Artificial Intelligence and Firms' Systematic Risk

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IESE - Workshop on Artificial Intelligence in Finance

Motivation

- STATED OBJECTIVES
  - *"This paper takes the first steps to explore how investments in artificial intelligence relate to changes in firms' systematic risk."*
  - *"firms' adoption of AI offers a unique laboratory to study the effects of technology at the onset of adoption, when it creates future growth opportunities for firms"*

- MY TAKE ON THE CONTRIBUTION
  - Explore the risk implications of AI investment.
    - Given the impressive growth in AI adoption this is an important question!

- RELEVANCE
  - Extremely topical.
  - Most papers in this literature assess the impact of AI on labor, returns, productivity, innovation, growth (first moment).
  - Less has been done, particularly empirically, on second moment implications, especially at the aggregate level.
  - Potentially a relevant contribution!

This Paper

- Data & Measurement:
  - Use job postings & resumes to compute firm-level shares of AI-labor.
  - Merge with Compustat firms and compute risk exposures.
- Empirical Design:
  - Long-differences specification relate changes in AI investment to changes in risk exposures (2010-2018).
- Findings:
  - Increases in AI share are positively related to increases in market beta.
- Mechanism:
  - AI increases firms' growth options:
    - Growth factor exposure increases with AI share.
    - Main result driven by upside beta.
    - Increased correlation of AI firms with all industries.
  - No effect on total volatility.
  - Results are not driven by cash flow volatility.

Contextualizing Results

Investment and Expected Returns

- Miller Modigliani (1961): *Firm value* $= M_t = \sum_{\tau=1}^{\infty} \frac{E[Y_{t+\tau} - \Delta B_{t+\tau}]}{(1+r)^{\tau}}$
  - Where:
    - M_t = Current market value.
    - r = Expected return.
    - $E[Y_{t+\tau}]$ = Expected earnings (profitability).
    - $E[\Delta B_{t+\tau}]$ = Expected change in book value (investment).

- Fama French (2014): $\frac{M_t}{B_t} = \sum_{\tau=1}^{\infty} \frac{E[Y_{t+\tau} - \Delta B_{t+\tau}]/(1+r)^{\tau}}{B_t}$.
  - Then (ceteris paribus):
    - $\uparrow E[Y_{t+\tau}] \Rightarrow \uparrow r$
    - $\uparrow M_t \Rightarrow \downarrow \frac{B_t}{M_t} \Rightarrow \downarrow r$
    - $\uparrow E[\Delta B_{t+\tau}] \Rightarrow \downarrow r$
  - Factor model: $r_{it} = \alpha + \beta(Mkt - Rf)_t + sSMB_t + hHML_t + pRMW_t + iCMA_t + \epsilon_{it}$
    - HML & CMA: $+ve$ correlation with each other & $-ve$ with the market.
    - HML is spanned by other factors, particularly CMA (not viceversa).
    - What's the source of predictability?

Growth Options Channel

- Berk, Green, and Naik (1999):
  - Firms own two types of assets:
    - Assets in place (less systematic risk).
    - Growth options (more systematic risk).
  - Exercising a growth option:
    - Increases share of assets in place.
    - Reduces systematic risk & expected returns.
    - Introduces predictability in expected returns.
  - HML: proxies for the share of assets in place & growth options.

Growth Options & Technology Investment

- Pastor and Veronesi (2009)
  - New technology as an uncertain TFP (Total Factor Productivity) shock.
  - Scale:
    - $\uparrow$ likelihood of new-tech large scale production $\Rightarrow$
      $\Rightarrow$ new-tech risk goes from idiosyncratic to systematic.
      $\Rightarrow \uparrow$ covariance across all sectors.
      $\Rightarrow$ U-shape: total return volatility (higher for new sector).
      $\Rightarrow$ Inverted-U-shape: $\frac{M}{B}$ and P (bubbles).
  - Empirical evidence: internet (Bharath, Viswanathan 2006), pharma/biotech (Mazzucato, Tancioni 2007), industry booms (Hoberg, Philips 2009).

- Kogan and Papanikolaou (2014)
  - New technology as an IST (Investment Specific Technology) shock.
  - Selection:
    - Exposure to IMC (Investment minus Consumption) factor captures cross-sectional differences in growth options (β^{IMC})
    - $\uparrow \beta^{IMC} \Rightarrow \uparrow \frac{M}{B} \Rightarrow \uparrow$ investment following IST shock.
      $\Rightarrow \beta^{IMC}$ $+ve$ correlation with β^{Mkt}.
      $\Rightarrow \beta^{IMC}$ $+ve$ correlation with $\frac{M}{B}$.
      $\Rightarrow$ Higher correlations specifically among high growth option firms.
  - Empirical evidence: Kogan and Papanikolaou (2014).

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Growth Options & AI Technology Investment: This Paper

COMMENT: What is the paper's main objective?

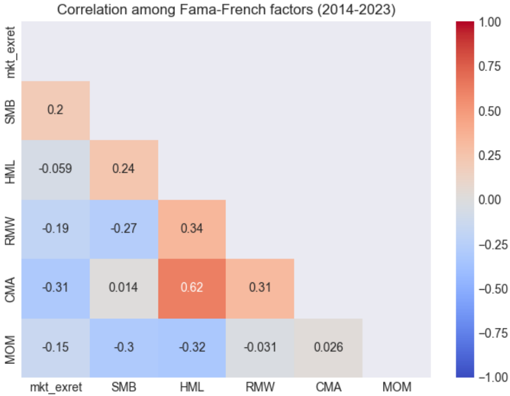
1. AI as a laboratory: Provide supporting evidence for theories of growth options generated by new technologies?
   - Take model predictions more seriously. E.g., Should we expect a bubble? Why is total volatility not rising?

2. AI as a focus: Better understand the source of productivity of the AI technology? Its implications for risk in the economy?
   - Neither of the proposed models seem to fit exactly.
   - Maybe AI works through multiple channels?
   - Abis and Veldkamp (2024): AI increases data to labor ratio. Data as a form of capital in the production of AI-powered insights.
   - There might an opportunity to speak of AI specialness as a GPT!

Selection Bias?

Selection Bias? Factors Correlation

- COMMENT:
  - Equity factors are correlated with each other.
  - Omitting factors that might correlate with AI shares could bias results.
- EVIDENCE:



Selection Bias? Long-Changes in CMA Exposure

- !!VERY ROUGH!! EVIDENCE:
  - Long-changes (2014-2023) in investment factor exposures ($\Delta\beta^{CMA}$) are significantly correlated with:
    - long-changes in market β.

	$\Delta\beta(CAPM)$	$\Delta\beta(4F)$	$\Delta\beta(6F)$
$\Delta\beta^{CMA}$	-0.104***	-0.241***	-0.042***
	(0.012)	(0.012)	(0.011)
const	0.028**	-0.038***	-0.003
	(0.012)	(0.012)	(0.011)
Observations	2651	2651	2651
R^2	0.029	0.137	0.005
Adjusted R^2	0.028	0.136	0.005
Note:	*p<0.1; **p<0.05; ***p<0.01		

- For comparison (using changes in AI share):
  - $\Delta\beta(CAPM)$ increases of 0.11
  - $\Delta\beta(4F)$ increases of 0.052

Selection Bias? Some suggestions

- SUGGESTIONS:
  - Show the correlation between changes in AI share and changes in investment factor or IMC exposures.
  - Include a 6-factor model in all analyses. Does the AI share maintain explanatory power?
  - Provide a broader discussion of the specialness of AI and its correlation with exposures to investment factors.
  - Asset pricing tests:
    - Is the factor constructed from AI shares spanned by the FF6 factors?
    - If not, does it help predicting the cross-section of returns?

Measurement
&
AI Specialness

Measure Construction

- PROCEDURE:
  1. Across all matched jobs compute a skill level AI-relatedness weight as: $w_s^{AI} = \frac{\#\ of\ jobs\ skill\ appears\ with\ core\ AI\ skills}{\#\ of\ jobs\ skill\ appears}$
  2. Either:
     - ★ Resumes → count most related AI skills in resumes. AI jobs ≥ 1.
     - ★ Job posting → job (j) AI-relatedness as: $\bar{w_s}^{AI}|s\ in\ j$. AI jobs $\bar{w_s}^{AI} > 0.1$
  3. AI-share for employer e in year $t = \frac{\#\ AI\ jobs_{et}}{\#\ total\ jobs_{et}}$
- COMMENTS:
  - Look-ahead bias: in early years the AI share is overstated by attaching a high relatedness to skills that will only become related in the future.
    - ★ Issue: measure might capture the propensity of firms to be at the forefront of innovation rather than AI-investment per se.
  - AI specialness: The measure contains skills that are not just AI specific.
    - ★ Issue: when constructing IT or robotics exposure only "non-AI" skills are used, if unconditionally there would be a significant overlap in skills, this would understate investment in other technologies.
- SUGGESTIONS:
  - Replicate results using narrow AI measure (manually curated keywords).

Conclusion

- I really enjoyed reading this paper.
- I strongly recommend it!