Artificial Intelligence and High-Skilled Work: Evidence from Analysts

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Motivation

- AI is a powerful form of automation that improves prediction and programs machines to act more like humans.
  - Many applications, making AI the most important general-purpose technology of this era (Bynjolfsson and McAfee, 2014).
  - In 2019, firm investment in AI exceeded $70 billion and AI-related startups raised $40 billion.

- Advances in AI raise questions about the future of work, what it will look like, and if any policy interventions are needed.
  - Rich literature on other technologies (Bresnahan et al., 2002; Autor et al., 2003; Bessen et al., 2019, Humlum, 2019; Koch et al., 2019).
  - Yet AI may be fundamentally different, especially for high-skilled workers (Acemoglu and Restrepo, 2019). Further, high-tech adoption usually made by incumbent firms yet not for AI.

Research Question

"With 80% of the data in the world created in the last two years, judgment matters more than ever. Technology is a complement to sound judgment and knowledge, not a substitute."

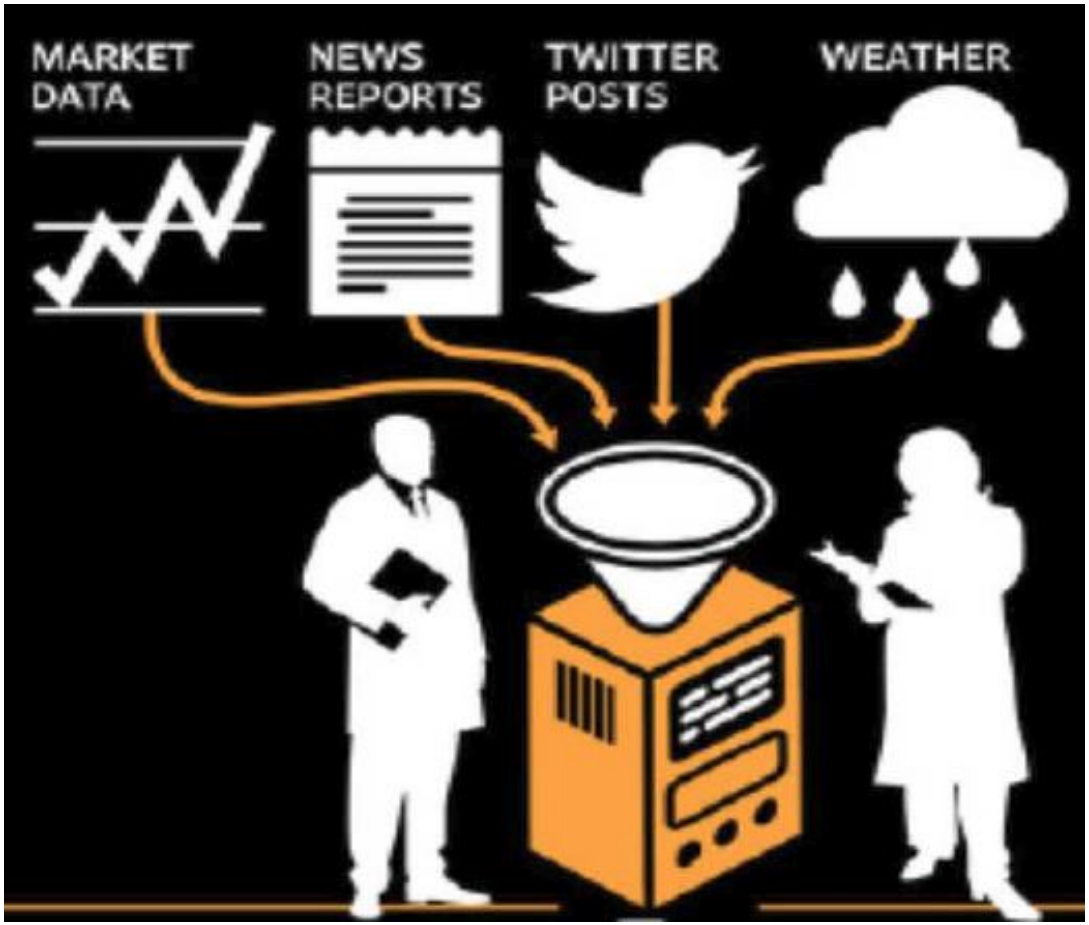
– Joyce Chang, Global Head of Research, J.P. Morgan

RQ: Given that AI and big data enhance prediction, what are the implications for incumbent workers traditionally tasked with prediction work?

Stock analyst context: advantage is well-defined prediction problem (i.e., forecast stock price/earnings), detailed data about performance and tasks requiring both soft and hard skills, and meaningful variation in AI intensity.

Many Firms Using AI to Do What Analysts Do

Rapidly expanding set of FinTechs streamlining and synthesizing many data sources relevant for investment recommendations.



Testable Hypotheses for Analysts' Response

We rely on a task-based framework (Autor, Levy, and Murnane, 2003) to develop the hypotheses:

Substitutes: Are analysts switching careers? Are they switching coverage to low-AI analyst stocks?

Complementary tasks: Does AI free up time for analysts to focus on their competitive advantage over AI (e.g., gathering of soft information, social skills)?

Product quality: Do analysts change the quality of their work product (i.e., earnings forecast)? If so, what economic channel is driving this change (e.g., effort vs. strategic change)?

Preview of Main Findings

1. **Substitutes:** Yes, analysts, especially highly-skilled ones, leave the profession and those that stay shift coverage to low AI stocks.

2. **Complementary tasks:** Yes, analysts turn to their soft skills. They increase meetings with management and investors and change the type of questions they ask on earnings calls.

3. **Product quality:** Quality improves. Increased effort and strategic motives play a role.

4. **Implications:** For overall efficiency gains, evidence consistent with substitution effect offseting some of the individual efficiency gains. For overall earnings, some indirect evidence consistent with decreased earnings for analysts.

Background

How Company Information Disseminates

Internal sources

- Company's public relations, reports to S.E.C.
- Insiders' and company's actions (e.g., insider trading, decisions to issue new bonds or equity)

External sources

- **Sell-side analysts (e.g., work for big banks or boutique brokerages)**
- Buy-side analysts (e.g., typically work for active mutual funds, hedge funds, etc.)
- Credit rating agencies
- Newspaper and other media outlets
- Indirectly (customers, twitter, satellite images, etc..)

Sell-side Analysts' Job Description

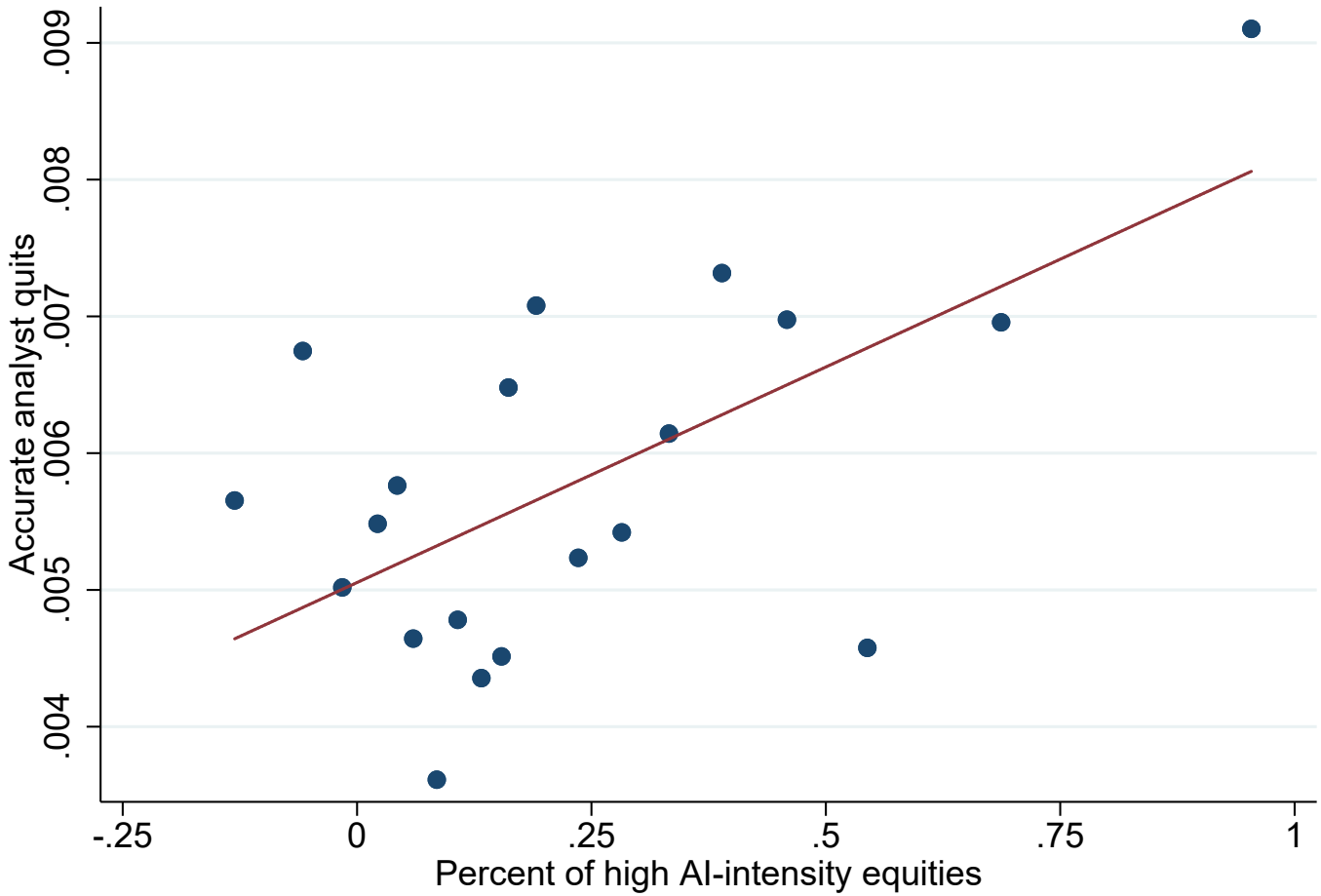
- Sell-side security analysts provide investment information through
  - Research reports
  - Earnings estimates
  - Stock recommendations (e..g, Buy or Hold)
- Analysts issue Upgrades and Downgrades of recommendations when their valuations are different from that of the market
- Given that new information is valuable to investors, analysts' efforts go toward uncovering new information and/or a different proprietary angle on the company

In the U.S., the Typical Analyst

- Is part of a cost center rather than a profit center
- Covers 10 to 15 stocks
- Covers a few industries
- Has to clear their recommendations through an internal committee because of conflicts of interest
- Has a "fiduciary responsibility" to investing clients
- Compensation is related to "abnormal trading volume" which is related to the "value" the analyst brings to clients
- The "value" is based on (i) accuracy of forecasts and recs, (ii) access to firms' management, and (iii) soft information

Consequences of AI: From All-Star to Jobless?!

Accurate Analyst Quitting vs. AI Intensity



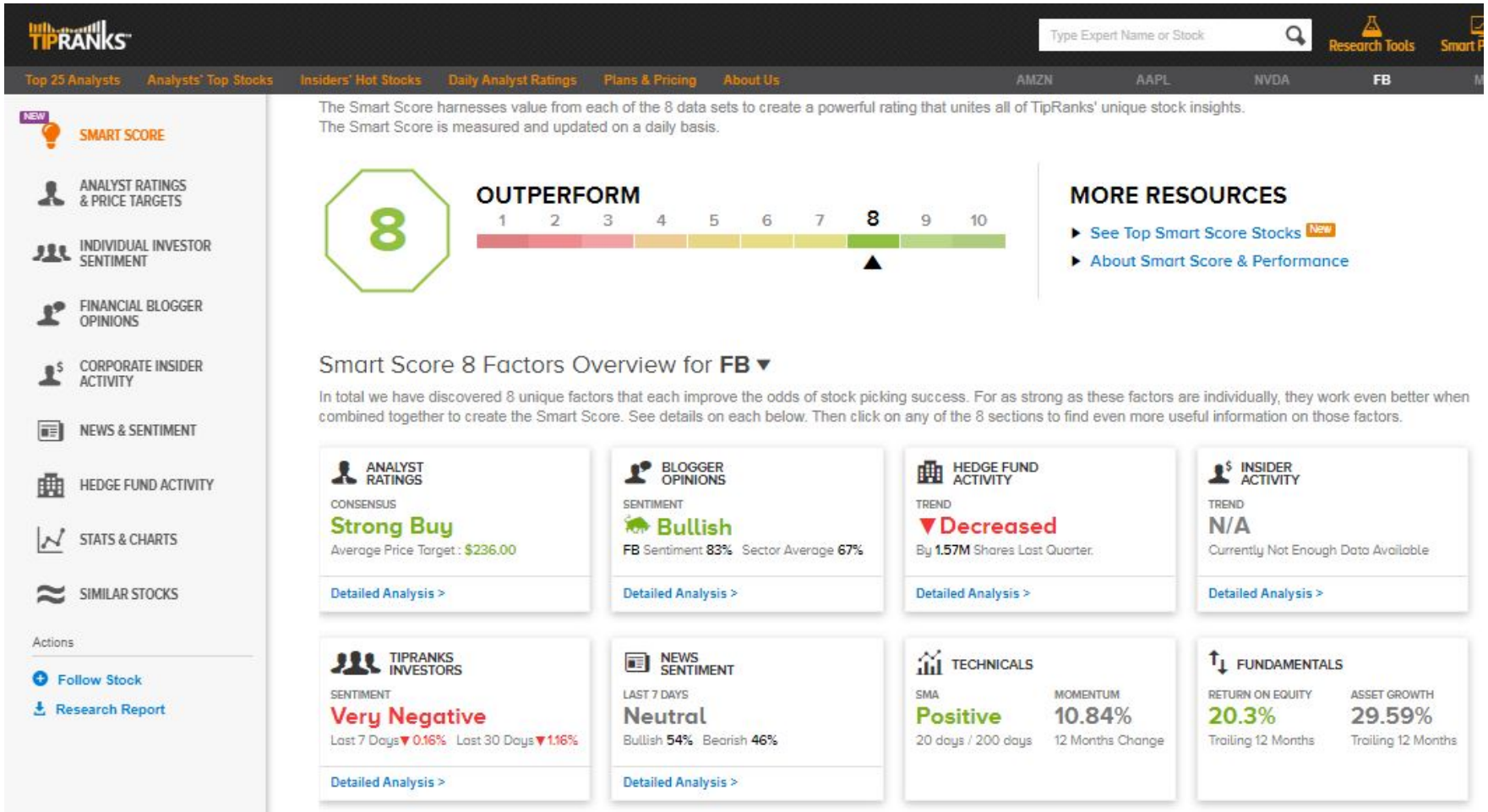
Source: Quarterly-analyst observations, controlling for workload, experience, reputation, and time.

Empirical Strategy

Roadmap of Empirical Strategy

- Measure of AI Intensity
- Regressions Linking AI Intensity to Analysts Jobs
- Instrument for AI Intensity
- Exclusion Restriction
- Relevance Condition

FinTech's AI-Powered Tools Provide Valuable Insights



Measure of AI Intensity

- AI intensity is the quantity of social media data TipRanks processes for a given stock in a quarter.
  - To put in perspective, Apple, Facebook, and Tesla get disproportionate social media attention (100x relative to household names like Starbucks or Coca-Cola).
  - Our sample covers 2010-2017. Social media data being processed roughly tripled over this time period.
- AI intensity matters to analysts even if they don't pay attention to social media.
  - Why? Social media produces "crowd wisdom" which is incorporated into prices via trades. So even if analysts don't pay attention to social media, they will "feel the pressure" because it will be harder for them bring "value" to clients (i.e., unique trading angles on a stock).

Linking AI Intensity to Analyst's Jobs

We analyze data at three levels: i = stock, j = analyst, b = *employer*, t = quarter

1. Analyst level:

$$Quits_{jt} = \beta High\_AI\_portfolio_{jt} + \Gamma X_{jt} + \kappa_b + \delta_t + \epsilon_{jt}$$

2. Analyst-stock level:

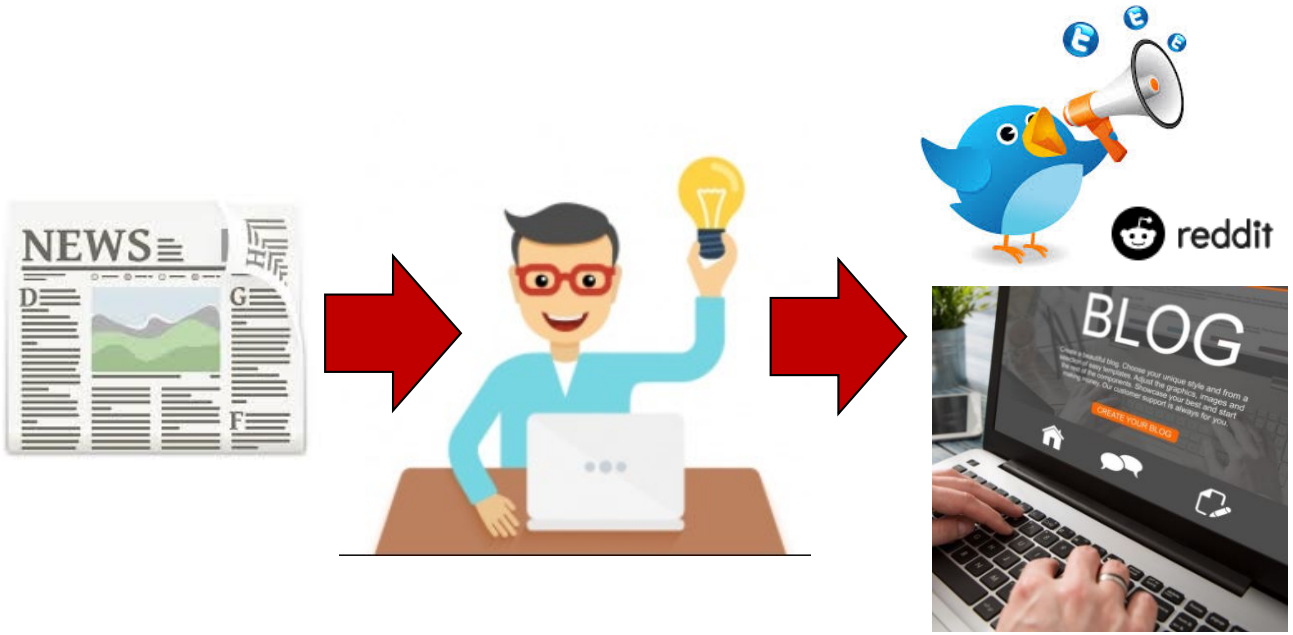
$$Accurate\_Forecast_{ijt} = \beta AI\_Intensity_{ijt} + \Gamma X_{ijt} + \theta_i + \alpha_j + \delta_t + \epsilon_{ijt}$$

3. Stock level:

$$Meetings_{it} = \beta AI\_Intensity_{it} + \Gamma X_{it} + \theta_i + \delta_t + \epsilon_{it}$$

Short Headline Length as an IV for AI Intensity

- Short news headlines attract attention, ultimately leading to more social media posts.



- Headline length quasi-random since advertisement sales for print editions determine headline length editor uses.
- Identification comes from incremental changes in social media data induced by short headlines.

Seemingly Random Variation in Headline Length

- Headlines ranging from 27 to 111 characters in length appearing in major U.S. newspapers after Wells Fargo scandal.
  - Wells Fargo Is Getting Heat
  - Wells Fargo Fined for Sales Scam
  - 5,300 Wells Fargo Staff Fired Over Bogus Accounts
  - Wells Fargo Fined $185m for Unauthorized Accounts
  - Wells Fargo Cuts Bank Sales Goals After $185m Fine for Fake Accounts
  - Wells Fargo Fined $185m Over Unauthorized Accounts That Harmed Customers
  - Wells Fargo to Pay $185 Million to Settle Allegations Its Workers Opened Fake Accounts
  - Wells Fargo Settled Over Its Bogus Accounts, but It Still Faces a Fight From Customers and Ex-Employees
  - Wells Fargo Fired 5,300 Workers for Improper Sales Push, the Executive in Charge Is Retiring With $125 Million

Exclusion Restriction and Headline Instrument (1)

- Worry that editor may exhibit selection bias by using short headlines for good companies. But evidence suggests headline length does not vary with stock characteristics.

	Dep. var. = Headline length
Log Market-to-Book	0.00
	(0.00)
Profitability	-0.53
	(0.77)
ROE	0.01
	(0.00)
Momentum	1.32*
	(0.79)
Firm Size	-0.02
	(0.05)
Adjusted R^2	0.1%
Observations	7,538,452

Exclusion Restriction and Headline Instrument (2)

- Worry that editor may exhibit selection bias by using short headline on more important news, but again, evidence suggests headline length orthogonal to news content.

Value-relevant events	Dependent variable = Headline length					
Any key event	0.22	-0.08				
	(0.29)	(0.10)				
Positive earnings surprise			-0.20	-0.39		
			(0.34)	(0.27)		
Negative earnings surprise			-0.83	-0.34		
			(0.76)	(0.54)		
Non-earnings event					0.42	0.13
					(0.31)	(0.10)
Firm controls	Y	Y	Y	Y	Y	Y
Quarter FE	Y	Y	Y	Y	Y	Y
Firm FE	N	Y	N	Y	N	Y
Adjusted R^2	9%	23%	9%	23%	9%	23%
Observations	431,710	431,240	431,710	431,240	431,710	431,240

Relevance of Headline Instrument

- Worry that short headlines induce social media posts but no info of value just tenth iteration of same idea.
- Growing literature in finance documenting "crowd wisdom" in social media posts (Da and Haung 2018, Cookson and Niessner, 2020, Grennan and Michaely, 2020, Da et al., 2020).
- We find significant increase in social media posts about a stock following a short newspaper headline in the USA Today. This holds even for those whose past posts consistently outperform the market.
- Is the short headline shock transient or more permanent? Both.

Testing Substitutes Hypothesis

Extensive Margin: Analyst Quits Job

- Analysts, especially highly skilled analysts, are more likely to quit when they cover more high-AI-intensity stocks.
- Point estimate suggests similar economic magnitude to work experience.
- Controls include work experience, reputation, and workload.

	Dep. var. = Quits	Dep. var. = Accurate and quits
% of stocks with high AI intensity	**0.028***	**0.068****
	(0.016)	**(0.021)**
Controls	Y	Y
Broker FE	Y	Y
Year FE	Y	Y
First-stage F statistic	1442.0	1442.0
t-statistic on IV	38.0	38.0
Analyst-quarter obs.	73,796	73,796

Where Do Analysts Go?

- For a random sample of 175 analysts that quit their job, we searched LinkedIn to find them. Full breakdown as follows:
  - Buy-side research (16.0%)
  - Corporate finance role (15.4%)
  - Asset management (14.3%)
  - Investor relations (12.0%)
  - Same firm, different role (10.3%)
  - FinTech (7.4%)
  - Entrepreneurship (7.4%)
  - Consulting (6.9%)
  - Corporate strategy (6.9%)
  - Other (4.0%)
- **Bottom line:** Talent is leaving. Many stay in research but some shift to other skills.

Intensive Margin: Initiates Stock Coverage

- Analysts are less likely to initiate coverage on stocks with high AI data intensity.
- Full set of stock, analyst, and news content controls.

Dep. var. = initiate stock coverage	(1)	(2)
AI intensity	**-0.040*** **	**-0.073*** **
	(0.014)	**(0.028)**
Controls	Y	Y
Analyst FE	Y	N
Stock FE	N	Y
Year FE	Y	Y
First stage *F*-statistic	76.4	54.1
t-statistic on IV	8.7	7.4
Analyst-stock-quarter obs.	244,214	244,979

Intensive Margin: Stops Covering Stock

- Analysts are more likely to stop covering stocks with high AI data intensity.
- Full set of stock, analyst, and news content controls.

Dep. var = stops stock coverage	(1)	(2)
AI intensity	**0.017*** **	**0.079*** **
	(0.006)	**(0.026)**
Controls	Y	Y
Analyst FE	Y	N
Stock FE	N	Y
Year FE	Y	Y
First stage *F*-statistic	108.7	72.4
t-statistic on IV	10.4	8.5
Analyst-stock-quarter obs.	632,962	633,225

Robustness: Zero-First-Stage Test

- **Intuition**: examine a subsample for which the first stage (IV on AI intensity) is likely to be 0, then look at the reduced form (IV on stock coverage) as it should be 0 too if the exclusion restriction is satisfied.
- **Subsample**: stocks in the lowest decile of market capitalization. Even if they have a short headline, little social media following to begin with so won't go viral.
- **Findings:** For the zero-first-stage subsamples, we see no effect. For the remaining subsamples, we see significant effects. Supports exclusion restriction assumption.

Summary: Substitution Hypotheses

- AI substitutes for high-skilled labor

  (i) Career switching, especially among top talent
  (ii) Stock coverage moves away from high-AI stocks

- Consistent with a rich literature on other tech (Lin, 2011, Acemoglu and Restrepo, 2017, Graetz and Michales, 2018, Bessen et al., 2019, Koch et al., 2019, Humlum, 2020).

- Nuance in this literature between early adopters vs. non-adopters, where ultimately, non-adopters lose employees as they reallocate to early adopters.

- Importantly, we see that with AI, where adoption is dictated by data and external competition, even top firms (adopting AI internally) are experiencing employee loss.

Testing Complementary Tasks Hypothesis

Bring in Novel Data for Testing Soft Skills

S&P
Capital IQ

Analysts' Focus On Earnings Call

- Evidence from earnings calls suggests AI intensity associated with increased efforts, especially toward complex/intangible topics.

Panel A. Analyst questions	Total questions (1)	Question complexity (2)
AI intensity	**0.082****	**0.088****
	(0.042)	**(0.043)**
Panel B. Question content	Easy-to-measure (1)	Hard-to-measure (2)
AI intensity	**-0.095***	**0.104***
	(0.051)	**(0.060)**
Controls	Y	Y
Stock FE	Y	Y
Year FE	Y	Y
First-stage *F* statistic	131.6	187.0
t-statistic on IV	11.5	13.7
Stock-quarter obs.	55,049	55,252

Analysts' Focus Shift to In-Person Meetings

- Evidence from meetings suggests AI intensity associated with increased focus on social skills.

	Total analyst meetings (1)	Meetings with management (2)	Meetings with investors (3)
% of stocks with high AI intensity	**0.137*** **	**0.114*** **	**0.167*** **
	(0.016)	**(0.017)**	**(0.015)**
Controls	Y	Y	Y
Broker FE	Y	Y	Y
Year FE	Y	Y	Y
First-stage *F* statistic	1470.0	1470.0	1470.0
t-statistic on IV	38.3	38.3	38.3
Analyst-quarter obs.	72,112	72,112	72,112

Analysts' Earnings Forecasts

- Within stock-analyst pairs over time, AI intensity associated with higher quality reports.
- Bold forecast consistent with both strategic (i.e., seeking attention) and effort mechanism.

	Dependent variable =				
	As % of consensus		As % of stock price		Bold
	Accuracy	Bias	Accuracy	Bias	forecast
	(1)	(2)	(3)	(4)	(5)
AI intensity	**0.145****	**-0.129****	**0.067***	**-0.126****	**0.126***
	(0.073)	**(0.059)**	**(0.039)**	**(0.050)**	**(0.065)**
Controls	Y	Y	Y	Y	Y
Analyst-by-stock FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
First-stage *F* statistic	71.7	71.7	72.0	72.0	71.7
t-statistic on IV	8.5	8.5	8.5	8.5	8.5
Analyst-stock-quarter obs.	564,173	564,173	593,433	593,433	564,173

Summary: Complementary Tasks and Product Quality

- AI complements soft-skill tasks

  (i) earnings call questions chage toward complex ideas
  (ii) shift to more meetings with management

- AI associated with improved product quality.

  Likely from soft-skill effort but cannot rule out strategic motives.

- Consistent with AI enhancing capabilities rather than replacing them (Bessen et al. 2019, Acemoglu and Restrepo, 2019).

- Supports the increased importance of non-cognitive skills (Heckman and Kautz, 2012, Castex and Dechter, 2014, Deming, 2017).

Implications

Motivation for Extending the Analysis

- Most policy debates about impact of AI on productivity, efficiency, and quality at expense of overall unemployment.
  - While we find AI substitutes for high-skilled analysts, it also enables high-skilled analysts that remain to put effort toward complementary tasks.
  - To think about overall relationship between AI and quality, we aggregate to the stock level and find the change in talent pool offsets individual improvements in product quality.
- AI is happening in a period of growing economic inequality. To inform debates about impact of AI on the wage distribution, we extend our analysis to explore some indirect evidence next.

Market Reaction and Implication for Earnings

- While earnings data is unavailable for analysts, their incentive pay is linked to excess trading.
- Higher AI data intensity is associated with lower excess trading, which suggests lower pay.

	Dep. var. = Excess Returns		Dep. var. = Excess Volume	
Market reaction	[0,1]	[0,5]	[0,1]	[0,5]
AI intensity	**-0.24%*** **	**-0.27%*** **	**-0.47*** **	**-0.034***
	(0.05%)	**(0.05%)**	**(0.10)**	**(0.19)**
Time FE	Y	Y	Y	Y
Analyst FE	Y	Y	Y	Y
Recommendation obs.	39,454	39,454	39,454	39,454

Conclusion

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RQ: Given that AI is a technology likely to change many industries, what are the implications for incumbent workers traditionally tasked with AI-type work?

Equity analyst results: suggest the future of work for these high-skilled workers will focus on their soft skills as analytic advantages decline. Some analysts, especially talented ones, will leave the profession. The changes in talent will offset some of the initial improvements in product quality.

Limitations: while sell-side analysts share characteristics with many high-skilled workers, the patterns we document may not generalize beyond this setting.