AI and Jobs: Has the Inflection Point Arrived?

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Agenda

Job = Task Set

Twenty-nine Tasks Associated with the Occupation of Radiologist

1. Obtain patients' histories from electronic records, patient interviews, dictated reports, or by communicating with referring clinicians.
2. Prepare comprehensive interpretive reports of findings.
3. Perform or interpret the outcomes of diagnostic imaging procedures including magnetic resonance imaging (MRI), computer tomography (CT), positron emission tomography (PET), nuclear cardiology treadmill studies, mammography, or ultrasound.
4. Review or transmit images and information using picture archiving or communications systems.
5. Communicate examination results or diagnostic information to referring physicians, patients, or families.
6. Evaluate medical information to determine patients' risk factors, such as allergies to contrast agents, or to make decisions regarding the appropriateness of procedures.
7. Provide counseling to radiologic patients to explain the processes, risks, benefits, or alternative treatments.
8. Instruct radiologic staff in desired techniques, positions, or projections.
9. Confer with medical professionals regarding image-based diagnoses.
10. Coordinate radiological services with other medical activities.
11. Document the performance, interpretation, or outcomes of all procedures performed.
12. Establish or enforce standards for protection of patients or personnel.
13. Develop or monitor procedures to ensure adequate quality control of images.
14. Recognize or treat complications during and after procedures, including blood pressure problems, pain, oversedation, or bleeding.
15. Administer radiopaque substances by injection, orally, or as enemas to render internal structures and organs visible on x-ray films or fluoroscopic screens.
16. Participate in continuing education activities to maintain and develop expertise.
17. Participate in quality improvement activities including discussions of areas where risk of error is high.
18. Supervise and teach residents or medical students.
19. Implement protocols in areas such as drugs, resuscitation, emergencies, power failures, or infection control.
20. Schedule examinations and assign radiologic personnel.
21. Provide advice on types or quantities of radiology equipment needed to maintain facilities.
22. Participate in research projects involving radiology.
23. Perform interventional procedures such as image-guided biopsy, percutaneous transluminal angioplasty, transhepatic biliary drainage, or nephrostomy catheter placement.
24. Administer or maintain conscious sedation during and after procedures.
25. Interpret images using computer-aided detection or diagnosis systems.
26. Serve as an offsite teleradiologist for facilities that do not have on-site radiologists.
27. Develop treatment plans for radiology patients.
28. Treat malignant internal or external growths by exposure to radiation from radiographs (x-rays), high energy sources, or natural or synthetic radioisotopes.
29. Conduct physical examinations to inform decisions about appropriate procedures.

Source: Agrawal et al. (2019)

A cognitive task, or task, is a function f mapping task input X to certain desirable output $Y = f(X)$, or a distribution $Y \sim f(X)$.

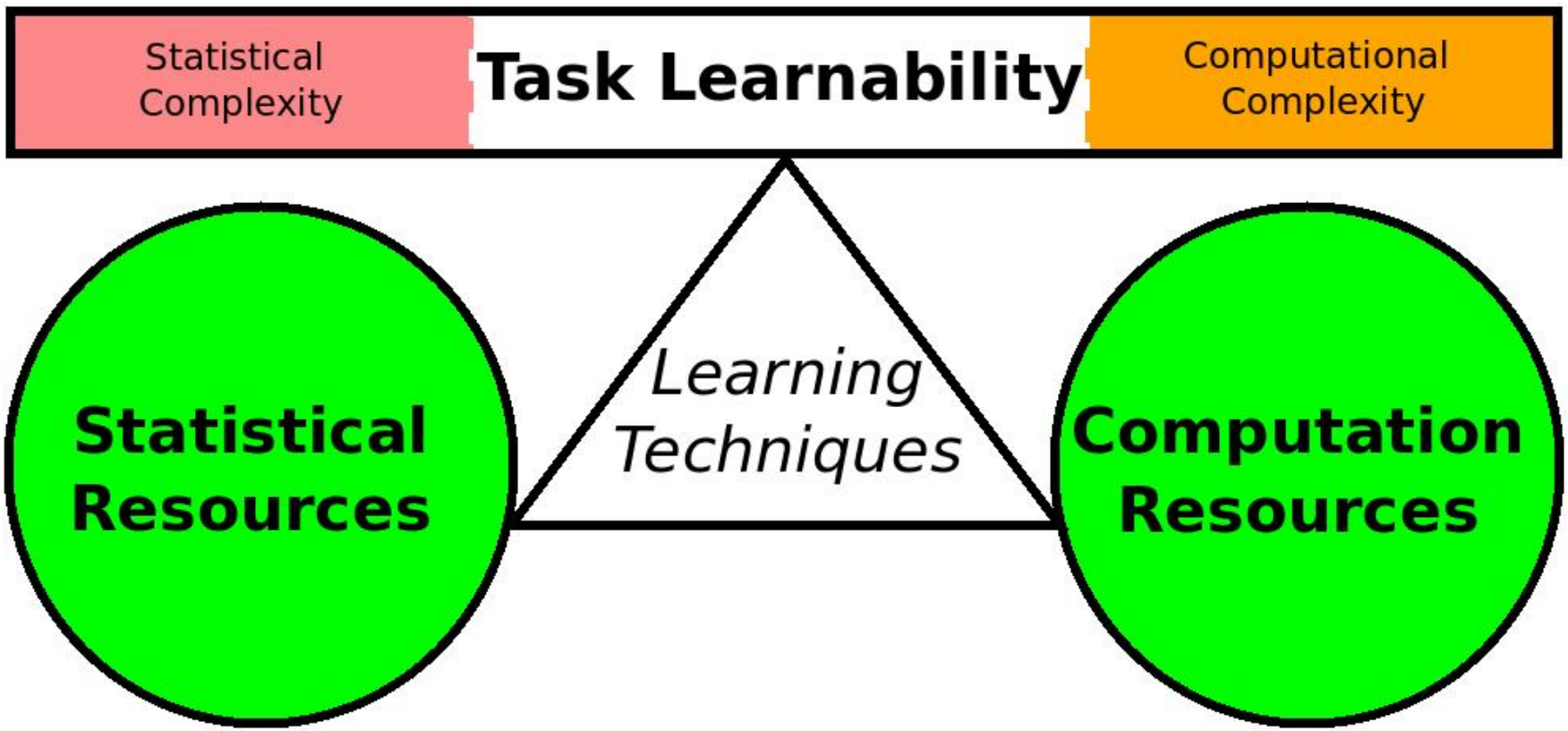
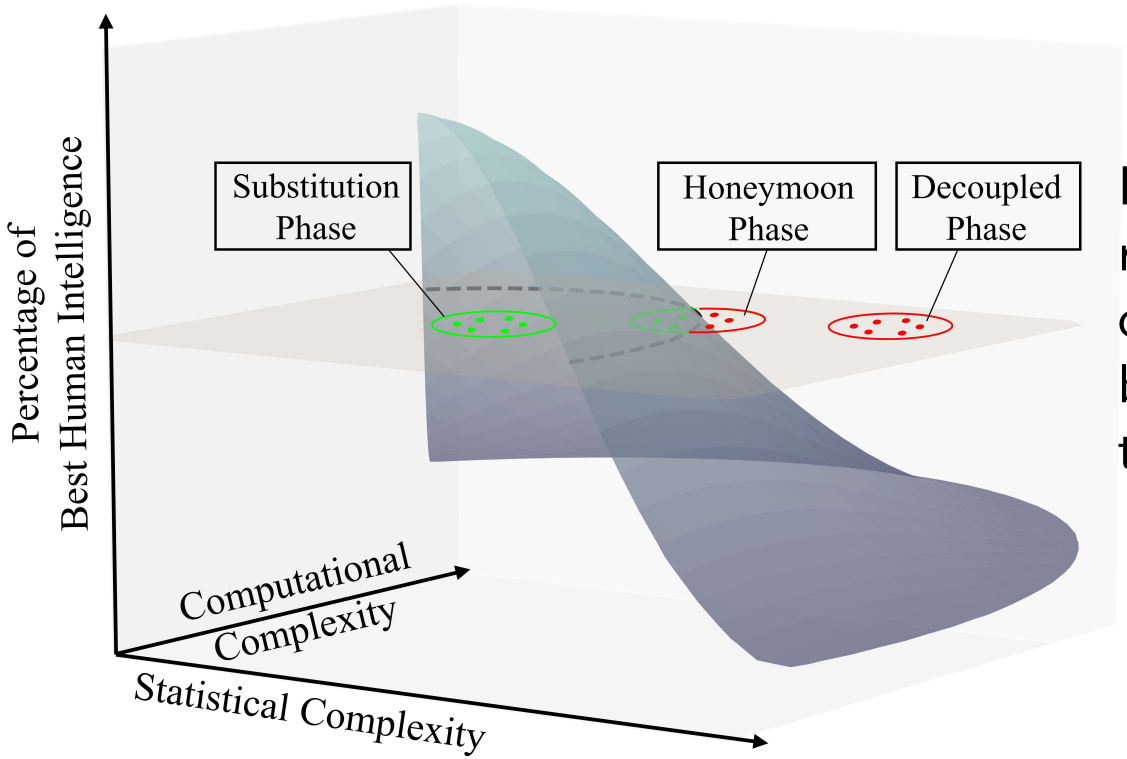


Figure: Understanding AI Progress through the Lens of 4 Factors

The 3 Phases of AI-Job Relationship

For a task to be satisfactorily completed by an AI, the AI performance needs to surpass a certain threshold. Conceptualize a minimal intelligence surface to represent this threshold for various tasks on the task plane.



Different organizations and regions may have different current intelligence surfaces because technology diffusion takes time.

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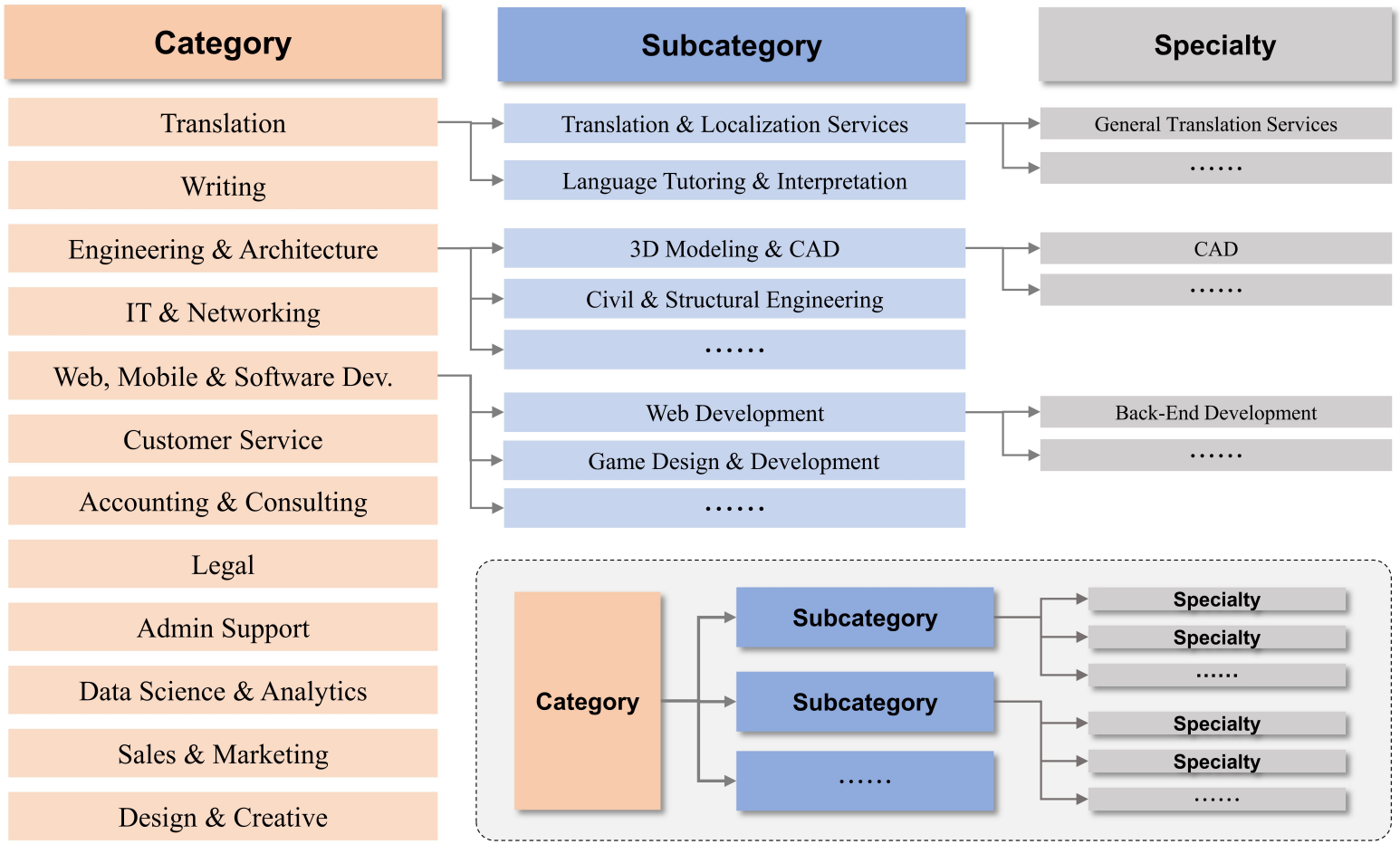
Empirical Context — An Online Freelancer Platform



Translation

- Language Localization, General Translation Services
- Technical Document Translation, Legal Document Translation
- Medical Document Translation

Web development

- Back-End Development
- Front-End Development
- Full Stack Development

Construction Design

- one of the least impacted industries by ChatGPT
- slow rate of digitalization
- fragmented structure
- reliance on specialized skills

We identified workers engaging in each of the three OLM and collected data during the sample period of

- 6 months before the shock: 2022/5 — 2022/10
- 10 months after the shock: 2023/1 — 2023/10

Variable	Definition
$Fjobearn_{it}$	worker i's earnings from focal jobs accepted in month t
$Fjobnum_{it}$	worker i's accepted number of focal jobs in month t
$Fjobratio_{it}$	worker i's ratio of focal jobs to all jobs in month t
$Fjobprice_{it}$	worker i's average price per focal job accepted in month t
$Fjobrating_{it}$	worker i's average rating of focal jobs accepted in month t
$Fhourprice_{it}$	worker i's average hourly rate from focal jobs accepted in month t
$Experience_{it}$	number of months since worker i's registration by month t

Measure	Count	Mean	Std. dev.	Min	Max
Construction Design OLM					
$Fjobearn_{it}$	86688	181.289	1244.317	0.000	66754.383
$Fjobnum_{it}$	86688	0.308	0.980	0.000	43.000
$Fjobratio_{it}$	86688	0.158	0.352	0.000	1.000
$Fjobprice_{it}$	14312	705.461	2261.041	1.000	66754.383
$Fhourprice_{it}$	5442	26.101	17.354	3.000	180.000
$Fjobrating_{it}$	8445	4.873	0.430	1.000	5.000
$Tenure_{it}$	86688	32.626	30.318	0.000	230.000
Translation & Localization OLM					
$Fjobearn_{it}$	91744	111.641	747.553	0.000	46785.879
$Fjobnum_{it}$	91744	0.433	1.473	0.000	124.000
$Fjobratio_{it}$	91744	0.169	0.356	0.000	1.000
$Fjobprice_{it}$	17449	319.918	1085.959	0.650	43915.000
$Fhourprice_{it}$	4793	21.613	15.023	3.000	500.000
$Fjobrating_{it}$	9726	4.926	0.329	1.000	5.000
$Tenure_{it}$	91744	38.929	33.022	0.000	197.000
Web Development OLM					
$Fjobearn_{it}$	172448	646.368	4439.452	0.000	294652.500
$Fjobnum_{it}$	172448	0.399	1.093	0.000	45.000
$Fjobratio_{it}$	172448	0.221	0.406	0.000	1.000
$Fjobprice_{it}$	35398	2226.121	7684.738	1.000	294652.500
$Fhourprice_{it}$	20019	29.062	22.495	3.000	500.000
$Fjobrating_{it}$	25458	4.851	0.491	1.000	5.000
$Tenure_{it}$	172448	45.559	38.651	0.000	280.000

Note: If worker i does not accept any focal jobs in month t, $Fjobprice_{it}$, $Fhourprice_{it}$, and $Fjobrating_{it}$ would be recorded as a null value, and $Fjobratio_{it}$ would be recorded as zero.

	Prematching				Postmatching			
	Mean treated	Mean control	t-test $p > \|t\|$	Std. diff.	Mean treated	Mean control	t-test $p > \|t\|$	Std. diff.
Accumulative *Fjobnum*	3.153	2.659	0.000	0.412	3.019	2.993	0.504	0.022
Accumulative *Experience*	3.628	3.327	0.000	0.344	3.518	3.556	0.174	-0.044
Average *Fjobprice*	5.423	5.994	0.000	-0.462	5.620	5.630	0.787	-0.009
Average *Fhourprice*	2.760	2.893	0.000	-0.241	2.803	2.785	0.312	0.033
Average *Fjobrating*	4.913	4.857	0.000	0.202	4.908	4.895	0.116	0.045

	Prematching				Postmatching			
	Mean treated	Mean control	t-test $p > \|t\|$	Std. diff.	Mean treated	Mean control	t-test $p > \|t\|$	Std. diff.
Accumulative *Fjobnum*	2.777	2.659	0.000	0.106	2.844	2.834	0.747	0.009
Accumulative *Experience*	3.516	3.328	0.000	0.202	3.477	3.463	0.575	0.015
Average *Fjobprice*	6.940	5.991	0.000	0.645	6.409	6.394	0.632	0.010
Average *Fhourprice*	2.975	2.892	0.000	0.144	2.905	2.914	0.554	-0.016
Average *Fjobrating*	4.852	4.857	0.377	-0.020	4.853	4.861	0.284	-0.028

Figure: Translation OLM (top); Web development OLM (bottom)

$$Y_{it} = \beta_0 + \beta_1 \times ChatGPT_{it} + \beta_2 \times X_{it} + \eta_i + \tau_t + \epsilon_{it}$$

	Variables		
	(1) log(Fjobnum)	(2) Fjobratio	(3) log(Fjobearn)
ChatGPT	-0.094***	-0.057***	-0.353***
	(0.014)	(0.011)	(0.072)
Observations	36416	36416	36416
N	2276	2276	2276
Adjusted R^2	0.469	0.272	0.344

	Variables		
	(1) log(Fjobnum)	(2) Fjobratio	(3) log(Fjobearn)
ChatGPT	0.062***	0.064***	0.510***
	(0.011)	(0.010)	(0.065)
Observations	50224	50224	50224
N	3139	3139	3139
Adjusted R^2	0.357	0.213	0.269

Figure: Translation (top); Web Development (bottom)

Note: The unit of analysis is worker-month. (1) *p<0.1, **p<0.05, ***p<0.01; (2) Clustered standard errors are in the parentheses; (3) We control for time fixed effect, worker fixed effect and worker tenure.

	Translation & Localization Jobs			Web Development Jobs		
	(1)	(2)	(3)	(4)	(5)	(6)
	log(Fjobnum)	Fjobratio	log(Fjobearn)	log(Fjobnum)	Fjobratio	log(Fjobearn)
Rel Time (t-6)	-0.036	-0.026	-0.155	-0.012	-0.009	-0.098
	(0.027)	(0.024)	(0.150)	(0.022)	(0.022)	(0.145)
Rel Time (t-5)	0.005	0.035	0.250	-0.021	-0.010	-0.117
	(0.028)	(0.025)	(0.158)	(0.023)	(0.022)	(0.145)
Rel Time (t-4)	-0.011	0.015	0.069	0.001	0.000	-0.046
	(0.025)	(0.024)	(0.145)	(0.021)	(0.022)	(0.145)
Rel Time (t-3)	0.013	0.028	0.089	0.027	0.024	0.143
	(0.025)	(0.023)	(0.140)	(0.022)	(0.021)	(0.145)
Rel Time (t-2)	0.005	0.027	0.165	0.013	0.005	0.102
	(0.023)	(0.022)	(0.137)	(0.020)	(0.020)	(0.134)
Rel Time (t)	-0.077***	-0.025	-0.251*	0.070***	0.077***	0.554***
	(0.026)	(0.023)	(0.149)	(0.022)	(0.021)	(0.143)
Rel Time (t+1)	-0.079***	-0.033	-0.196	0.055***	0.052**	0.432***
	(0.024)	(0.022)	(0.135)	(0.021)	(0.021)	(0.134)
Rel Time (t+2)	-0.067***	-0.025	-0.170	0.066***	0.064***	0.504***
	(0.026)	(0.022)	(0.138)	(0.022)	(0.021)	(0.143)
Rel Time (t+3)	-0.110***	-0.054**	-0.352**	0.044**	0.060***	0.401***
	(0.025)	(0.022)	(0.143)	(0.022)	(0.021)	(0.143)
Rel Time (t+4)	-0.096***	-0.040*	-0.255*	0.060***	0.070***	0.540***
	(0.025)	(0.024)	(0.148)	(0.021)	(0.021)	(0.138)
Rel Time (t+5)	-0.095***	-0.042*	-0.301**	0.047**	0.044**	0.336**
	(0.027)	(0.024)	(0.147)	(0.023)	(0.022)	(0.150)
Rel Time (t+6)	-0.096***	-0.052**	-0.276**	0.068***	0.069***	0.566***
	(0.025)	(0.022)	(0.137)	(0.021)	(0.021)	(0.137)
Rel Time (t+7)	-0.105***	-0.052**	-0.364***	0.062***	0.056***	0.559***
	(0.025)	(0.023)	(0.140)	(0.023)	(0.022)	(0.143)
Rel Time (t+8)	-0.134***	-0.063***	-0.372***	0.074***	0.091***	0.632***
	(0.025)	(0.022)	(0.135)	(0.023)	(0.022)	(0.146)
Rel Time (t+9)	-0.123***	-0.053**	-0.296**	0.084***	0.071***	0.542***
	(0.025)	(0.022)	(0.135)	(0.022)	(0.022)	(0.142)

Robustness Checks

	Translation & Localization Jobs			Web Development Jobs		
	(1)	(2)	(3)	(4)	(5)	(6)
	log(Fjobnum)	Fjobratio	log(Fjobearn)	log(Fjobnum)	Fjobratio	log(Fjobearn)
ChatGPT	-0.064***	-0.038**	-0.277***	0.042**	0.052***	0.382***
	(0.020)	(0.016)	(0.104)	(0.017)	(0.015)	(0.103)
Observations	36416	36416	36416	50224	50224	50224
N	2276	2276	2276	3139	3139	3139
Adjusted R^2	0.469	0.272	0.344	0.357	0.213	0.269

Figure: market-specific trends

Additional robustness check: generalized synthetic control method

Agenda

A Cournot Model of Freelancer Market

There are n workers each producing the same type of service with the same marginal cost $(1-a)c$ with $c > 0$.

- $a \in [0,1]$: AI level for the focal job, interpreted as the percentage of tasks that can be satisfactorily completed by AI for the production of the service.
- q_i: the quantity of services produced by worker i
- $p = S(a) - \sum_i q_i$: market demand for the focal job
- $S(a)$: market potential, **decreasing** and **concave**
  - For more AI literate potential employers, their CIS are above the minimal intelligence surface for the focal job.
  - As AI matures, i.e., increase in a, more potential employers become AI literate, lifting their CIS.
  - Technology adoption often accelerates over time (e.g., S-curve) due to word-of-mouth before it eventually saturates.

Consider the more interesting case with $|S'(0)| < c$ and $|S'(1)| > c$.

Each worker maximizes profit $\pi_i = pq_i - (1-a)cq_i$ by choosing the service quantity. In equilibrium,

$$q_i^* = \frac{S(a)-(1-a)c}{n+1}, \qquad \pi_i^* = \left(\frac{S(a)-(1-a)c}{n+1}\right)^2$$

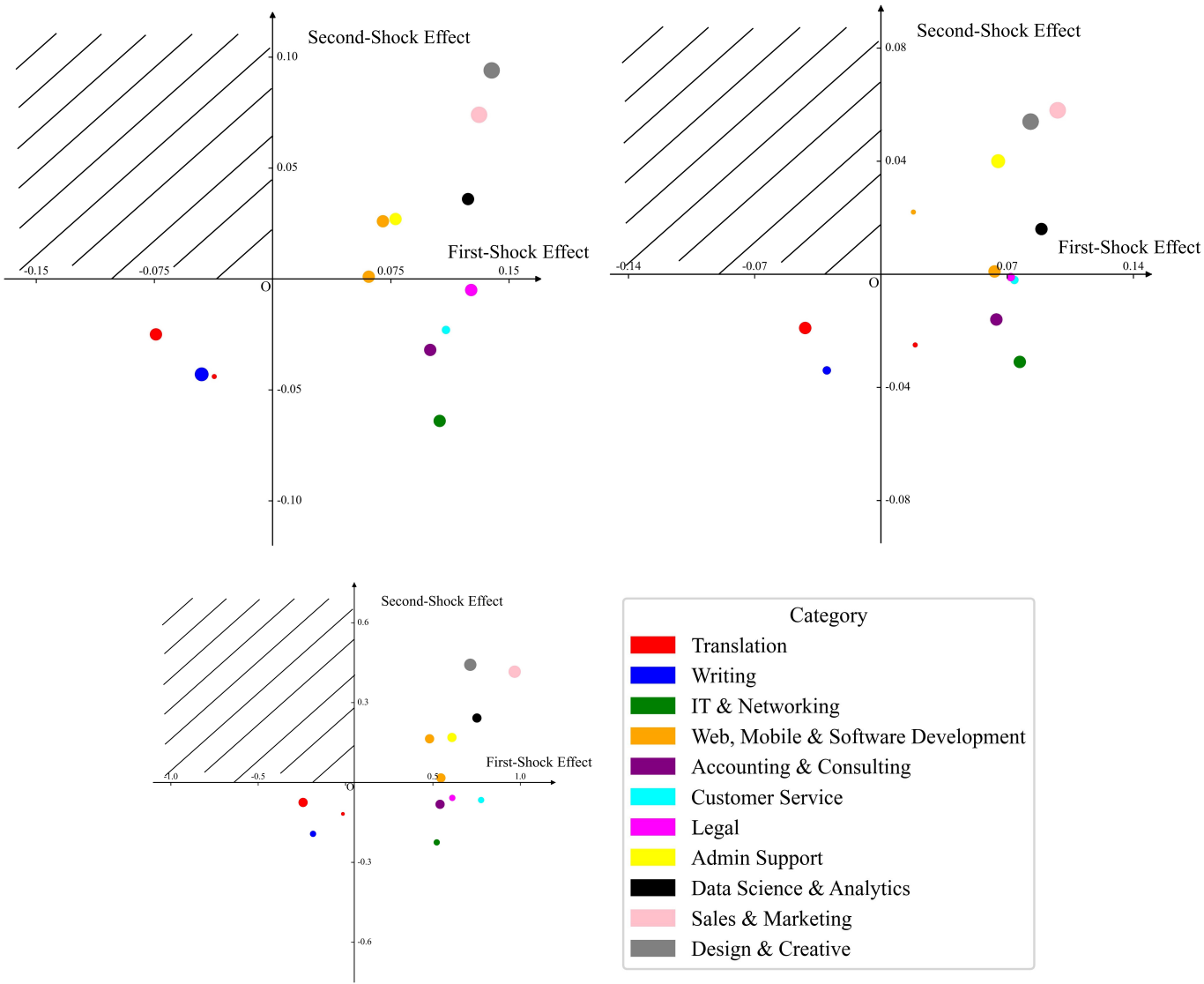
$$\frac{\partial q_i^*}{\partial a} = \frac{S'(a)+c}{n+1}, \qquad \frac{\partial \pi_i^*}{\partial a} = 2\pi_i^* \frac{S'(a)+c}{n+1}$$

Define the **inflection point** for the focal job as the unique solution $a^* \in (0,1)$ of the equation $S'(a)+c=0$. Both q_i^* and π_i^* increase in a when $a < a^*$ but decreases in a when $a > a^*$.

Inflection Point Conjecture

Each worker enjoys higher job volume and more profit whenever AI level increases, up to the point of a^*, after which further increase in AI level reduces both job volume and profit. Moreover, a worker's revenue also decreases in AI level after it crosses the inflection point (i.e., $a > a^*$).

$$Y_{it} = \beta_0 + \beta_{1,1} \times ChatGPT3.5_{it} + \beta_{1,2} \times ChatGPT4.0_{it} + \beta_2 \times X_{it} + \eta_i + \tau_t + \epsilon_{it}$$



Agenda

Conclusions

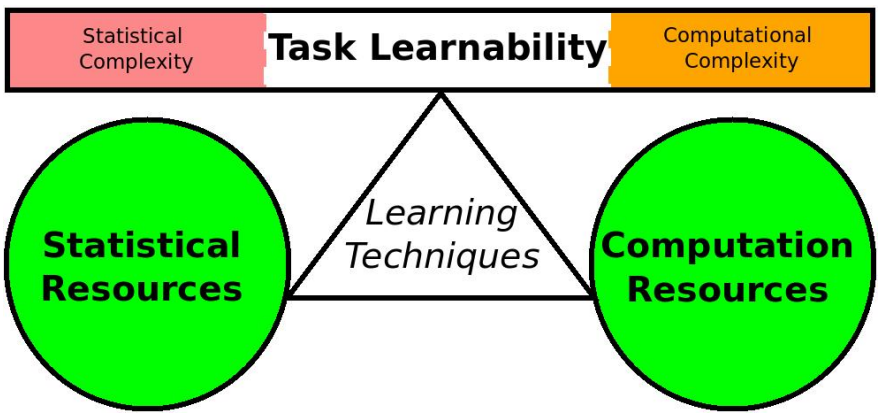
Contributions

- Theoretically, we proposed the inflection point conjecture, contrasting the effect of AI on workers/jobs in two distinct phases.
- Empirically, we leveraged the releases of ChatGPT to test the conjecture, using data from a large online labor market.
- By evaluating the dynamic relations between AI and jobs, we offer insights to future workers in the age of rapid AI progresses.

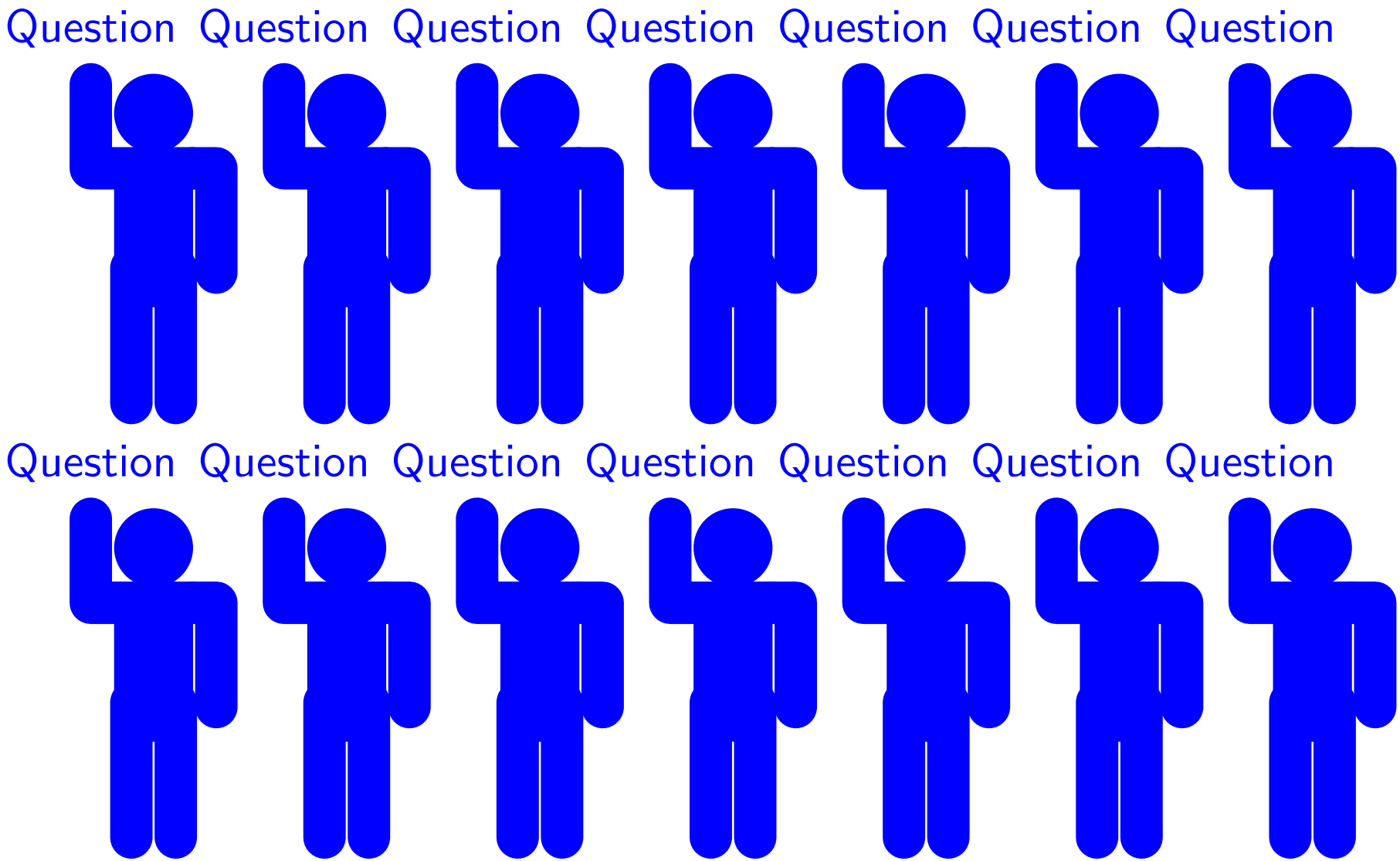
Limitations

- empirical robustness
- ultra-freelance economy: *tasklization*

AI-Proof Jobs?



- **S**urprise: jobs requiring unexpected thinking (e.g., researchers?)
- **E**motion: jobs involving the satisfaction of humans' emotional needs for human.
- **AI**: development & maintenance of AI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