

>>> AI in the Office and the Factory:
>>> Evidence from Administrative Software Data

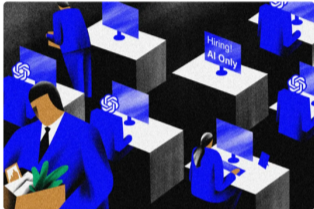
Name: Gustavo de Souza

Date: January 6, 2026

>>> Q: What is the Effect of AI on the Labor Market?

Will ChatGPT take your job — and millions of others?

The latest AI wave will disrupt the workplace. Teachers could be most affected. But it could end up creating more jobs.



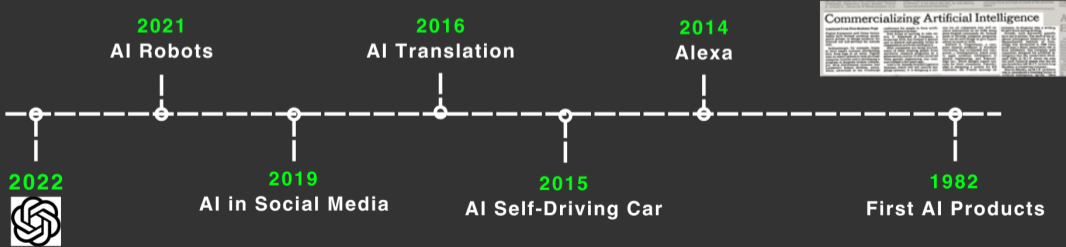
(Photo: Shutterstock)

By Somesh Jha



>>> Q: What is the Effect of AI in the Labor Market?

- * AI has a long history and multiple applications
- * AI: large amount of data to make accurate predictions (Agrawal, Gans, and Goldfarb 2018)
- * Challenge: measure AI in its diverse applications



>>> AI in the Office and the Factory

- * **Data:** nearly all commercial AI software developed in Brazil
 - * programmer provided information in the technology used
 - * intended use of the software
 - * 1983 to 2023: includes LLMs but most applications are predictive AI 1

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 - * programmer provided information in the technology used
 - * intended use of the software
 - * 1983 to 2023: includes LLMs but most applications are predictive AI 1
- * **Fact:** AI is used in management and production

>>> AI in the Office and the Factory

* Office:

- * AI decreases employment and hollow-out the wage distribution

⇒ Consistent with automation

(Acemoglu and Restrepo 2019, Webb 2020, Aum and Shin 2025, Hui et al. 2023, Hampole et al. 2025)

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* Factory:

- * AI increases employment of young, low-education, and low-ability workers
- * increases wages at the bottom but decrease them at the top
- * effect larger for occupations related to machine operation

⇒ Consistent with capital deepening + deskilling

(Brynjolfsson et al. 2025, Peng et al. 2023, Kanazawa et al. 2022, McElheran et al. 2025, Alam et al. 2024, Marr and Ward 2019)

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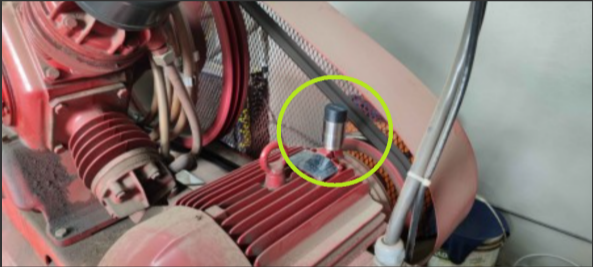
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(Brynjolfsson et al. 2025, Peng et al. 2023, Kanazawa et al. 2022, McElheran et al. 2025, Alam et al. 2024, Marr and Ward 2019)

- * **Reconcile** the different findings in the literature

>>> Example: AI for Predictive Maintenance



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Sensor:

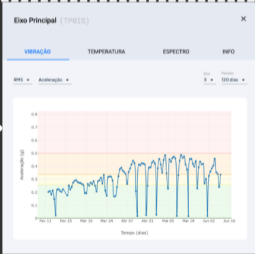


>>> Example: AI for Predictive Maintenance

Sensor:



High Frequency Data:

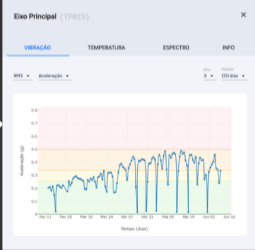


>>> Example: AI for Predictive Maintenance

Sensor:



High Frequency Data:



Neural Network to Predict Failure:



Alarmes

Junho de 2024

- Previsibilidade de quebra em 23 dias.**
Misturador
Máquina usada para misturar 17% de ingredientes essenciais.
Servidor: Servidor A
Unidade: Unidade Principal
[verificar manutencao](#)
- Previsibilidade de quebra em 4 dias.**
Refrigeracao
Máquina usada para armazenar 17% de ingredientes essenciais.
Servidor: Servidor B
Unidade: Unidade Principal
[verificar manutencao](#)

Maior de 2024

- Previsibilidade de quebra em 4 dias.**
Misturador
Máquina usada para misturar 17% de ingredientes essenciais.
Servidor: Servidor C
Unidade: Unidade Secundaria
[verificar manutencao](#)

>>> Example: AI for Predictive Maintenance

- * How predictive maintenance AI affects employment:

- * **Factory:**

 - ⇒ machine downtime ↓, TFP ↑, employment ↑ (Benhanifia et al. 2025, Schmitz 2005)

- * **Office:**

 - * Automates maintenance planning, report generation, and inventory control

 - ⇒ employment ↓

>>> Data

>>> Administrative Software Registry

- * Copyright protection to source code of computer programs since 1980s
 - * Registration at the Nat. Inst. of Industrial Property (NIIP)
 - * Protects the code, not the idea
 - * Charges and fines for piracy

>>> Cases of Source Code Theft are Common



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NEWS

Former xAI Engineer Sued After Allegedly Uploading Entire Codebase to OpenAI

BY ABHIMANYU GUPTA • AUGUST 30, 2025 6:57 PM PDT

Yahoo Employee Stole 570,000 Pages of Source Code the Day He Quit to Join a Competitor



Alex Lee

>>> Cases of Source Code Theft are Common

NEWS

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Quantitative Trader Accused Of Stealing Firm's Source Code

By **Theresa Schliep** · January 8, 2025, 8:47 PM EST

New York federal prosecutors have accused a quantitative trader of stealing the secrets of a billion-dollar company's source code from his former employer to use at his own trading firm, according...

Employee Stole 570,000 Source Code the Day in a Competitor

AI/ML, Governance, Risk and Compliance, Government Regulations

Former Google engineer charged with stealing AI trade secrets

February 6, 2025

 Share

>>> Administrative Software Registry

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 - * Protects the code, not the idea
- * Provides proof of ownership:
 - * Piracy takedown requests, litigation, government procurement
 - * firms and programmers use it to signal experience

>>> Broad Coverage:

96% of Software Firms have Registration

* In 2016, among software firms with more than two years:

* 96% had at least one software registration

* Employment-weighted: 99.9%

>>> Example of Software Registration

FEDERATIVE REPUBLIC OF BRAZIL
MINISTRY OF THE ECONOMY
**NATIONAL INSTITUTE OF INDUSTRIAL
PROPERTY**
DIRECTORATE OF PATENTS, COMPUTER PROGRAMS, AND
TOPOGRAPHIES OF INTEGRATED CIRCUITS

Certificate of Software Registration

Case N^o: **BR512021001026-4**

The National Institute of Industrial Property issues this certificate of registration of a computer program, valid for 50 years starting from January 1st following the date of May 3, 2021, in accordance with §2, Article 2 of Law No. 9,609 of February 19, 1998.

Title: iMachine AI: Online Predictive Maintenance System for Electric Machines Using Machine Learning Techniques

Publication Date: 05/03/2021

Creation Date: 04/28/2021

Owner(s): TECHPLUS AUTOMACAO

Author(s): SAMARONE RUAS

Programming Language: PYTHON

Application Domain: AD-06; FQ-04; IF-10; IN-02

Technical Class: AP-01; AT-05; IA-01; IT-01; TC-03

Hash Algorithm: SHA-512

Digital Hash Summary:
cec9fe6467e2da2a9cc51fad00cfaedf52adc26dd5f352d4f4ed7c8600e399415383cc
2d542eab52cf2a49bf66955b20317e
bf21bafa7273d7edc0b534767588

Issued on: 05/25/2021

Approved by:
Carlos Alexandre
Fernandes Silva Head
of DIPTO

>>> Registration Contain Software Title



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>>> Registration Contain Area in Which the Software is Used



The certificate is a document from the National Institute of Industrial Property of Brazil. It features the national emblem at the top center, a barcode to the right, and the text 'FEDERATIVE REPUBLIC OF BRAZIL' and 'NATIONAL INSTITUTE OF INDUSTRIAL PROPERTY'. Below this, it specifies the 'DIRECTORATE OF PATENTS, COMPUTER PROGRAMS, AND TOPOGRAPHIES OF INTEGRATED CIRCUITS'. The title of the certificate is 'Certificate of Software Registration'. The case number is 'BR512021001026-4'. A paragraph explains that the institute issues this certificate for a computer program registered on January 1st, 2021, in accordance with Law No. 9,609 of February 19, 1998. The title of the software is 'iMachine AI: Online Predictive Maintenance System for Electric Machines Using Machine Learning Techniques'. It lists the publication date (05/03/2021), creation date (04/28/2021), owner (TECHPLUS AUTOMACAO), and author (SAMARONE RUAS). The programming language is PYTHON. The application domain is highlighted with a red dashed box and contains 'AD-06; FQ-04; IF-10; IN-02'. The technical class is 'AP-01; AT-05; IA-01; IT-01; TC-03'. The hash algorithm is SHA-512. A digital hash summary is provided. The issue date is 05/25/2021. A red dashed box highlights a list of 225 application domains: AD-06: Factory Planning, FQ04: Metrology (Measurement), IF-10: information Management, and IN-02: Manufacturing Technology. The certificate is approved by Carlos Alexandre Fernandes Silva Head of DIPTO.

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- AD-06: Factory Planning
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225 Application Domains

Approved by
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>>> Registration Contain Technology Used


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bf21bafa7273d7edc0b534767588

Issued on: 05/28/2021

- **AP-01: Application**
- **AT-05: Industrial Automation**
- **IA-01: Artificial Intelligence**
- **IT-01: Instrumentation**
- **TC-03: Pattern Recognition**

97 Technical Classes

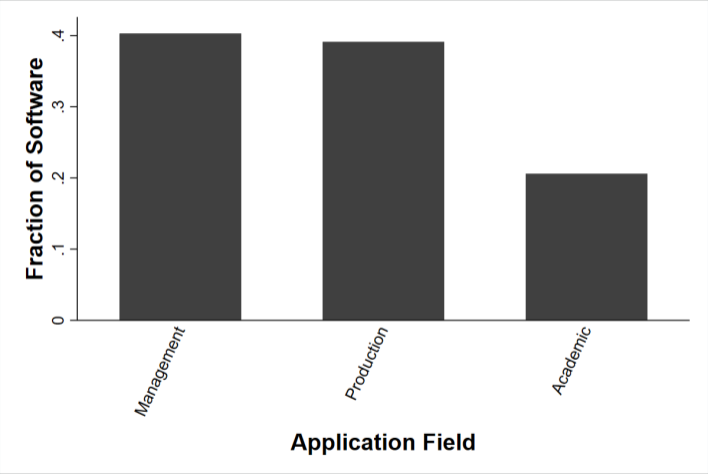
Approved by:
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>>> Data

- * All software registrations from 1985 to 2023;
 - * limit sample to those classified as AI
- * Labor market outcomes (2003-2022):
 - * administrative matched employer-employee dataset

>>> Statistics of AI Software

>>> AI is Used in the Office and the Factory



>>> What Does a Production AI Do?

- * Find AI applications in the production engineering literature
- * Use LLM to classify AI into those different applications

>>> Production AI Coordinates Workflow and Controls Quality

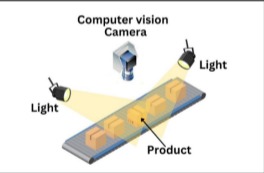
- * Find AI applications in the production engineering literature;
- * Use LLM to classify AI into those different applications
- * Most common AI Applications:
 - * 40% is Manufacturing Execution Systems(MES)/Enterprise Resource Planning(ERP)
(Chen et al. 2006, Capgemini 2020, Shojaeinasab et al. 2022)

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(Chen et al. 2006, Capgemini 2020, Shojaeinasab et al. 2022)
 - * 20% is quality control
(Ghelani et al. 2024, Tariq et al. 2024, Elsafty et al. 2024, Shi et al. 2023)

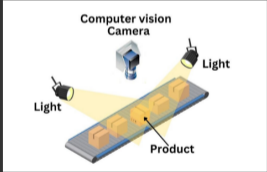
>>> Tbit's Quality Control AI

Record Production Line

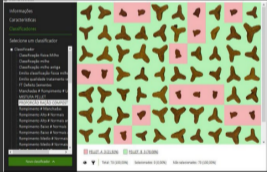


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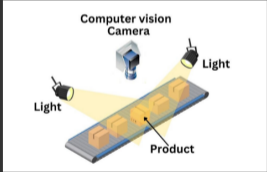


AI Measures Product Quality

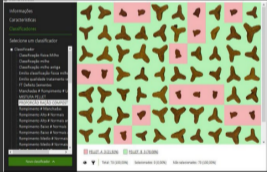


>>> Tbit's Quality Control AI

Record Production Line



AI Measures Product Quality



Give Workers Information

Recalibrate Machines

Adjust Inputs



>>> Empirics

>>> Empirical Model

- * Main empirical model

$$y_{o,t} = \beta AI \text{ Exposure}_{o,t} + \mu_o + \mu_t + X'_{o,t}\theta + \epsilon_{o,t}$$

where

- * $y_{o,t}$ is a labor market outcome for occupation o in year t , such as employment
- * occupation o : 6-digits; 2,600 occupations
- * time t : 2003-2022

>>> Empirical Model

- * Main empirical model

$$y_{o,t} = \beta \text{AI Exposure}_{o,t} + \mu_o + \mu_t + X'_{o,t}\theta + \epsilon_{o,t}$$

where

- * $\text{AI Exposure}_{o,t}$ text similarity between tasks performed by occupation o and AI software developed up to year t
- * measures overlap between tasks performed by occupation o and AI software
- * Follows Kogan et al. (2023), de Souza and Li (2023), and Webb (2020)

>>> Empirical Model

* Main empirical model

$$y_{o,t} = \beta AI \text{ Exposure}_{o,t} + \mu_o + \mu_t + X'_{o,t}\theta + \epsilon_{o,t}$$

where

* μ_o, μ_t : occupation and time fixed effect

>>> Empirical Model

- * Main empirical model

$$y_{o,t} = \beta AI \text{ Exposure}_{o,t} + \mu_o + \mu_t + X'_{o,t}\theta + \epsilon_{o,t}$$

where

- * $X_{o,t}$: one-digit occupation-year fixed effect, U.S. patent-based AI exposure measure (Webb, 2020), lag of $y_{o,t}$

>>> Instrument: Heterogeneous Exposure to Decrease in AI Dev. Cost

- * Exogenous variation: changes in the cost of creating software

Popularity Programming Language in the U.S. ↑

⇒ Libraries, Resources, and Community ↑

⇒ Cost of AI Software in Brazil ↓

- * Heterogeneous exposure across occupations from language specialization

- * legacy code (Meyerovich and Rabkin, 2013)

- * technical characteristics (Rabah et al., 2010)

>>> Example: Cobol & R

COBOL

- * Developed in 1959. Basis of financial system.
- * 80% of in-person transactions use COBOL
- * popularity↓, community↓, difficulty hiring
- * Relatively more costly to develop AI software for banking automation

⇒ Banking workers relatively less exposed to AI

R

>>> Example: Cobol & R

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⇒ Banking workers relatively less exposed to AI

R

- * Developed in 1990s for statistics
 - * Tiobe Index: 15th most popular language
 - * Relatively less costly to develop AI software for report generation
- ⇒ Archivists relatively more exposed to AI

>>> Lagged Resources for a Programming Language in the US

- * Measure of easiness to develop AI software targeting occupation o in year t :

$$AI \text{ Ease-of-Dev}_{o,t} = \frac{\text{Resources in } US_{l,t-2}}{\text{Resources in } US_{l,t-2}}$$

- * *Resources in $US_{l,t-2}$* : number of pages in Google.com for programming language l

>>> Lagged Resources for a Programming Language in the US

A screenshot of a Google search interface. The search bar contains the text "Fortran". To the right of the search bar are icons for clearing the search, voice search, image search, and a magnifying glass. Below the search bar is a navigation bar with links for "AI Mode", "All", "Images", "Videos", "News", "Shopping", "Maps", "More", and "Tools". A dropdown menu is open under the "Tools" link, showing options for "Any time", "All results", and "Advanced Search". At the bottom of the dropdown, it displays "About 13,500,000 results (0.31s)".

>>> Specialization of a Programming Language in a Tech. Class

- * Measure of easiness to develop AI software targeting occupation o in year t :

$$AI\ Ease-of-Dev_{o,t} = \frac{Resources\ in\ US_{l,t-2} \times Specialization_{l,p}}{\quad}$$

- * $Specialization_{l,p}$: how common programming language l is used in technical field p

$$Specialization_{l,p} = \frac{Stack\ Overflow\ posts\ tagging\ language\ l\ and\ tech\ class\ p}{Stack\ Overflow\ posts\ tagging\ language\ l}$$

>>> Specialization of a Programming Language in a Tech. Class

The screenshot shows the Stack Overflow website interface. At the top, there is a search bar with the text "[r] [database]". Below the search bar, there are three search results for R database questions. Each result includes the number of votes, the number of answers, the number of views, the question title, a snippet of the question text, the tags, the user who asked the question, and the time it was asked.

stackoverflow About Products For Teams [r] [database] Log in Sign up

62 votes
✓ 10 answers
250k views
R database r statistics
REnthusiast 1,681 asked Aug 11, 2013 at 11:04

16 votes
✓ 4 answers
12k views
R database r dataframe rodbc r-dbi
mchen 10.3k asked Dec 12, 2013 at 14:42

7 votes
✓ 2 answers
13k views
R r database
user1172558 655 asked Feb 15, 2012 at 7:08

>>> Specialization of a Programming Language in a Tech. Class

The screenshot shows the Stack Overflow website with a search bar containing "[r] database". Three search results are visible, each with a title, a brief description, and associated tags.

- Result 1:**
 - 62 votes
 - ✓ 10 answers
 - 250k views
 - Title: [Error in contrasts when defining a linear model in R](#)
 - Text: "When I try to define my linear model in R as follows: `lm1 <- lm(predictorvariable ~ x1+x2+x3, data=dataframe.df)` I get the following error message: Error in `contrasts<-`(`*tmp*`, value = ..."
 - Tags: `R`, `database`, `r`, `statistics`
 - Author: [REnthusiast](#) 1,681 asked Aug 11, 2013 at 11:04
- Result 2:**
 - 16 votes
 - ✓ 4 answers
 - 12k views
 - Title: [How to pass data.frame for UPDATE with R DBI](#)
 - Text: "With RODBC, there were functions like `sqlUpdate(channel, dat, ...)` that allowed you pass `dat = data.frame(...)` instead of having to construct your own SQL string. However, with R's DBI, all I see are ..."
 - Tags: `R`, `database`, `r`, `dataframe`, `rodbc`, `r-dbi`
 - Author: [mchen](#) 10.3k asked Dec 12, 2013 at 14:42
- Result 3:**
 - 7 votes
 - ✓ 2 answers
 - 13k views
 - Title: [How to create ID column in R](#)
 - Text: "I have a longitudinal data in a long format. I want to create an ID variable based on the variable-column that identifies each observation of my data. How do I do that in R? Example: I have this data ..."
 - Tags: `R`, `r`, `database`
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>>> Average Exposure of Occupations to AI in each Class

- * Measure of easiness to develop AI software targeting occupation o in year t :

$$AI\ Ease-of-Dev_{o,t} = \frac{Resources\ in\ US_{l,t-2} \times Specialization_{l,p} \times \overline{AI\ Exposure}_{p,o,t-2}}{}$$

- * $\overline{AI\ Exposure}_{p,o,t-2}$: average text-similarity between AI software developed up to 2 years ago, in application p , and occupation o

>>> Average Over Language and Technical Class

* Measure of easiness to develop AI software targeting occupation o in year t :

$$AI\ Ease-of-Dev_{o,t} = \sum_{l,p} \frac{Resources\ in\ US_{l,t-2} \times Specialization_{l,p} \times \overline{AI\ Exposure}_{p,o,t-2}}{N_l N_p}$$

>>> Instrument

- * Measure of easiness to develop AI software targeting occupation o in year t :

$$AI\ Ease-of-Dev_{o,t} = \sum_{l,p} \frac{Resources\ in\ US_{l,t-2} \times Specialization_{l,p} \times \overline{AI\ Exposure}_{p,o,t-2}}{N_l N_p}$$

- * Instrument:

$$AI\ Ease-of-Dev\ IV_{o,t} = \sum_{s=2003}^t AI\ Ease-of-Dev_{o,s}$$

- * Identification Assumption (Goldsmith-Pinkham et al, 2020):

- * Parallel trends between occupations with high- and low- $\overline{AI\ Exposure}_{p,o,t-2}$

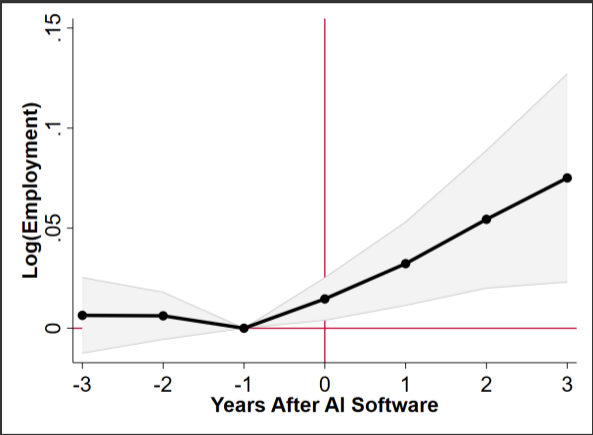
>>> Results: AI Increases Employment of
Low-Skilled Workers

>>> AI Increases Employment of Low-Skilled Workers

	(1)	(2)	(3)	(4)	(5)
	<i>log(Employment)</i>	<i>log(Employment)</i>	<i>log(Employment)</i>	<i>log(Employment)</i>	<i>log(Employment)</i>
<i>AI Exposure</i>	0.0229*** (0.00600)	0.0194*** (0.00722)	0.0202*** (0.00624)	0.0158** (0.00622)	0.0177*** (0.00631)
<i>N</i>	45,336	45,336	45,119	45,336	45,119
Fix Effects Interacted with Year:					
1-Digit Occ.	-	✓	✓	-	-
Main Sector	-	-	✓	-	✓
2-Digits Occ.	-	-	-	✓	✓

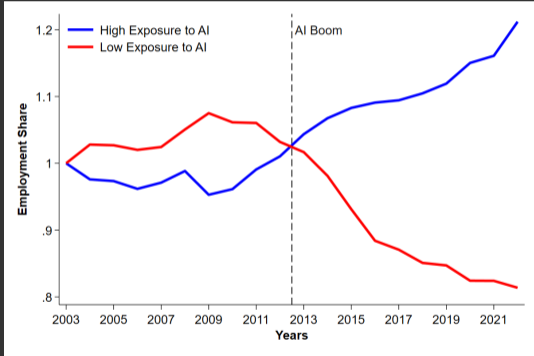
>>> AI Increases Employment of Low-Skilled Workers

Figure: Dynamic Effect of AI on Employment



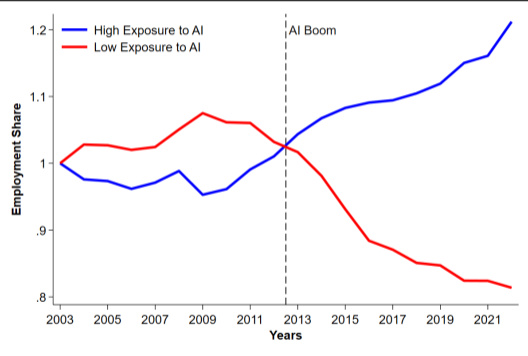
>>> Employment Growth Correlates with the AI Boom

(a) Occ. More Exposed Had Larger Growth

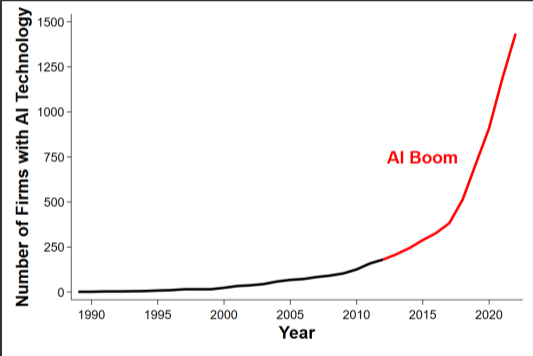


>>> Employment Growth Correlates with the AI Boom

(a) Occ. More Exposed Had Larger Growth



(b) AI Development Boomed in 2010s



>>> AI Changes the Composition of Workers

Table: AI Increases Employment of Younger and Less Skilled Workers

	(1)	(2)	(3)
	<i>log(Age)</i>	<i>log(Yrs. Education)</i>	<i>log(Experience)</i>
<i>AI Exposure</i>	-0.00498*** (0.00112)	-0.00658*** (0.00113)	-0.0199*** (0.00591)
<i>N</i>	45,336	45,332	45,336

>>> AI Decreases Average Wages

Table: AI Lowers Wages and Inequality Due the Entry of Low-Ability Workers

	(1)
	<i>log(Wage)</i>
<i>AI Exposure</i>	-0.0229*** (0.00380)
<i>N</i>	45,336

>>> AI Brings In Low-Ability Workers

Table: AI Lowers Wages and Inequality Due the Entry of Low-Ability Workers

	(1)	(2)
	<i>log(Wage)</i>	<i>Ability</i>
<i>AI Exposure</i>	-0.0229*** (0.00380)	-0.0196*** (0.00401)
<i>N</i>	45,336	19,885

>>> After Controlling for Composition, AI Increases Wages

Table: AI Lowers Wages and Inequality Due the Entry of Low-Ability Workers

	(1)	(2)	(3)
	<i>log(Wage)</i>	<i>Ability</i>	<i>Wage Residual</i>
<i>AI Exposure</i>	-0.0229*** (0.00380)	-0.0196*** (0.00401)	0.00493* (0.00286)
<i>N</i>	45,336	19,885	19,885

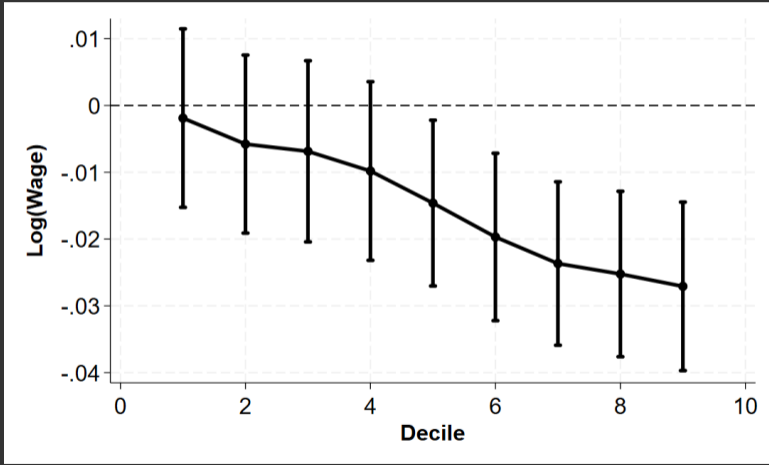
>>> AI Decreases Inequality Within Occupations

Table: AI Lowers Wages and Inequality Due the Entry of Low-Ability Workers

	(1)	(2)	(3)	(4)
	<i>log(Wage)</i>	<i>Ability</i>	<i>Wage Residual</i>	<i>log(Std. Wage)</i>
<i>AI Exposure</i>	-0.0229*** (0.00380)	-0.0196*** (0.00401)	0.00493* (0.00286)	-0.0345*** (0.00992)
<i>N</i>	45,336	19,885	19,885	45,208

>>> AI Decreases Wages at the Top of the Wage Distribution

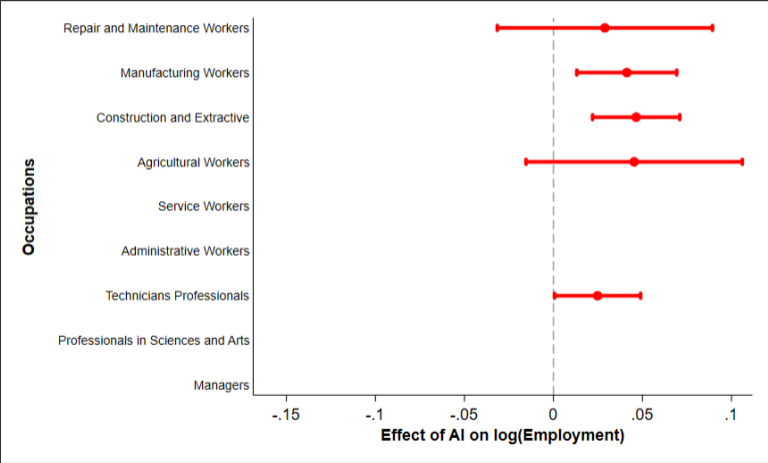
Figure: Effect of AI in Different Within-Occupation Wage Deciles



>>> Results: AI Shrinks the Office and
Expands the Factory

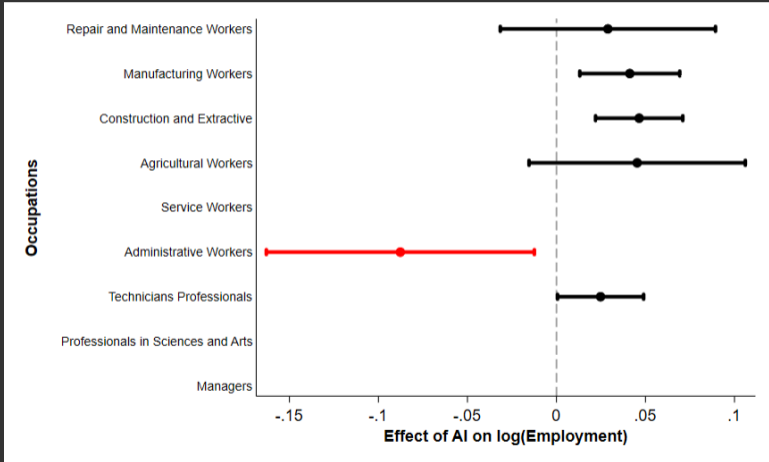
>>> AI Increases Employment of Production Workers

Figure: Effect of AI on Employment of Different Occupations



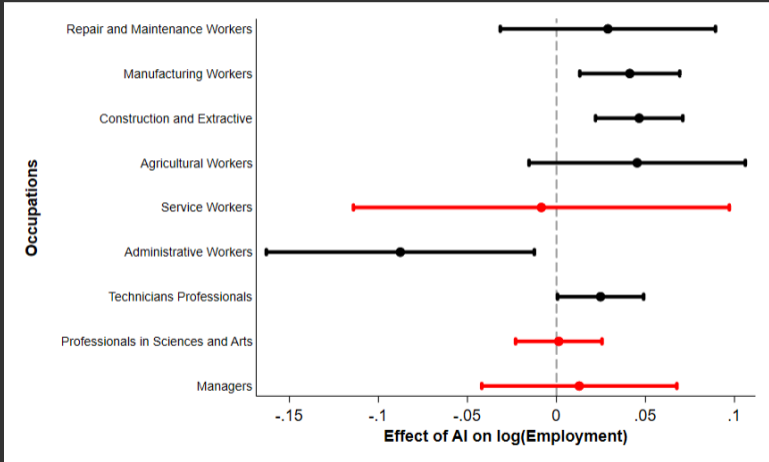
>>> AI Decreases Employment of Administrative Workers

Figure: Effect of AI on Employment of Different Occupations



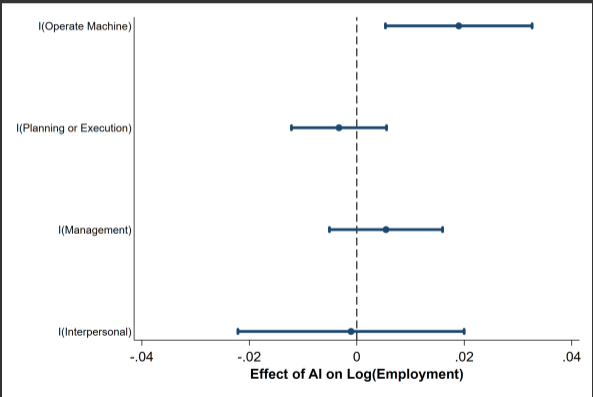
>>> No Effect on Professionals

Figure: Effect of AI on Employment of Different Occupations



>>> AI Has Larger Employment Effects in Machine-Operating Jobs

$$y_{o,t} = \beta_1 AI Exposure_{o,t} + \beta_2 AI Exposure_{o,t} \times \mathbb{I}_o \{Task\} + \mu_o + \mu_t + X'_{o,t} \theta + \epsilon_{o,t}$$



>>> What You Learned Today:

* Production:

- * AI increases employment of low-ability workers
- * AI increases wages at the bottom but decrease them at the top
- * The effect is larger for occupations related to machine operation
- * **Story:** capital deepening + deskilling
- * Consistent with experimental evidence + AI use in production
(Bresnahan 2021, Agrawal et al. 2019, McElheran et al. 2025, Autor 2024, Brynjolfsson et al. 2025, Peng et al. 2023, Kanazawa et al. 2022, Alam et al. 2024)

* Office:

- * AI decreases employment
- * **Story:** Automation
(Acemoglu and Restrepo 2019, Webb 2020, Aum and Shin 2025, Hui et al. 2023, Hampole et al. 2025)

>>> 2001: a space odyssey



>>> AI Take Over

I'm sorry, Dave.



I'm afraid I can't do that.

>>> 2022: a brazilian odyssey



>>> Real AI: Provide Information \implies Employment \uparrow

I'm here to help, Dave.



Here is how you can do that.