Generative AI and Firm Values: The Labor Channel

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ChatGPT and Generative AI are rapidly changing the economy

ChatGPT is about to revolutionize the economy. We need to decide what that looks like.

AI to boost world economy by over 15 trillion dollars in seven years

Goldman Sachs: ChatGPT could see the loss of 300 million jobs worldwide

Tinkering With ChatGPT, Workers Wonder: Will This Take My Job?

Artificial intelligence is confronting white-collar professionals more directly than ever. It could make them more productive — or obsolete.

Enchanted by ChatGPT, Bill Gates calls AI 2nd revolutionary tech after GPU

AI "will be able to do everything that a human brain can, but without any practical limits on the size of its memory or the speed at which it operates," says Microsoft co-founder.

Yes, ChatGPT Is Coming for Your Office Job

White-collar workers may soon face the AI disruption everyone's been panicking about. But the news may be better than you think.

The Robots Have Finally Come for My Job

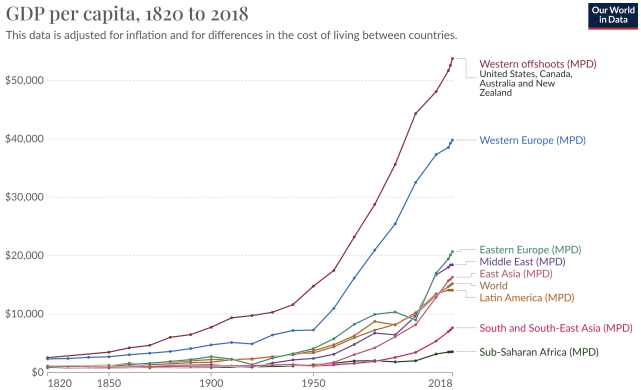
Could ChatGPT lay waste to millions of professional jobs, including journalists?

- McKinsey: *"Generative AI could add the equivalent of $2.6 trillion to $4.4 trillion annually...to the global economy"*

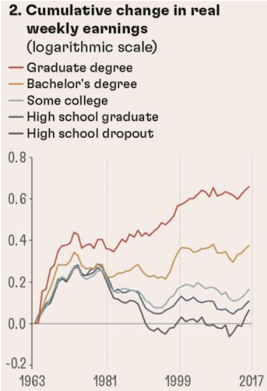
What are the consequences for firms and workers?

Economic Impact of Technology

- Past technologies (electricity, engines, telephones, medicine) improved life and longevity.
- Technological progress historically leads to job transformation, not just displacement.
- Long-run net benefits often larger than short-run net benefits



Technology and Inequality



Potential channels of technology-induced inequality :

1. Productivity of skilled and unskilled workers differently impacted
2. Capital cost reductions benefiting some workers more than other
3. Machines replacing some workers entirely for particular tasks
4. Increased concentration of market power in a few firms as a result of technology

How does Generative AI affect these channels?

What is Generative AI?

Generative AI comprises tools that are capable of...

- Generating text and hold conversations (Large Language Models, e.g. Generative Pre-Trained Transformers)
- Create images, movies, music based on prompts
- Take actions based on complex sensory inputs (robotics, autonomous vehicles)
- Generally understanding patterns in input data and executing tasks based on it

Generative AI models learn the patterns and structure of their **input training data** and then generate **new data** that has desired characteristics

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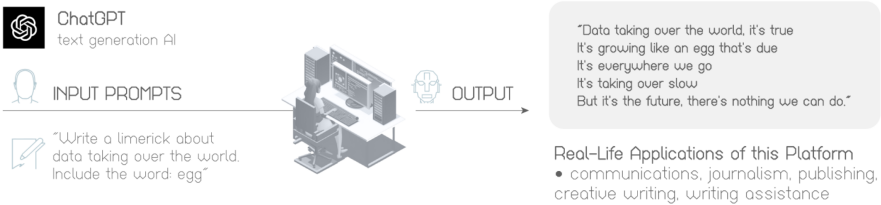

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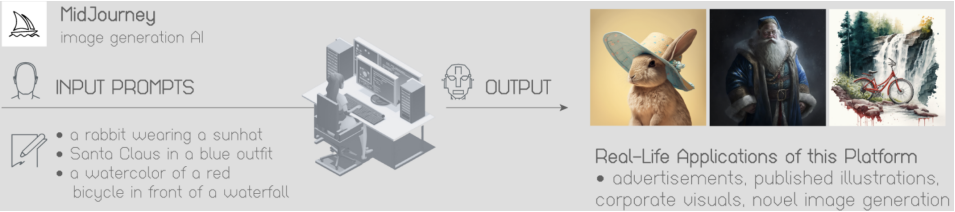

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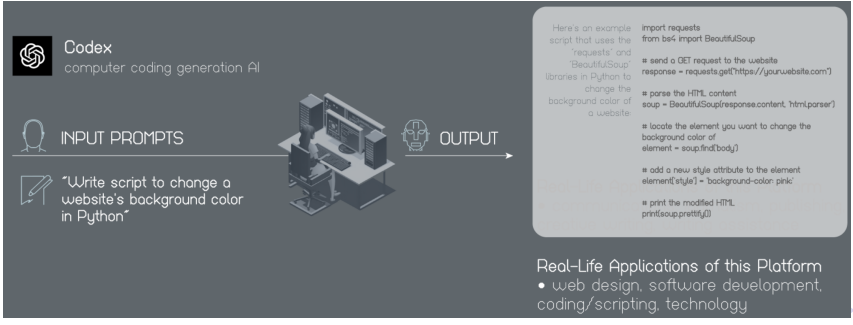

What is ChatGPT?

- Released on Nov. 30, 2022, as a chat interface application by OpenAI
- Its “base model” was GPT 3.5, a large language model that can understand and generate human-like text
- Capable of performing a wide range of language tasks with minimal context
- Related models: GPT 3.5 Turbo, GPT 4 etc. — for use as base models to power other applications

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You

Describe ChatGPT in a sonnet in the style of Shakespeare

ChatGPT

In the realm of cyber, a mind was wrought,

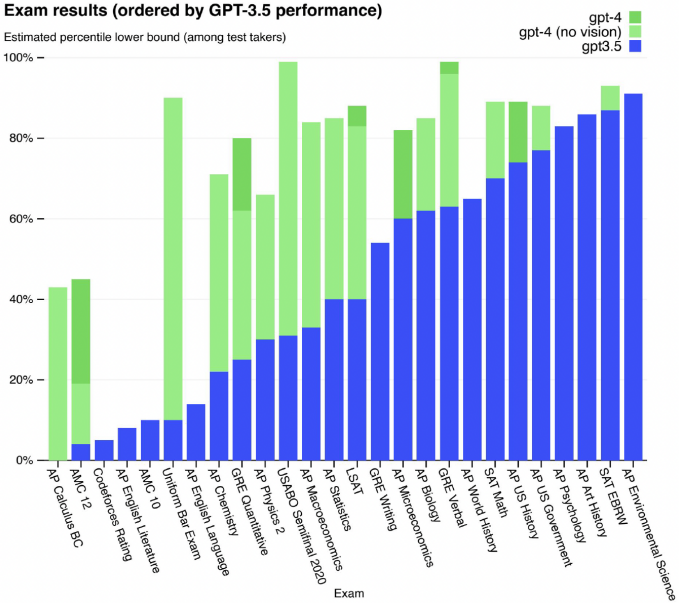
A creature born from circuits, code, and thought.

ChatGPT, its name, a bard in binary guise,

Crafting words with care, under digital skies.

Like Puck, it plays in realms of question deep,

GPT Performance on Exams



Generative AI Impact on Firms

Potential GenAI benefits for firms

1. **Productivity improvements from incorporating AI (Focus today)**
   - "General Purpose Technology" likely to affect *all* workers to *some* degree
   - Affects a **broad range of companies**
   - To improve productivity, can either be a substitute for or complementary to labor

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2. Generative AI improvements can also create product demand

- Companies *making* or *supporting* AI advances benefit directly from booming demand
- For example, semiconductor manufacturers, cloud computing providers, big technology companies with AI products (e..g Nvidia, Microsoft) have seen high returns since ChatGPT release on Nov. 30, 2022.
- Affects a **smaller number of companies/industries**

Early studies show large potential for productivity improvements through Gen. AI

Large effects of incorporating AI language models into white-collar work:

- *Jia et al. (2023):* sales agents with upfront AI lead generation and phone screening are more likely to learn to solve unusual problems, and double their conversion rate
- *Noy & Zhang (2023):* writing press releases, short reports, analysis plans, and delicate emails with ChatGPT decreases time taken by 0.8 SDs and increases output quality by 0.4 SDs
- *Peng et al. (2023):* AI pair programmer (GitHub Copilot) makes software developers 56% faster
- **General pattern: greater improvement for less-skilled workers**

Who is most likely to benefit from these productivity increases / labor cost savings?

Exposure to GenAI: Measurement

tasks $\rightarrow$ occupations $\rightarrow$ firms

Task Exposure to Generative AI Technology

- **Data:** Occupational Information Network (ONET): details 19,265 tasks for 923 occupations
- **Approach:** Score worker *tasks* for exposure to GenAI
- **Scoring:**
  - Submit rubric, two examples, and an occupation-task statement pair to Open AI's GPT 3.5 Turbo API $\Rightarrow$ returns a score and an explanation for the scoring (Eloundou et al., 2023)
    1. $X^T = 0$ No exposure
    2. $X^T = 1$ 50% time saving, equal quality is already feasible
    3. $X^T = 0.5$ 50% time saving equal quality requires overlays
- Occupation-level Exposure: **average exposure score of the occupation's tasks**

Examples: GPT Scoring of **Task Exposure** to Generative AI

Occupation	Task	Score	Explanation
Telemarketers	Adjust sales scripts to better target the needs and interests of specific individuals.	1	The model can learn from the sales scripts and the needs and interests of specific individuals to adjust the sales scripts.
Web Developers	Write supporting code for Web applications or Web sites.	1	The model can write code based on the specifications provided in the text input.
Paralegals and Legal Assistants	Investigate facts and law of cases and search pertinent sources, such as public records and internet sources, to determine causes of action and to prepare cases.	.5	The model can assist in searching pertinent sources and summarizing information, but it may not be able to retrieve up-to-date facts from the internet. Additional software could be developed on top of the LLM to retrieve up-to-date facts and combine them with the LLM capabilities.
Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Connect heating or air conditioning equipment to fuel, water, or refrigerant source to form complete circuit.	0	The task requires physical interaction with equipment and materials, which cannot be done by the LLM.
Physician Assistants	Perform therapeutic procedures, such as injections, immunizations, suturing and wound care, and infection management.	0	The task requires physical interaction with patients, which cannot be done by the LLM.

Highest **Occupation Exposure** to Generative AI Technology

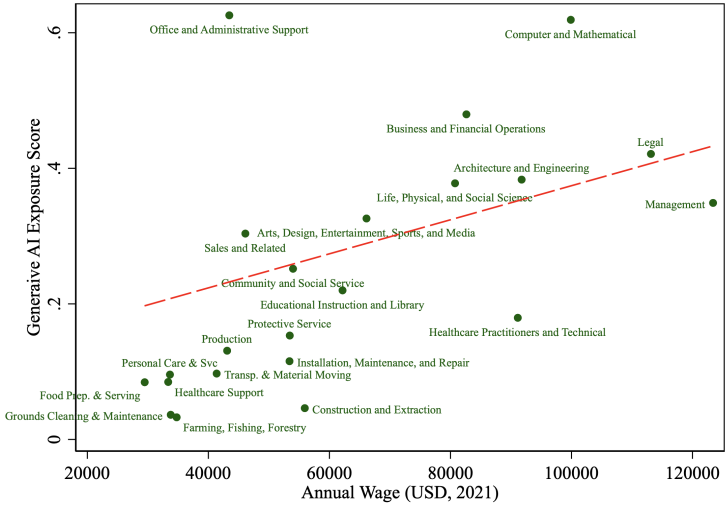
SOC Code	Occupation Title	Exposure Score
41-9041	Telemarketers	.96
43-9081	Proofreaders and copy markers	.95
43-3031	Bookkeeping, accounting, and auditing clerks	.87
15-2021	Mathematicians	.86
15-1251	Computer programmers	.85
43-9022	Word processors and typists	.85
43-3011	Bill and account collectors	.83
27-3091	Interpreters and translators	.82
43-9111	Statistical assistants	.82
15-1254	Web developers	.81
43-6011	Executive secretaries and executive administrative assistants	.77
43-3051	Payroll and timekeeping clerks	.77
43-6014	Secretaries and administrative assistants, except legal, medical, and executive	.77
43-5061	Production, planning, and expediting clerks	.76
15-1212	Information security analysts	.75
43-6013	Medical secretaries and administrative assistants	.75
27-3043	Writers and authors	.75
43-4021	Correspondence clerks	.74
43-9061	Office clerks, general	.74
41-3091	Sales representatives of services, except advertising, insurance, financial services, and travel	.73

Lowest **Occupation Exposure** to Generative AI Technology

SOC Code	Occupation Title	Exposure Score
39-5093	Shampooers	0
51-6041	Shoe and leather workers and repairers	0
51-6042	Shoe machine operators and tenders	0
51-3023	Slaughterers and meat packers	0
47-2022	Stonemasons	0
47-2221	Structural iron and steel workers	0
51-2041	Structural metal fabricators and fitters	0
29-9093	Surgical assistants	0
51-6052	Tailors, dressmakers, and custom sewers	0
47-2082	Tapers	0
49-9052	Telecommunications line installers and repairers	0
47-2053	Terrazzo workers and finishers	0
51-6064	Textile winding, twisting, and drawing out machine setters, operators, and tenders	0
47-2044	Tile and stone setters	0
51-9197	Tire builders	0
49-3093	Tire repairers and changers	0
51-4194	Tool grinders, filers, and sharpeners	0
39-3031	Ushers, lobby attendants, and ticket takers	0
49-9064	Watch and clock repairers	0
53-7073	Wellhead pumpers	0

17% (132 of 785) BLS occupations have zero exposure - subset shown.

Occupation Exposure to Generative AI Technology and Wages



Firm Exposure to Generative AI technology

- **Data:** LinkedIn profiles from Revelio Labs $\Rightarrow$ firm employment by occupation
- **Firm Gen. AI exposure:** computed for 5,907 Compustat firms in March 2022:

$$X^f = \sum_{O \in f} EmpShare_{f,O} * X^O$$

Firm Exposure to Generative AI technology

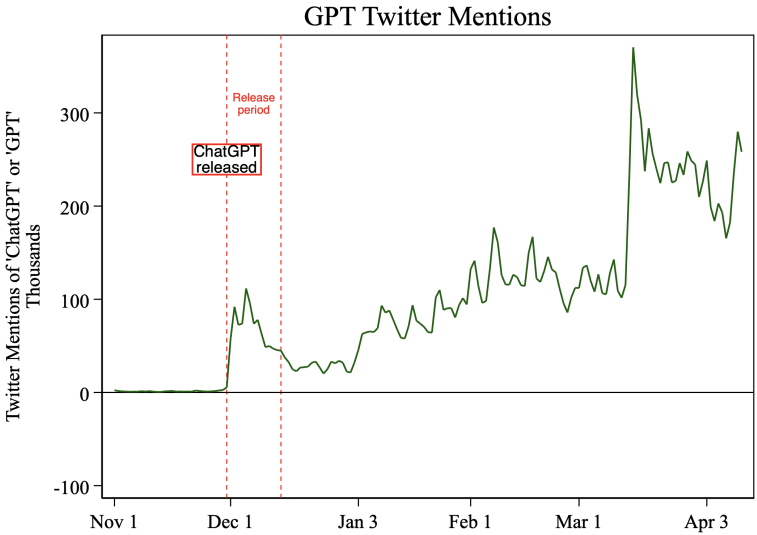
Panel A: Top 15 Large U.S. Companies with Highest Exposure to Generative AI			
Company Name	Gen. AI exposure	MktCap	Subsector
International Business Machines Corp	.488	128	Other Information Svcs
Intuit Inc.	.48	110	Publishing Industries (exc. Internet)
QUALCOMM Inc.	.479	123	Computer & Electronic Prod. Mfg.
Fiserv Inc.	.475	64	Data Processing, Hosting, & Related Svcs
NVIDIA Corporation	.468	360	Computer & Electronic Prod. Mfg.
S&P Global Inc	.452	108	Admin. & Support Svcs
Broadcom Inc	.449	234	Computer & Electronic Prod. Mfg.
Verizon Communications Inc	.444	165	Telecommunications
Microsoft Corp	.442	1790	Publishing Industries (exc. Internet)
3M Co	.442	66	Paper Mfg.
Advanced Micro Devices Inc	.441	104	Computer & Electronic Prod. Mfg.
ServiceNow Inc	.434	79	Publishing Industries (exc. Internet)
Adobe Inc	.427	155	Data Processing, Hosting, & Related Svcs
PayPal Holdings Inc	.418	81	Data Processing, Hosting, & Related Svcs
Thermo Fisher Scientific Inc	.411	215	Computer & Electronic Prod. Mfg.

Firm Exposure to Generative AI technology

Panel B: Bottom 15 Large U.S. Companies with Lowest Exposure to Generative AI			
Company Name	Gen. AI exposure	MktCap	Subsector
Starbucks Corp	.119	114	Food Svcs & Drinking Places
McDonald's Corp	.194	193	Food Svcs & Drinking Places
Target Corp	.235	69	General Merchandise Stores
Walmart Inc	.235	382	General Merchandise Stores
Lowe's Cos Inc	.238	120	Build. Mat., Gard. Equip., Supplies Dealers
TJX Companies Inc (The)	.243	92	Clothing & Clothing Accessories Stores
Costco Wholesale Corp	.252	202	General Merchandise Stores
Union Pacific Corp	.253	127	Rail Transp.
CSX Corp	.256	64	Rail Transp.
United Parcel Service Inc	.256	149	Couriers & Messengers
Home Depot Inc. (The)	.261	321	Build. Mat., Gard. Equip., Supplies Dealers
Norfolk Southern Corp	.272	56	Rail Transp.
Tesla Inc	.283	390	Transp. Equipment Mfg.
Northrop Grumman Corp	.291	84	Computer & Electronic Prod. Mfg.
Mondelez International Inc	.292	91	Food Mfg.

Impact on **Firm Values** from **Firm Exposure** to Generative AI

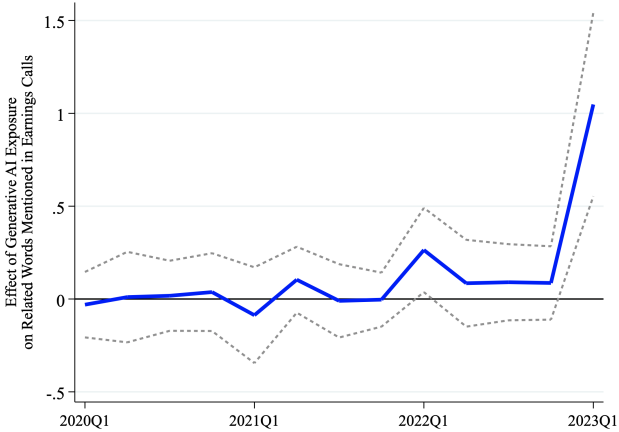
Public attention to Generative AI technology spiked after ChatGPT release



More exposed firms communicate *more* about Gen. AI

- Collected panel of earnings conference call transcripts for S&P 500 firms
- Count monthly mentions of:: “llm”, “chatgpt”, “gpt”, “generative”, “language model”

$$\mathbb{1}[\text{Mentions Gen. AI}]_{it} = \alpha_t + \beta_t \text{Gen AIExposure}_i + \gamma \mathbb{1}[\text{Mentions Gen. AI}]_{i,2019} + \varepsilon_{i,t}$$

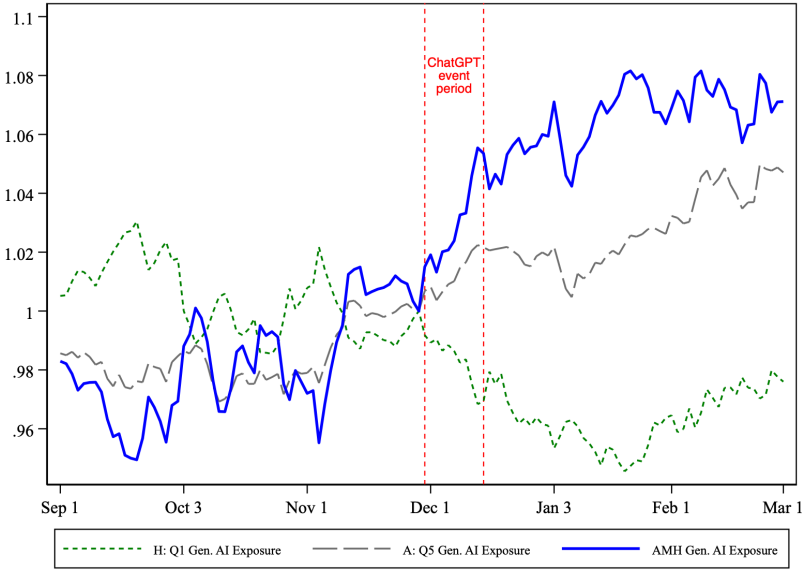


1 SD Δ in firm exposure $\Rightarrow$ 6.7ppt increase in likelihood of mentioning Gen. AI in Q1 2023

Stock Portfolio Returns and Generative AI Exposure

- Sort stocks by Gen. AI exposure quintiles
- Form long-short portfolio that **compares stock returns of high vs. low exposure firms**
- Q5 (Artificial) - Q1 (Human) = AMH
- **AMH returned 0.4% daily during 2 weeks after ChatGPT release**
- Overall market return was *negative* over these 2 weeks
- Differences in returns are insignificant during rest of sample

AMH Portfolio Returns Over Time



Is Data a Complement to Generative AI?

Agrawal, Gans & Goldfarb (2019): *"Machine learning...[represents]...one particular aspect of intelligence: prediction...Prediction is useful because it is an input into decision-making...[which] also requires collection and organization of data."*

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Many Generative AI applications require proprietary **data and data management** capabilities:

- **Fine-tuning** and customization of LLMs requires large firm-specific training data sets
- **Process automation** requires data pipeline to/from LLM
- **Task-specific prompting** is improved by data on desired outputs (e.g. past customer interactions)
- LLM **analytical capabilities** enable extraction of new data from existing data, decision support and creative output generation based on input data

Measuring firm ability to access data

2 Methods of Measurement:

1. *10K-based Data Value measure*: Ask ChatGPT to read Business Description section of most recent firm annual report. Assesses if firm's business products suggest access to data relevant for Generative AI analytics, based on mentions of 6 topics: general nature of the company's business, the scale and reach of the firm, data collection mechanisms, data utilization, data infrastructure & management, and data regulation and privacy. 0 = no, 1 = little, 2 = moderate, 3 = high

2. *Data Management Skills*: share of roles that tend to require high level of "data management skills" in a firm's employment structure $\Rightarrow$ data managers as a proxy for valuable data to be managed (Abis & Veldkamp, 2023)

   Result: higher firm values due to Gen. AI are driven by companies with more data assets!

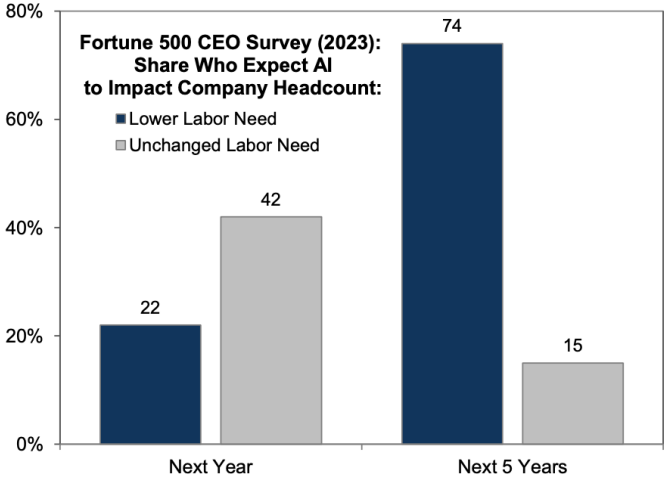
More data access increases firm value impact of Generative AI

$$\text{ChatGPT Release Cumul. Returns}_i = \beta \times \text{GenAI Exp}_i + \gamma \text{GenAI Exp}_i \times \text{Data}_i + \textit{Controls} + \varepsilon_i,$$

Dep. var.:	ChatGPT Release Cumul. Returns		
	(1)	(2)	(3)
GenAI Exp	0.216***	-0.035	-0.085
	(2.621)	(-0.403)	(-0.992)
GenAI Exp × 10K Data Value		0.216**	
		(2.144)	
10K Data Value		-0.073*	
		(-1.816)	
GenAI Exp × Data Mgmt Skill Share			12.122**
			(2.339)
Data Mgmt Skill Share			-3.815
			(-1.644)
R-squared	0.05	0.11	0.12
Observations	2085	1910	2043

What is the impact of Generative AI on Labor?

CEOs have realized that Generative AI will affect labor needs



Source: Fortune, Goldman Sachs Global Investment Research

Labor Impact: Complement or substitute to workers?

Important to distinguish between Gen. AI **complementing or substituting** workers

- **Substitute:** can use Gen. AI *instead* of worker $\Rightarrow$ **lower** labor demand and wages
- **Complement:** Gen. AI used *by* the worker increases productivity $\Rightarrow$ **higher** labor demand and wages
- *Example:* computer-based automation substituted for routine-task occupations in offices and factories in the 2000s, but complemented non-routine analytical occupations

We **distinguish impact** by which tasks in an occupation Gen. AI makes more productive:

- **Core tasks (key for performing the function):** high potential for replacement by Gen. AI or colleagues supported by Gen. AI
- **Supplemental tasks:** worker still needed for key occupational functions; worker more effective but not easily replaced.

More exposed firms reduce hiring for exposed roles

Data on job postings for highest exposure occupations—test for change after ChatGPT:

$$\text{High-Exp Job Posting}_{firm,t} = \beta \text{Post-ChatGPT}_t \times \text{GenAI Exp}_{firm} + \text{FEs} + \varepsilon_{firm,t},$$

Panel:	Firm×Month		Firm×Qtr	
Job category:	ln(Highest Exp. Terc. Jobs)		Gross Profitability	
	(1)	(2)	(3)	(4)
Post × GenAI Exp	-1.378***	-3.038***	0.016**	0.056***
	(-3.747)	(-2.991)	(2.265)	(3.189)
Post × ShareSupp		-2.302**		0.059**
		(-2.029)		(2.007)
Post × GenAI Exp × ShareSupp		8.100**		-0.231***
		(2.037)		(-2.946)
Observations	36,900	36,880	14,621	14,614
Month FE	X	X	X	X
Firm FE	X	X	X	X
Total Firm Job Postings	X	X		

Gen AI exposure affects core tasks ⇒ hiring impact more negative, firm profits higher

Wages and hiring have declined more for more exposed occupations

Estimate wage / job posting change in monthly data Jan. 2019 - July 2023:

$$\ln(wage_{i,t}) = \alpha_{occ} + \alpha_t + \chi \mathbb{1}[\text{Post-ChatGPT}]_t \times [\text{Gen. AI Exposure}]_{occ} + \gamma' X + \text{FEs} + \varepsilon_{it},$$

Panel Unit:	Occ. × Month		Worker× Month	
Dep var.:	ln(Job Postings)		ln(Wage)	
	(1)	(2)	(3)	(4)
Post × GenAI Exp	-0.382***	-0.636***	-0.031**	-0.058***
	(-4.035)	(-4.955)	(-2.573)	(-3.868)
Post × ShareSupp		-0.274***		0.003
		(-2.830)		(0.218)
Post × GenAI Exp × ShareSupp		0.943***		0.079*
		(3.410)		(1.747)
Observations	43,512	36,176	271,000	247,362
Occupation FE	X	X	X	X
Month FE	X	X	X	X
CBSA FE			X	X
Individual Characteristics			X	X

Worker-level controls: age, age aquared, experience, experience squared, race, education

Gen AI exposure affects core tasks ⇒ hiring impact is more negative, wages decline more.

Summary: economic impact of Gen. AI so far

- Large technological shock with widespread immediate positive impact on firm values
- Higher impact on white-collar jobs, high-skilled, high-wage occupations
- Short-run impact on workers seems negative (fewer jobs, lower wages), but...
  - ...early adoption of Gen. AI by firms may differ from later adoption
  - "point solution" vs. "system solution" (Agrawal, Gans, Goldfarb)
  - "so so technology" (Acemoglu & Restrepo) - early use cases may be replacement rather than innovation
- Importance of data for realizing value of Gen. AI might impact adoption patterns...
  - Delay in adoption for companies catching up in data infrastructure?
  - Increasing concentration of AI in few companies due to "data flywheel"—better data $\Rightarrow$ better AI $\Rightarrow$ more customers $\Rightarrow$ better data...?

What's on the horizon?

- **Robotics:** likely "humanoid robots" in daily life very soon, filling grocery shelves, making delivery...
- **Interactive infrastructure:** We will soon be talking to buildings, statues, doors, drones, etc. - the elevator can be the receptionist
- **Personalized AI assistants:** chat bots that can assist the elderly, while also gossiping about the neighbors, order their groceries, email their grandchildren, and analyze their vitals for a remote medical check-up
- Health care, Biotech research, autonomous vehicles, surveillance, entertainment, content creation, etc. all poised for large disruptions in coming years
- That's just with current models, but better versions are likely coming soon...

Thank you for listening!

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