AI, Task Changes in Jobs, and Worker Reallocation

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AI and the Labor Market

- Public fascination and fear (esp. large-scale job losses & inequality)
- Earlier technologies (computers, industrial robots) were skill-biased and increased wage inequality
- Theory stresses different channels:
  1. Automation (replaces labor)
  2. Productivity of AI in automated tasks $\uparrow$ (benefits capital and/or labor)
  3. Productivity of labor in other tasks (complementarity or specialization) ($\uparrow$ wages)
  4. Creation of new tasks (enhancement for labor)

This paper

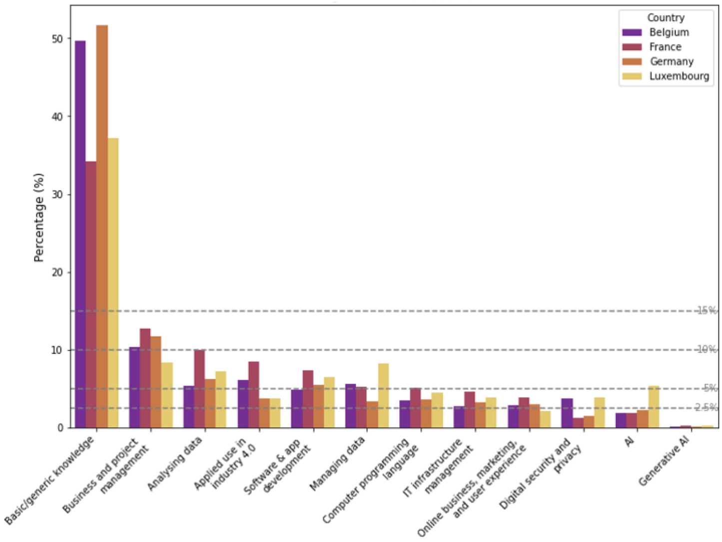
Research Questions:

1. How does AI shift job tasks?
2. How do workers adjust to AI?
3. Does AI result in job displacement?
4. Is AI skill-biased?

Empirical Setting

- Evidence for Germany's labor market
- Focus on worker level
- Focus on 'first' wave of AI (pre-gen AI)

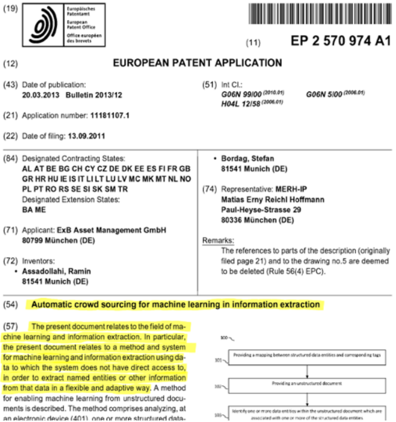
Demand for AI Skills in Europe



Most firms (still) search for basic AI skills

New AI (and Robot) Measure for Europe

- **Data: European Patent Office** (1990 to 2018)
- Keyword-based classification using NLP
    - Use patent text (title & abstract) as input
    - NLP steps: remove stopwords & special characters, stemming, tokenization
    - Sample keywords: machin[e] learn[ing], neural network, bayes[ian] learn[ing], robot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Remarks: The references to parts of the description (originally filed page 21) and to the drawing no.5 are deemed to be deleted (Rule 56(4) EPC).

(54) Automatic crowd sourcing for machine learning in information extraction

(57) The present document relates to the field of machine learning and information extraction. In particular, the present document relates to a method and system for machine learning and information extraction using data to which the system does not have direct access to, in order to extract named entities or other information from that data in a flexible and adaptive way. A method for enabling machine learning from unstructured documents is described. The method comprises analyzing, at an electronic device (401), one or more structured data-

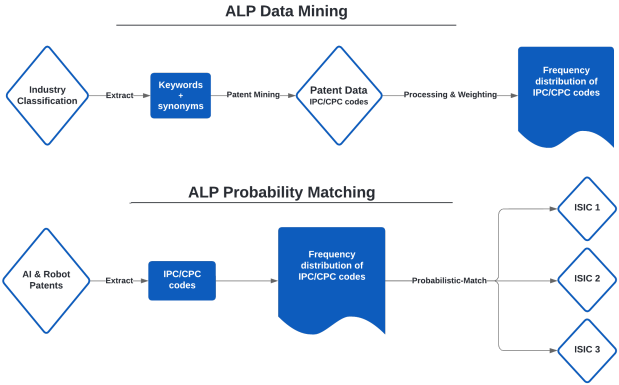
Patents by year

What is Captured?

CPC Code	Description	Share
G10L	Speech Analysis & Processing; Speech or Audio Coding or Decoding	26.3
G06F	Electric Digital Data Processing	12.3
G06N	Computing Arrangements based on Specific Computational Models	9.5
G06K	Graphical Data Reading; Presentation of Data	9.5
G06B	Controlling or Regulating Systems; Monitoring or Testing Arrangements	5.0
A61B	Diagnosis; Surgery; Identification	2.4
G06T	Image Data Processing or Generation	2.0
H04L	Transmission of Digital Information; Telegraphic Communication	1.8
G01C	Measuring Distances; Surveying; Navigation; Gyroscopic Instruments	1.8
G01N	Investigating or Analysing Materials	1.4
H04M	Telephonic Communication	1.4
H04N	Pictoral Communication	1.3
B60R	Vehicles, Vehicle Fittings or Parts	1.0
G01S	Radio Direction-Finding; Determining Distance or Velocity	0.9
B60W	Control of Vehicle Sub-Units; Hybrid Vehicles	0.8

Mapping Patents to Industries that Use Them

- Apply probabilistic mapping (Lybbert & Zolas 2014, 2019)
- From patent CPC codes to ISIC industry codes



AI industries

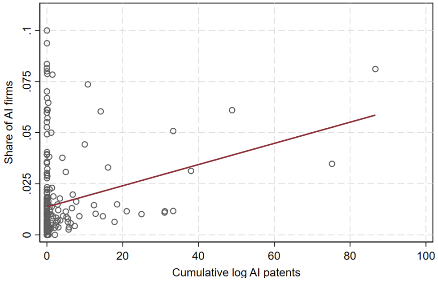
Industry-level (3-digit) AI and Robot Measures

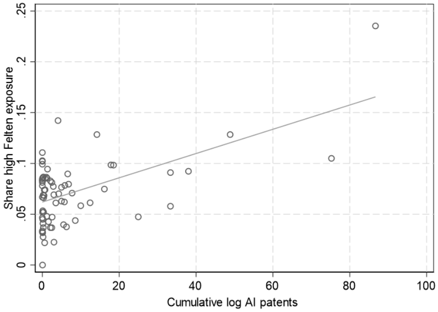
$$AI_{ip} = \sum_{t \in p} Log(1 + AIPat_{it})$$

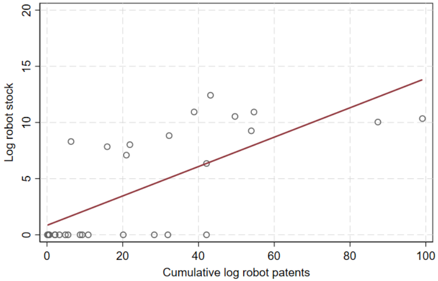
$$Rob_{jt} = \sum_{s=1990}^{t} Log(1 + RobPat_{js})$$

- Patents as cumulative process of knowledge creation (p = sum of patents from 1990 until year t)
- Log transformation: adjust for large differences across industries
- Similar: inverse hyperbolic, log(0.1+patents), log sum of patents
- 3 periods (p): 1990-2006, 1990-2011, 1990-2018

Validation: Correlation with Other Proxies







Top left: AI firms (Istari.ai)

Top right: Occupational exposure (Felten et al.)

Bottom: Robot Installations (IFR)

How Does AI Change Jobs?

Worker Level Survey on Job Tasks (BiBB/BAuA)

- Time-consistent task data for waves 2006, 2012, and 2018
- Extensive margin: do you perform the following task on your job?
- Focus on 18-65, working full-time in the private sector

Routine tasks
Monitoring/operating machines/tech. processes
Manufacturing/producing of goods/products
Transporting, storing, shipping
Measuring, quality checks

Manual tasks
Repairing
Accomodating, hosting, preparing food
Caring, healing
Protecting, securing, guarding, regulating traffic
Cleaning, waste disposal, recycling

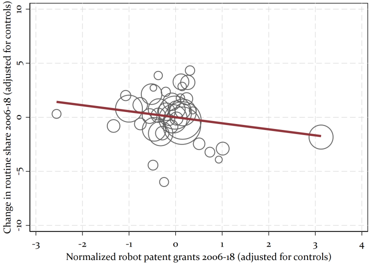
Abstract tasks
Developing, researching, constructing
Gathering information, investigating, documenting
Organizing/planning of work processes
Working with computer/tablet
Promoting, marketing, advertising, PR
Teaching, training, educating
Consulting, informing
Buying, procuring, selling

$$TaskShare = \frac{\text{No. tasks performed in category}}{\text{Total No. tasks performed}} * 100$$

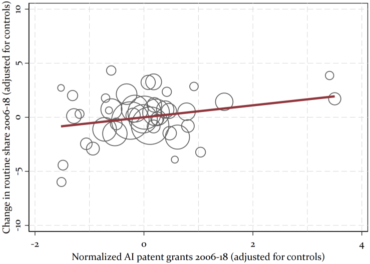
Descriptives

Industry-level Correlations

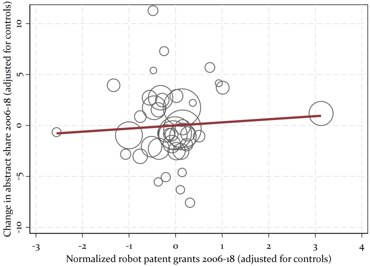
ΔRob and Δ Routine



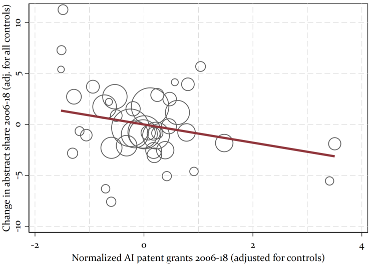
ΔAI and Δ Routine



ΔRob and Δ Abstract



ΔAI and Δ Abstract



Worker-level Task Changes

$$Task_{joit} = \beta^{AI} AI_{ip} + \beta^{Rob} Rob_{ip} + \theta_o + \mu_i + \delta_t + \gamma X_{jt} + \epsilon_{joit}$$

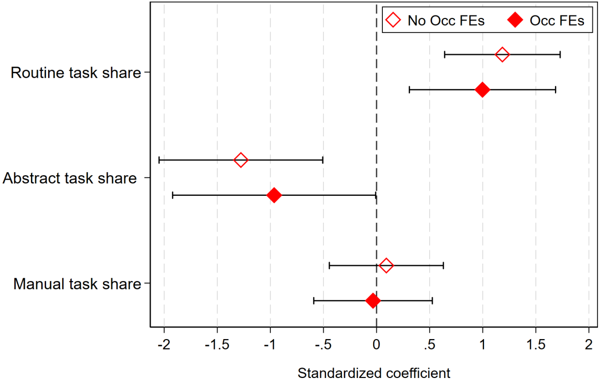
where

- j: worker, o: occupation, i: industry, t: wave and p: patent period
- Y: Share in routine, analytical and manual tasks
- AI and robot patent-based measures
- Controls: 2-digit industries, 3-digit occupations, workforce characteristics (edu, age, gender, nationality), state and wave dummies

⇒ Exploit industry-level variation in exposure over time, between workers in same occ with similar demographics

Balancing Test

Task Changes between & within Occupations



AI reduces abstract tasks and increases routine tasks

Most changes occur within detailed occupations

AI ↑ monitoring/operating machines/technical processes

AI ↓ gathering information, investigating, documenting

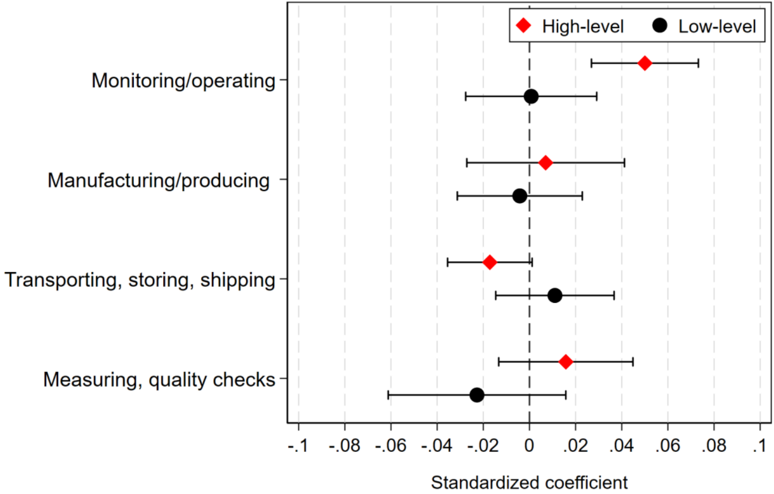
Detailed Tasks

Evolution of AI Effect

	Survey Year		
	2006	2012	2018
Routine task share	0.41	0.62**	0.91***
	(0.42)	(0.30)	(0.21)
Abstract task share	-0.30	-0.32	-0.88**
	(0.61)	(0.59)	(0.23)
Manual task share	-0.12	-0.29	-0.03
	(0.23)	(0.26)	(0.15)

⇒ Effect of AI gets stronger over time

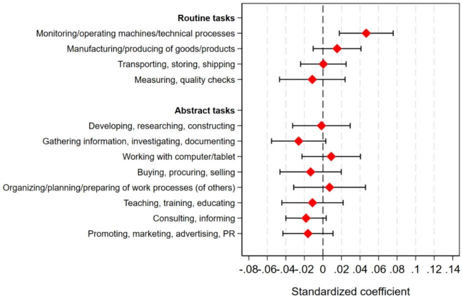
AI and Routine Tasks



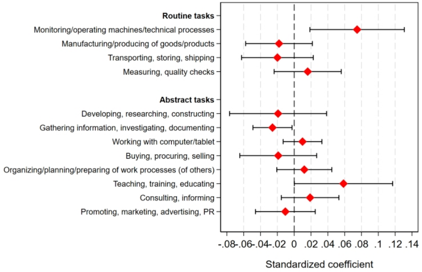
AI ↑ high-level routine tasks (workers using a computer or tablet and performing abstract tasks)

Task Changes by Worker Skill

Less-skilled workers



High-skilled workers



Both groups ↓ information gathering. AI ↑ monitoring for all skills, but teaching only for high skilled workers.

⇒ High-skilled compensate decline in abstract tasks, low-skilled cannot

Implications for Worker Careers?

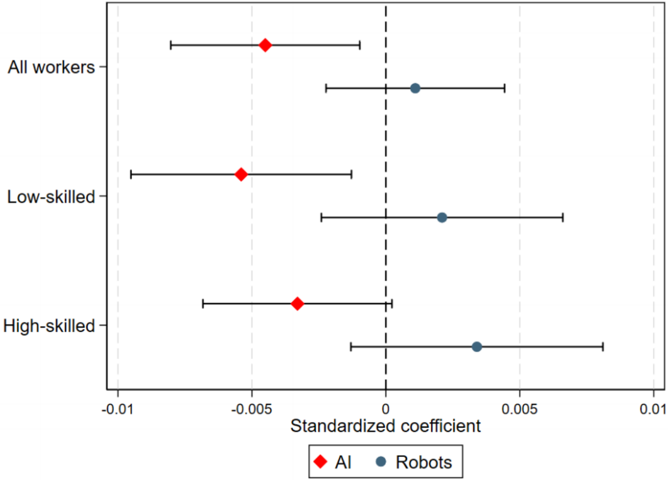
- Automation? → Displacement effects
- Task Shifts within Job? → No displacement, wage changes
- Productivity gains → Wage gains

Administrative Data on Worker Careers

- 2% Sample of workers' careers and wages (SIAB)
- Information on firm, detailed occupation and industry
- Daily wages (subject to right-censoring)
- Aggregate into 3 periods: 2004-09, 2010-15, 2016-21

⇒ Merge our AI and robot measures at 3-digit industry and period level

Employment Effects: Broad, but small



AI ↓ employment for all skill groups, but the effects are (so far) small

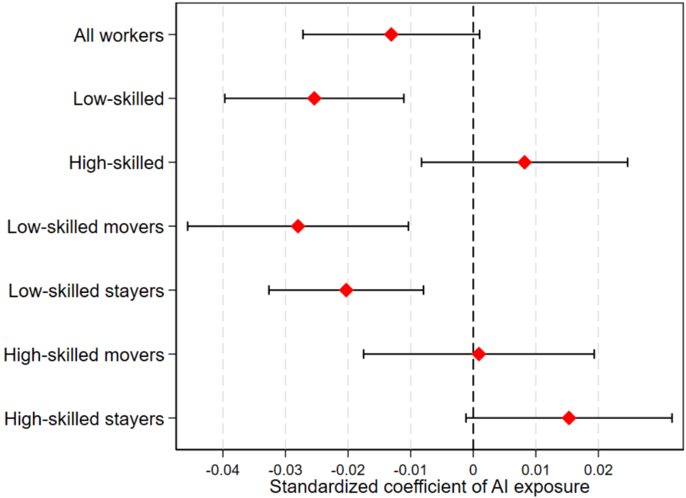
Reallocation Effects: Across industries

	Firm Change	Occupation Change	Different Industry (3-digit)	Different Industry (2-digit)	Same Industry (2-digit)	Lower AI Exposure Industry	Higher AKM Firm	Lower AKM Firm
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
AI	0.014***	0.001	0.007	0.002	0.013**	0.039***	0.007	0.007*
	(0.005)	(0.008)	(0.005)	(0.004)	(0.005)	(0.008)	(0.004)	(0.004)
Robots	-0.018***	-0.090	-0.019***	-0.017***	0.002	0.000	-0.015***	-0.004
	(0.004)	(0.007)	(0.004)	(0.004)	(0.003)	(0.001)	(0.003)	(0.003)
Mean Y	0.358	0.312	0.241	0.218	0.141	0.087	0.181	0.155
Observations	952,750	952,750	952,750	952,750	952,750	952,750	894,582	894,582

$\Rightarrow$ Workers move away from exposed industries to similar industries

No evidence for higher occupational mobility

Wage Effects



AI ↓ less-skilled wages; high-skilled stayers benefit from higher productivity

Lessons

1. AI $\downarrow$ abstract and $\uparrow$ (high-level) routine tasks
2. AI affects all skill levels
3. Automation rules: employment declines in exposed industries
   Worker level: small, mostly reallocation to similar industries
4. Less-skilled workers harmed by automation, while high-skilled benefit from complementary skills/productivity gains
5. For Germany, AI seems to be inequality-increasing

Thanks for your attention!

Contact:

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Worker-level analysis

Gathmann, Grimm & Winkler (2025), 'AI, Task Changes and Worker Reallocation', CEPR Discussion Paper

Firm-level analysis

Gathmann & Grimm (2024), 'Labor Market Effects of AI and Robotic Technologies', mimeo, LISER

Skill demand of European firms

Feimi, Gathmann, Gregory & Marguerit (2025), 'Skill Demand in the Age of AI: Evidence from Europe', mimeo, LISER

Appendix

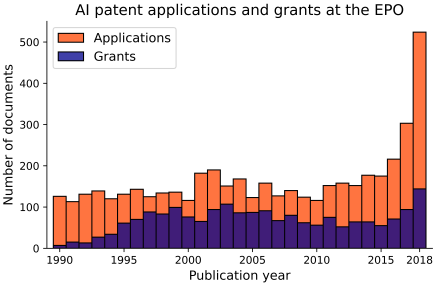
Definition of AI

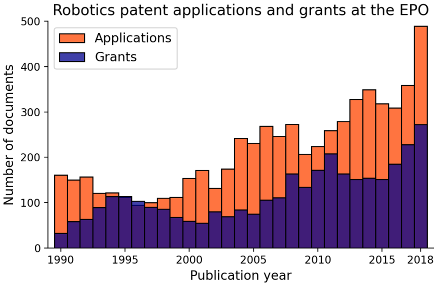
Definition of AI from OECD's AI expert group (AIGO):

'*An AI system is a machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations or decisions influencing real or virtual environments. It uses machine and/or human-based inputs to perceive real and/or virtual environments; abstract such perceptions into models (in an automated manner e.g. with machine learning (ML) or manually); and use model inference to formulate options for information or action. AI systems are designed to operate with varying levels of autonomy.*' Back

Evolution of AI and Robotics Patents

Development of AI and robotics patents between 1990 and 2018:





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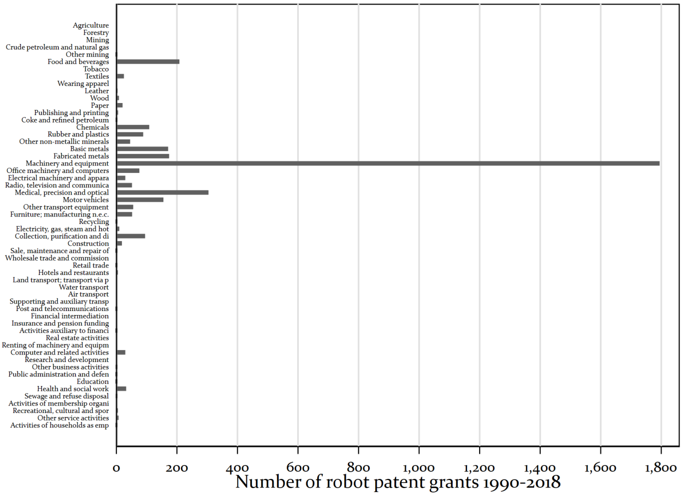
Distribution of Robot Patents



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Industries with largest number of AI patents

Table: Number of AI patents 1990-2018

	Number of patents
Manufacture of computers and peripheral equipment	643.0
Manufacture of consumer electronics	405.2
Manufacture of communication equipment	147.1
Manufacture of measuring, testing, navigating and control equipment	92.2
Manufacture of optical instruments and photographic equipment	75.3
Manufacture of general-purpose machinery	72.0
Motion picture, video and television programme activities	69.7
Sound recording and music publishing activities	65.7
Manufacture of special-purpose machinery	52.4
Medical and dental practice activities	46.5

Robots

Descriptives of Detailed Tasks

	mean/sd	mean/sd	mean/sd	mean/sd
Monitoring/operating machines/technical processes	5.51	7.04	6.24	3.06
	(6.58)	(8.79)	(6.59)	(5.01)
Manufacturing/producing of goods/products	3.13	4.86	3.59	1.36
	(6.09)	(9.43)	(6.24)	(3.60)
Transporting, storing, shipping	6.36	8.78	7.29	3.12
	(7.74)	(10.47)	(7.87)	(5.07)
Measuring, quality checks	8.69	9.71	8.75	8.24
	(6.71)	(9.51)	(6.63)	(5.87)
Developing, researching, constructing	3.79	2.51	2.99	6.33
	(5.32)	(5.08)	(4.75)	(5.99)
Gathering information, investigating, documenting	9.78	7.49	9.09	12.33
	(6.66)	(7.60)	(6.67)	(5.56)
Promoting, marketing, advertising, PR	3.74	2.11	3.02	6.15
	(5.54)	(4.58)	(5.17)	(6.05)
Organizing/planning/preparing of work processes (of others)	8.08	6.87	7.51	9.98
	(6.39)	(7.32)	(6.31)	(5.92)
Teaching, training, educating	6.49	3.99	5.99	8.56
	(6.27)	(6.32)	(6.13)	(6.10)

Descriptives of Detailed Tasks

Consulting, informing	10.53	9.25	10.07	12.16
	(6.72)	(8.47)	(6.84)	(5.39)
Buying, procuring, selling	4.30	3.13	4.32	4.58
	(5.70)	(5.44)	(5.79)	(5.49)
Working with computer/tablet	10.51	8.07	9.96	12.72
	(7.82)	(9.34)	(8.02)	(6.18)
Repairing	5.40	6.92	6.27	2.58
	(6.70)	(9.21)	(6.77)	(4.48)
Accomodating, hosting, preparing food	1.53	2.14	1.55	1.30
	(3.83)	(5.19)	(3.84)	(3.30)
Caring, healing	2.08	2.39	1.99	2.21
	(4.42)	(5.06)	(4.42)	(4.21)
Protecting, securing, guarding, regulating traffic	4.13	5.23	4.39	3.10
	(5.77)	(7.23)	(5.87)	(4.83)
Cleaning, waste disposal, recycling	5.97	9.49	6.97	2.24
	(7.65)	(11.37)	(7.62)	(4.38)

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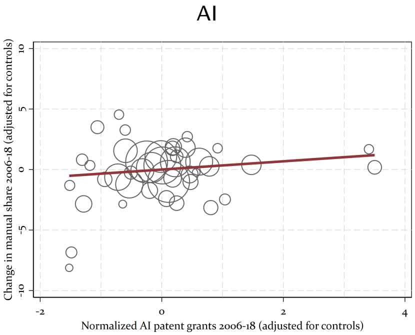
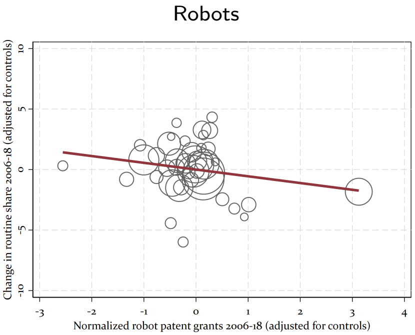
Technology and Manual Tasks (Industry-Level)





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Balancing test: Initial tasks cannot predict future patents

	Dependent variable:			
	AI patents 2006-18		Robot patents 2006-18	
	(1)	(2)	(3)	(4)
Routine task share 2006 (%)	0.21	-0.21	0.85***	-0.21
	(0.18)	(0.18)	(0.38)	(0.26)
Abstract task share 2006 (%)	0.05	-0.07	0.20	-0.12
	(0.10)	(0.10)	(0.18)	(0.14)
Manufacturing sector		5.24***		13.32***
		(1.13)		(2.99)
Primary sector		0.01		-0.66
		(0.40)		(0.57)
SD of dep. var.	3.87	3.87	8.91	8.91
R^2	0.04	0.27	0.14	0.42
Obs.	233	233	233	233

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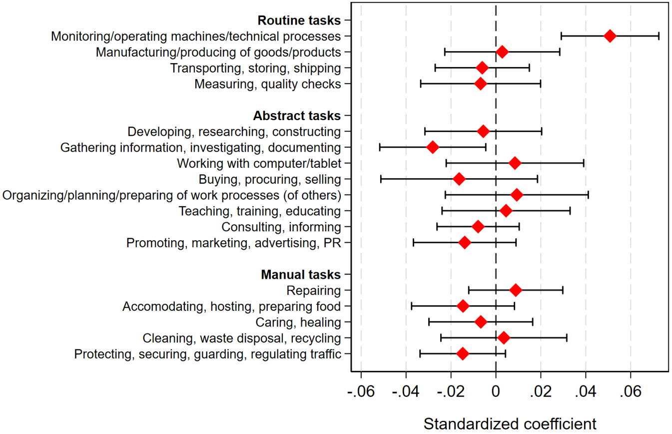
AI and individual tasks (LPMs)



- **increase in monitoring/operating machines/technical processes**
- **decrease in gathering information, investigating, documenting**