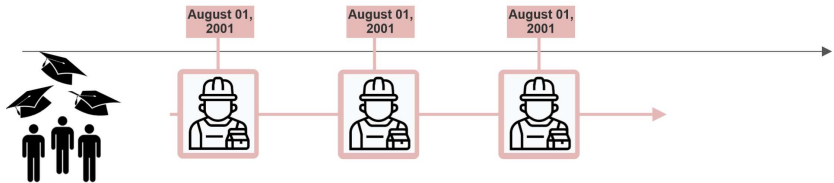
- School tracks:
  - basic or intermediate track (9/10y) ⇒ VT (“unskilled” trainees)
  - upper track (12/13y) ⇒ university;  $\approx 1/3$  VT (“skilled” trainees)

# Reform: Missing school graduates

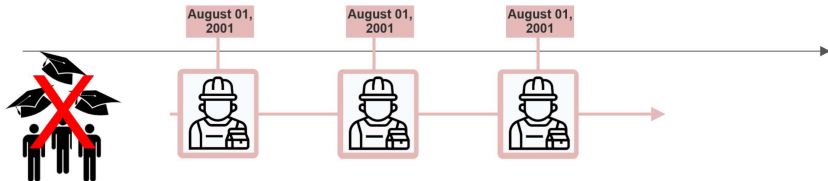


- Reform: years of schooling in upper track from 12 to 13 years
  - Delayed response to reunification
- ⇒ **2001: No upper track graduation cohort**

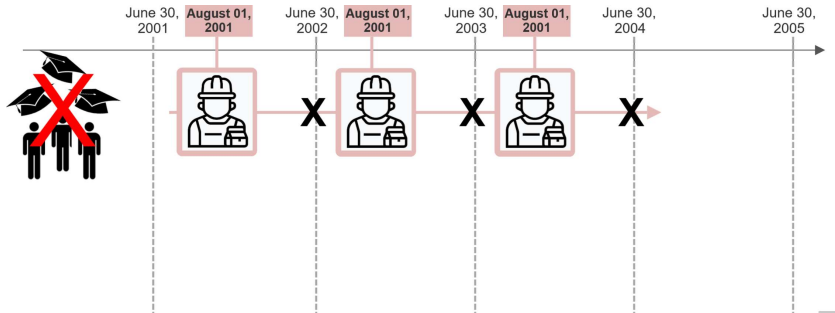
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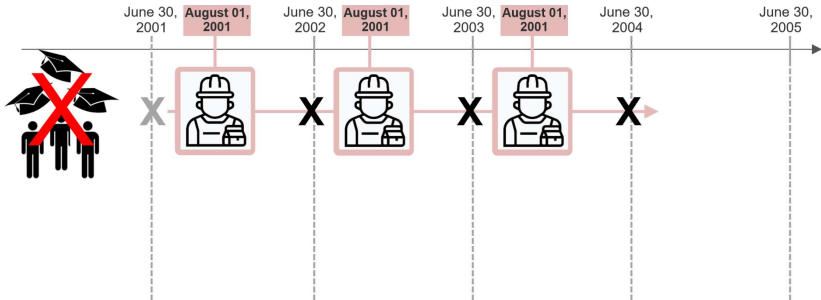


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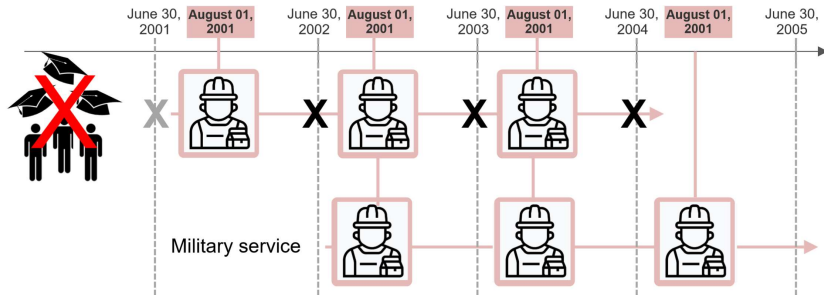




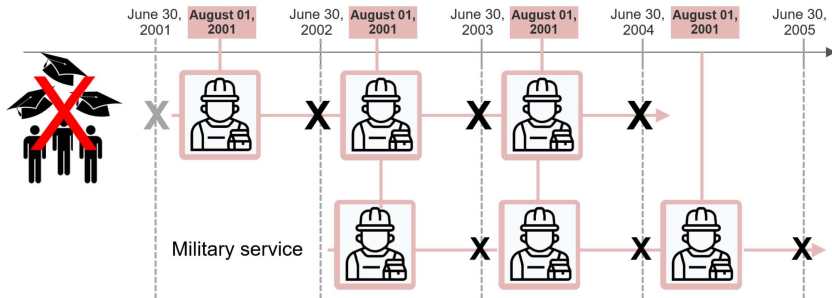
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# DiD Event Study

$$Y_{jbt} = \sum_{t=1998, t \neq 2000}^{t=2005} \alpha_t (Treated_b \times Year_t) + \psi_t + \phi_b + \epsilon_{jt} \quad (1)$$

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## Matching on pre-treatment firm characteristics [▶ Details](#)

- 1 Exact matching within broad industry groups
- 2 + Mahalanobis distance matching (log employment, share of skilled trainees, investments per worker)

# Reform Effects

- ① Trainee employment





# Reform Effects

① Trainee employment

② Firm investments



# Reform Effects

- ① Trainee employment
- ② Firm investments
- ③ Link to technology adoption



# Reform Effects

- ① Trainee employment
- ② Firm investments
- ③ Link to technology adoption
- ④ Mechanism



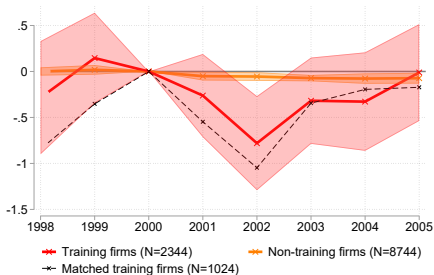
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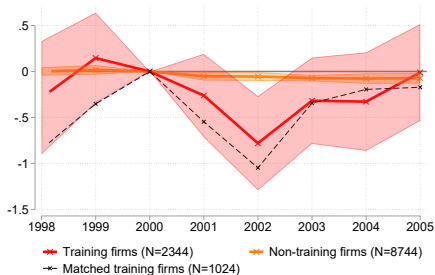
# Employment of skilled trainees drops

(A) New skilled trainee hires

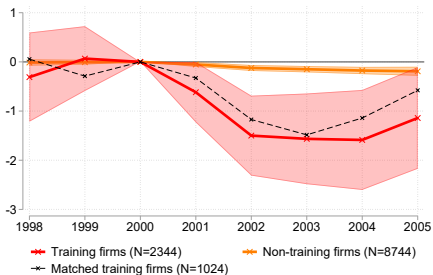


# Employment of skilled trainees drops

## (A) New skilled trainee hires



## (B) Number of skilled trainees



Notes: Event study coefficients plus 90% confidence bands.

## Little substitution with other workers

Do firms compensate the loss of trainees?

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- Partly substituted with workers with **completed vocational training**

# Reform Effects

- ① **Trainee employment**
  - Reduction in trainee employment
- ② Firm investments
- ③ Link to technology adoption
- ④ Mechanism

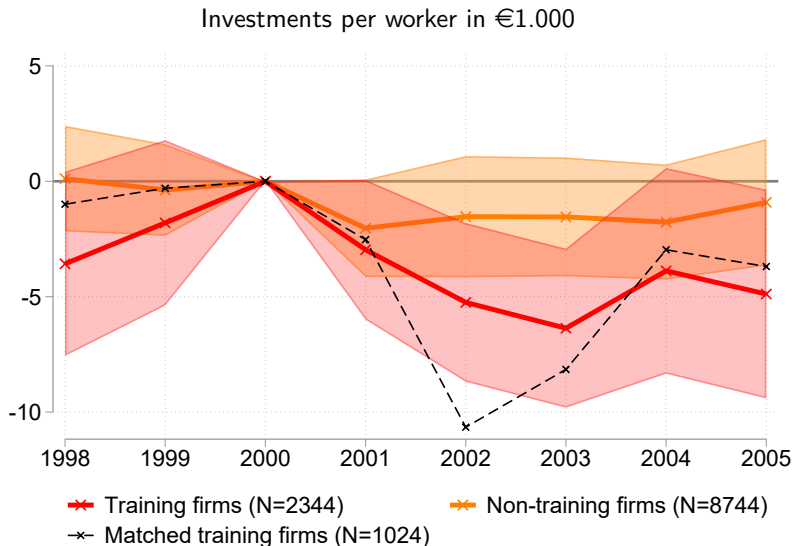


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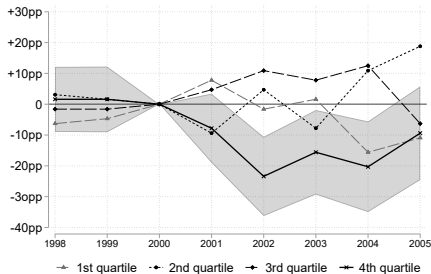
# Firm investments decline





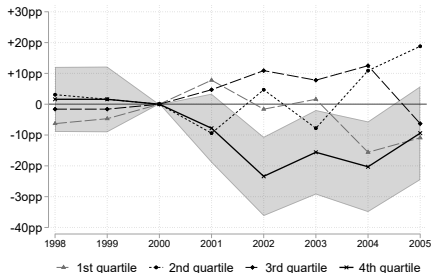
# Investments decline at the intensive and extensive margin

(A) Intensive margin

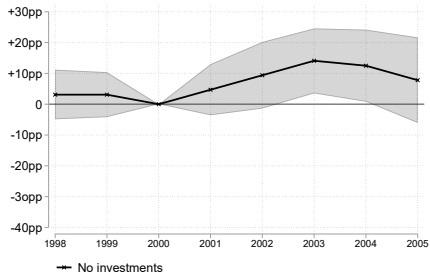


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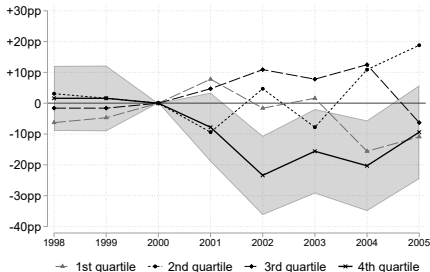
## (B) Extensive margin



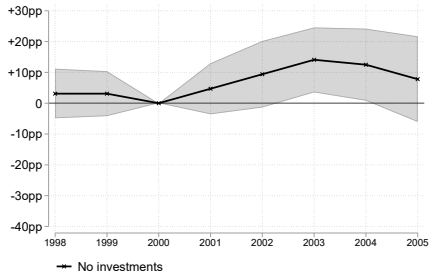
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# Investments decline at the intensive and extensive margin

## (A) Intensive margin



## (B) Extensive margin



Notes: Event study coefficients plus 90% confidence bands.

- **Long-term impact:** only 24% of firms with a foregone investment spike make up for it later

# Reform Effects

## ① Trainee employment

## ② Firm investments

- significant reduction in firm investments
- ... among training firms only
- ... in particular hindering **large** investments
- ... **long-term** effect on the capital stock
- consistent **IV** results [▶ More](#)
- **Robust** across specifications [▶ More](#)
- **Placebo**: no investment drop in West Germany [▶ More](#)



## ③ Link to technology adoption

## ④ Mechanism

# Reform Effects

## ① Trainee employment

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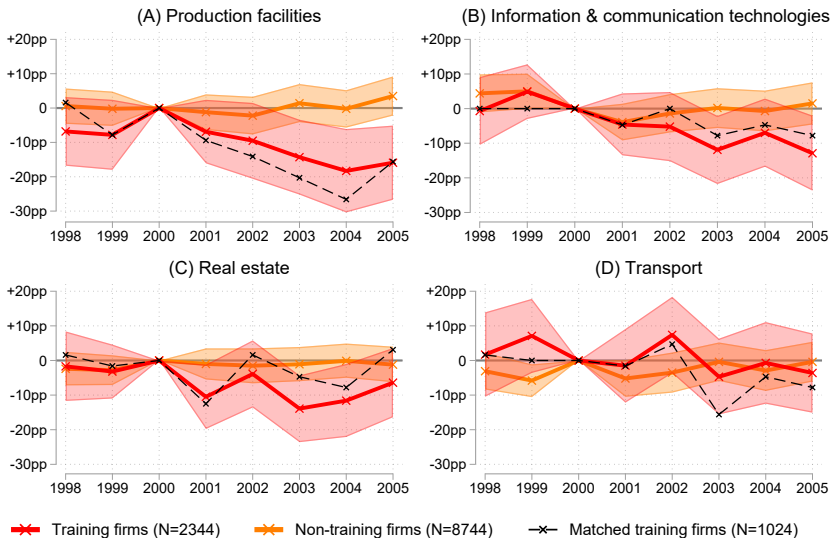
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## ③ Link to technology adoption

## ④ Mechanism

# Investments in production technology decrease



# Reform Effects

- ① Trainee employment
- ② Firm investments
- ③ **Link to technology adoption**
  - Decrease in investment in **production facilities**
  - Reduction in **organizational changes** [▶ More](#)
  - Depreciation of **technical state** of machinery [▶ More](#)
  - Decrease in **retraining** of incumbent workers
- ④ Mechanism



# Reform Effects

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## ④ Mechanism



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- Scarcity of young job-starters ⇒ Retraining too costly ⇒ Less adoption

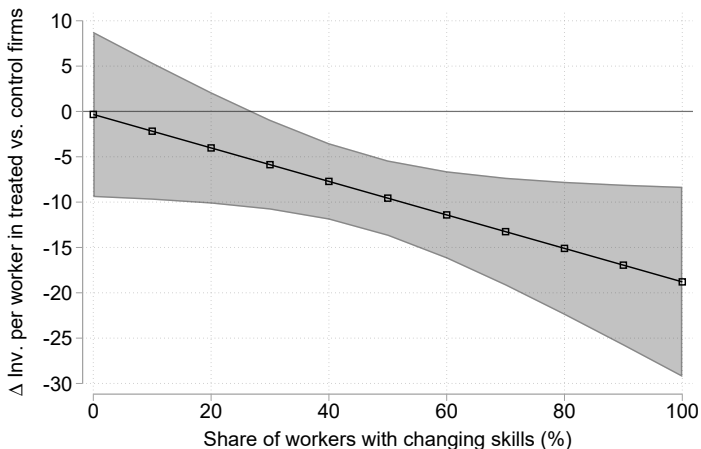
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- ≡ **Young job-starters complementary to new technologies**

# Assumption I: new technologies require new skills

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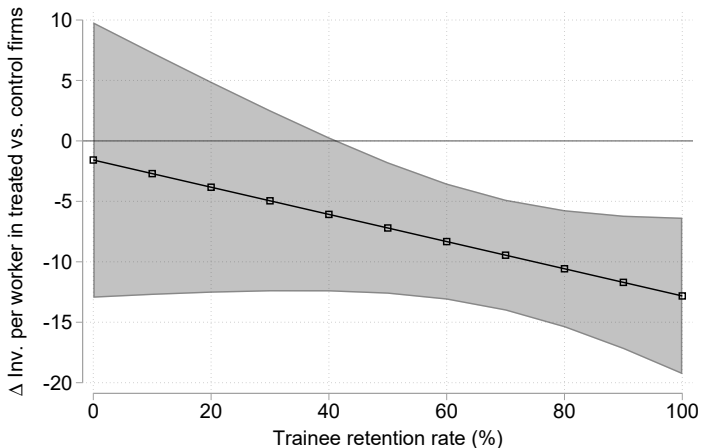
Firms with **high exposure to new skills** drive investment decline  
(following Lipowski et al., 2023)



## Assumption II: firms retain trainees

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Firms with **high trainee retention rates** drive investment decline



# Reform Effects

- ① Trainee employment
- ② Firm investments
- ③ Link to technology adoption
- ④ **Mechanism**
  - Empirical evidence compatible with need for trainees to acquire **new skills**



# Conclusion

- **This paper:** Causal impact of labor shortages on firm investments using education reform
  - **Main Result:** Shortages of young job-starters ↓ firm investments; particularly in new production technologies
- ⇒ Less hope to counteract labor shortages by substituting labor with capital than expected



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Thank you!

Further comments and questions always very welcome:  
[caecilia.lipowski@zew.de](mailto:caecilia.lipowski@zew.de)

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# Contribution

- ① **Endogenous technical change** (e.g. Acemoglu, 2002; Lewis, 2011; Carneiro et al., 2022)  
⇒ Here: Focus on young workers; clean identification strategy, firm level
- ② **Technology-induced skill changes** (Chari & Hopenhayn, 1991; Card & Lemieux, 2001; Deming & Noray, 2020)  
⇒ Here: Consequence: slow-down in technology adoption when young workers are scarce
- ③ **Effect of hiring frictions on firm outcomes** (e.g. D'Acunto et al., 2020; Le Barbanchon et al., 2023)  
⇒ Here: Focus on young workers and firm investments ⇒ provide mechanism

# Sample selection and size

[◀ Data](#)

	Initial	After imputation	W/o West Germany	W/o health/educ/ social services	W/o small firms	W/o unbalanced firms	After matching
# Observations	90964	104597	45100	39175	20438	11088	6992
# Firms	21261	21261	8907	7798	3870	1386	755
# Treated firms	15007	15007	2942	2555	1290	463	437
# Control firms	6263	6263	5966	5244	2580	923	318

**Notes:** Small establishments: establishments with at least ten employees in each year.

Unbalanced establishments: establishments existing and with non-missing values throughout the entire time window of analysis 1998 to 2005 in the two main variables of interest: number of skilled trainees and establishment investments.

# Descriptives of imputed observations

[← Data](#)

	Non-imputed	Add. observations	Difference	p-value
<i>Employment &amp; Wages</i>				
Overall employment	136.63	92.81	43.81	.00
Share skilled trainees	.69	.53	.16	.01
<i>Industry</i>				
Agriculture	.04	.03	.01	.01
Manufacturing	.34	.48	-.15	.00
Energy, water, waste	.03	.03	0	.41
Construction	.12	.11	.01	.37
Retail/motor vehicles	.09	.08	0	.62
Transport	.03	.02	.01	.01
Business services	.14	.11	.03	.00
Public administration	.15	.09	.06	.00
Other services	.07	.05	.02	.01
<i>Investments</i>				
Inv. per worker (in €1,000)	14.53	11.67	2.86	.16
Prob. to invest	.79	.8	-.02	.18

# Variables on Investments (1) ▶ Data

## ① **Inv. in production facilities ( $\approx 60\%$ ), ICT ( $\approx 60\%$ ), real estate ( $\approx 30\%$ ), transport ( $\approx 30\%$ ):**

“Did your establishment invest in one or more of the following areas?”

- Real estate and buildings?
- Electronic data processing (EDP), information and communication technology (ICT)?
- Production facilities, plant and equipment, furniture and fixture?
- Means of transport, transportation systems?”

## ② **Investments (€):**

“What was the approximate sum of all investments?”

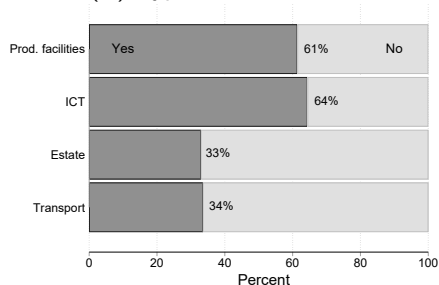
# Descriptives

[▶ Data](#)

## (A) Investments per Worker in €1000

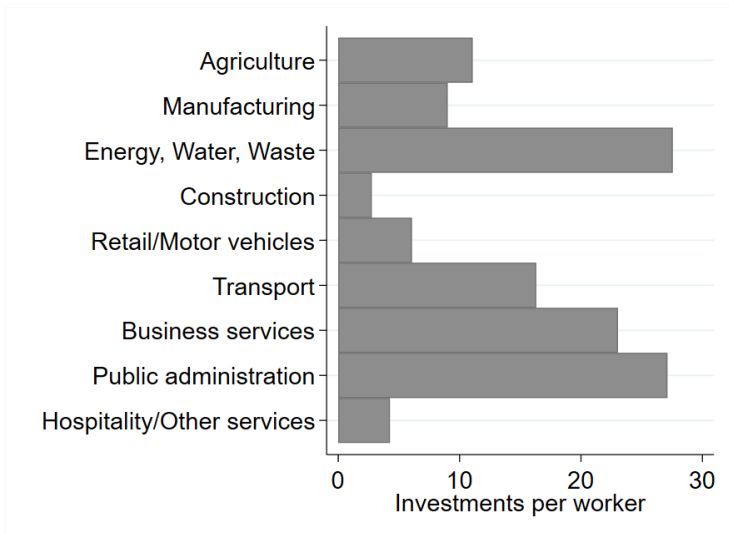
Share of obs. w/o investments	19.3%
5 <sup>th</sup> percentile	€185
25 <sup>th</sup> percentile	€1,333
50 <sup>th</sup> percentile	€4,760
75 <sup>th</sup> percentile	€16,406
95 <sup>th</sup> percentile	€67,488
Mean	€15,820

## (B) Type of Investment

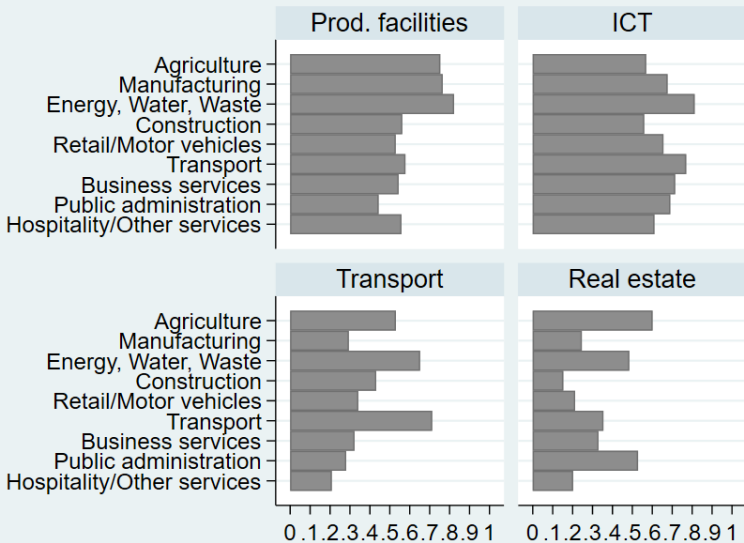




# Investments by Industries (1) ▶ Data



# Investments by Industries (2) ▶ Data



## Variables on Investments (2) [▶ Data](#)

### 3 **Technology status of machinery:**

“How do you assess the overall technical state of the plant and machinery, furnitures and fixtures of this establishment compared to other establishments in the same industry?”

1 – completely out-of-date; 5 – state-of-the-art equipment

## Variables on Investments (2) ▶ Data

### 3 **Technology status of machinery:**

“How do you assess the overall technical state of the plant and machinery, furnitures and fixtures of this establishment compared to other establishments in the same industry?”

1 – completely out-of-date; 5 – state-of-the-art equipment

### 4 **Organizational Change:** “Has one or more of the following organizational changes been carried out within your establishment?”

- Restructuring of departments or areas of activities
- Downward shifting of responsibilities and decisions
- Introduction of team work/working groups with their own responsibilities
- Introduction of units/departments carrying out their own cost and result calculations”

⇒ Sum of these four possibilities following Battisti et al. (2023)

# Imbalance - Targeted variables

← Identification

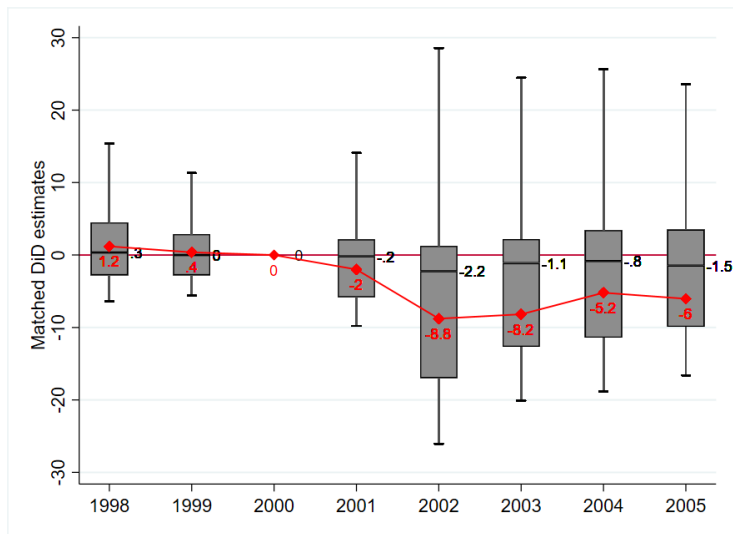
	Mean Treated	$\Delta$ Mean Unmatched	$\Delta$ Mean Matched
<i>Industry</i>			
Agriculture	0.06	0.01 (0.82)	0
Manufacturing	0.25	-0.10*** (-3.75)	0
Energy, Water, Waste	0.03	0.01 (0.63)	0
Construction	0.10	0.01 (0.68)	0
Trade/Motor vehicles	0.10	0.02 (1.27)	0
Transport	0.04	0.00 (0.40)	0
Business services	0.13	0.01 (0.43)	0
Public administration	0.20	0.03 (1.42)	0
Hospitality/Other services	0.07	0.00 (0.13)	0
<i>Training firm in 1998 (0/1)</i>			
Exposure in 1998	0.17	-0.05** (-2.44)	0
<i>Mahalanobis matching variables</i>			
Inv per worker in 2000	10.58	-0.82 (-0.92)	0.80 (0.78)
Inv per worker in 1999	11.41	-0.88 (-0.94)	0.88 (0.83)
Inv per worker in 1998	11.56	-0.87 (-0.93)	0.67 (0.64)
Share skilled trainees in 2000	0.53	-0.06 (-0.60)	0.11 (1.18)
Share skilled trainees in 1999	0.48	-0.09 (-0.93)	0.08 (0.90)
Share skilled trainees in 1998	0.47	-0.14 (-1.34)	0.06 (0.69)
Pre avg. log(total employment)	4.31	0.00 (0.03)	0.02 (0.26)
N		1386	872

# Imbalance - Untargeted variables

← Identification

	Mean Treated	$\Delta$ Mean Unmatched	$\Delta$ Mean Matched
Total investment	523.80	-49.10 (-1.50)	22.28 (0.58)
Prob to invest	0.85	-0.04*** (-2.35)	-0.02 (-1.09)
Inv in prod facilities	0.63	-0.06*** (-2.74)	-0.02 (-0.87)
Inv in ICT	0.68	-0.03 (-1.59)	-0.04 (-1.48)
Inv in real estate	0.37	-0.01 (-0.31)	0.00 (0.14)
Inv in transport	0.37	-0.01 (-0.23)	0.02 (0.92)
Org Change	0.77	-0.04 (-0.80)	0.09 (1.53)
Wage skilled trainees	21.45	1.25* (1.74)	0.61 (0.61)
Wage trainees	17.76	-0.11 (-0.29)	-0.15 (-0.32)
# of skilled trainees	0.96	-0.27 (-1.26)	0.07 (0.35)
# of unskilled trainees	8.37	0.13 (0.10)	2.16*** (2.63)
N		1386	872

# Median investment drop smaller than average

[← Main](#)

# More affected firms reduce investments more [← Main](#)

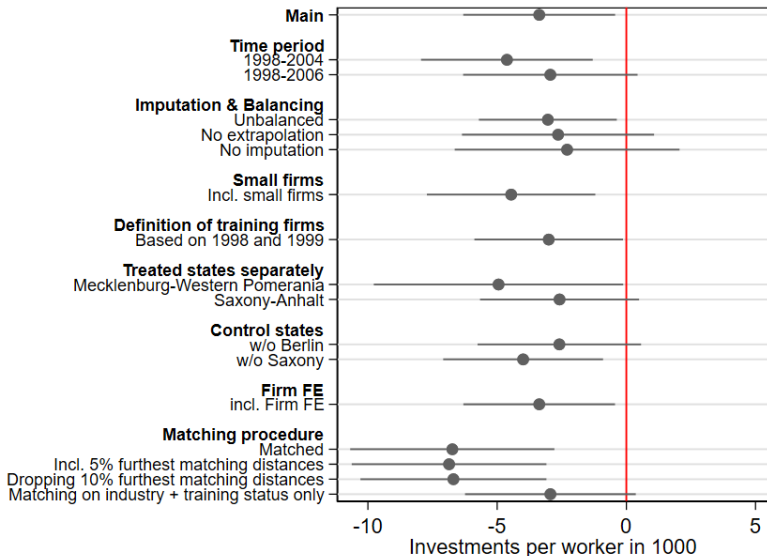
Exploit variation in trainee usage at firm-level:

	1999-2005			2000-2005
	OLS (1)	IV at treatment level (2)	IV at state level (3)	IV at treatment level (4)
$N^{Trainees}$	0.222* (0.116)	0.672** (0.315)	0.360* (0.201)	0.628** (0.317)
Observations	2051	2051	2051	1758
p-value KP		0.012	0.085	0.013
F-Stat		12.33	20.00	7.86

Notes: Outcome: Investments per worker in €1000. P-value KP = p-value of the second stage coefficient as by the Kleibergen-Pape test. Standard errors clustered at the firm level. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .



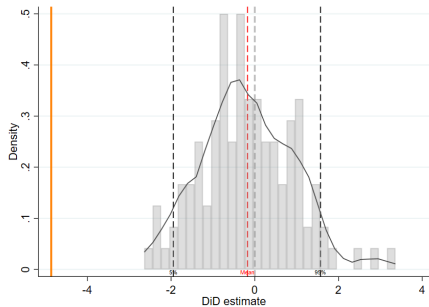
# Investment drop is robust

[← Main](#)


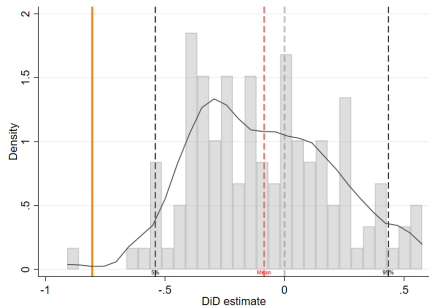
# Placebo Treated States in West Germany

[← Main](#)

(A) Investments per worker in €1,000



(B) Investments in production facilities



# Policy Implication

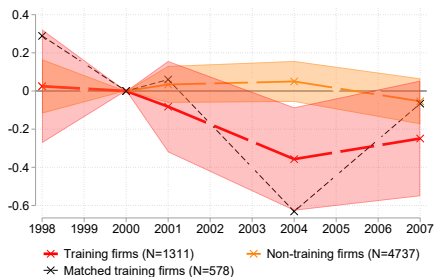
[← Conclusion](#)

- Consequences of demographic change more detrimental than expected
  - ⇒ Mobilize young workers
  - ⇒ Reduce firms' dependence on young workers by subsidizing retraining
  - ⇒ Merely increasing retirement age is not enough

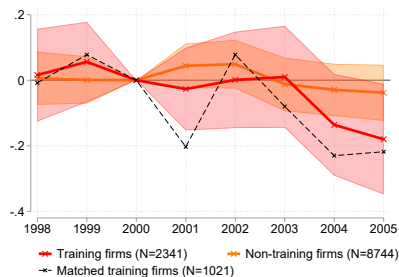
# Technical change slows down

[← Main](#)

### (A) Organizational changes



### (B) Technical status of machinery



Notes: Event study coefficients plus 90% confidence bands.