Joshua Lev Krieger

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EDUCATION

PhD Candidate, MIT Sloan School of Management (exp.) 2017

Department: Technological Innovation, Entrepreneurship, & Strategic Management (TIES)

Committee: Pierre Azoulay, Scott Stern, Fiona Murray, and Alessandro Bonatti

B.A., Cornell University 2008

Majors: Economics, Government

PEER-REVIEWED PUBLICATIONS

- Azoulay, Pierre, Jeffrey L. Furman, **Krieger, Joshua L.**, and Fiona Murray. "Retractions." *Review of Economics and Statistics*, 97(5). December, 2015: 1118–36.

- **Krieger, Joshua L.**, Fiona Murray, J. Scott Roberts, and Robert C. Green. "The Impact of Personal Genomics on Risk Perceptions and Medical Decision-Making." *Nature Biotechnology*, 34(9). September, 2016: 912–18.

WORKING PAPERS

- "Trials and Terminations: Learning from Competitors' R&D Failures" *Job Market Paper*.

- "The Career Effects of Scandal: Evidence from Scientific Retractions" (with Pierre Azoulay and Alessandro Bonatti). National Bureau of Economic Research Working Paper #21146. *Under review*.

RESEARCH IN PROGRESS

- Novelty in Drug Development (with Danielle Li and Dimitris Papanikolaou). *Manuscript Preparation.*

- Judging the Impact of R&D Failure: Evidence from Stock Returns. *Data Analysis*.

- Mergers and the Direction of Drug Innovation (with Ramana Nanda and Jennifer Kao). *Data Construction*.

TEACHING EXPERIENCE

- Entrepreneurial Strategy Spring 2016
  Teaching Assistant for Professor Scott Stern
- Regional Entrepreneurship Acceleration Lab Fall 2015
  Teaching Assistant for Professors Fiona Murray and Phil Budden
- Competitive Strategy, Executive MBA Program Spring 2014–2015
  Teaching Assistant for Professors Pierre Azoulay and Scott Stern
- Ethics in Biomedical Research, Harvard-MIT Health Sciences and Technology Program Fall 2014
  Guest Lecturer
- MIT-Sabanci EMBA Program on Entrepreneurship Spring 2014
  Teaching Assistant for Bill Aulet

- Advanced Strategic Management — Fall 2013
  Teaching Assistant for Professor Michael Cusumano

FELLOWSHIPS & GRANTS

- National Science Foundation, Science of Science & Innovation Policy (SciSIP) Grant — 2016–2019
  "Collaborative Research: The Impact of Research Costs on the Direction of Scientific Discovery Frontier Tools & Applications"
  (with Jeffrey Furman, Florenta Teodoridis and Ajay Agrawal)
- Kauffman Dissertation Fellowship — 2016–2017
- Value of Medical Research Fellowship, National Bureau of Economic Research — 2016
- Technology-Based Entrepreneurship Research Grant — 2014
  Hammond, Krasner and Roberts Entrepreneurship Funds
- Sloan Foundation Research Grant — 2014
  Program on the Economics of Knowledge Contribution and Distribution
  (with Pierre Azoulay and Jeffrey Furman)
- Ronald A. Kurtz Doctoral Fellowship, MIT Sloan — 2011–Present

CONFERENCE PRESENTATIONS

- REER Conference; Atlanta, GA — Nov. 2016
- Academy of Management Annual Meeting; Anaheim, CA — Aug. 2016
  Symposium on "Driving the Direction of Innovation"
- Industry Studies Association Conference; Minneapolis, MN — May 2016
- MIT Sloan Healthcare & Bioinnovations Conference (Poster); Cambridge, MA — Feb. 2016
- Consortium on Competitiveness and Cooperation (CCC); New York, NY — Apr. 2015
- American College of Medical Genetics and Genomics Annual Meeting (Poster); Nashville, TN — Mar. 2014

REFEREE

- *Science Translational Medicine*
- *Industry and Innovation*
- *Health Economics*
- *Journal of Law, Economics and Organization*

PROFESSIONAL EXPERIENCE

Cornerstone Research (Boston, MA) — 2008–2011
Analyst, Senior Analyst

ADDITIONAL RESEARCH EXPERIENCE

- International Policy Institute for Counter-Terrorism (Herzliya, Israel) — Summer 2008
- Center for Strategic & International Studies (Washington, D.C.) — Summer 2007
- Research Assistant for Professor Fiona Murray (MIT Sloan) — Summer 2006
- Cholesterol Metabolism Research (MIT Biology Department) — Summers 2001–2003, 2005

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November 28, 2016

Application for the NBER Post-Doctoral Fellowship

Areas: Innovation Policy and Entrepreneurship

Dear Members of the Search Committee,

I am writing to apply to the NBER post-doctoral fellowships in Innovation Policy and Entrepreneurship for the year 2017-2018. I'm a PhD Candidate at the MIT Sloan School of Management in the Technological Innovation, Entrepreneurship and Strategic Management.

Research Overview

My research examines the competitive dynamics of R&D strategy. I am particularly interested in how the introduction of new knowledge generated by rivals impacts the direction of R&D efforts. Understanding how new information alters project portfolio decisions is important for firms investing in uncertain new technologies, as well as for policy-makers, who wish to spur innovation through regulatory policy (e.g. disclosure requirements).

News about novel discoveries is crucial for firms who build on related knowledge to create new technologies and products. Announcements about R&D outcomes and exciting new findings force competing firms to reassess their current approach and decide how to exploit external signals. Similarly, failed projects and retracted findings may also have serious consequences for industry rivals. In the wake of these negative news events, firms must determine how to interpret failures and apply the lessons to their own project portfolios. With this research stream, I hope to add to our theoretical and empirical understanding of how firms, investors and individuals prioritize among different uncertain investments, while reacting to and learning from new information.

My empirical work utilizes large and novel data to gain a fine-grain picture of competition and investments across innovative projects and products. For example, I have collected data sets on the molecular novelty and target similarity in drug development projects, connected genomic risk markers to behavioral survey responses, and used text analysis tools to evaluate the relatedness of scientific research projects. I have also used bibliometric analyses to measure the utilization and diffusion of knowledge, as well as the reputation of individual researchers. In my ongoing research, I continue to construct and use detailed data on technological distance and progress to accurately characterize competition and productivity in R&D-based sectors of the economy.

Current Research

My current body of work includes two published papers, and three working papers. This section provides more detail on the three working papers, and two additional early stage projects.

1. Trials & Terminations: Learning from Competitors' R&D Failures *(Job Market Paper)*

This paper develops a theoretically motivated approach to analyzing project continuation decisions, where firms may resolve uncertainty through news about competitors' failures, as well as through their own results. I

examine the trade-offs between product-market competition and potential learning from parallel R&D projects in the setting of drug development. Leveraging the industry's unique characteristics to overcome barriers to measuring the project-level response to competitor news, I employ a difference-in-differences strategy to evaluate how project termination news alters a firm's own project discontinuation decisions. The findings reveal that firms are most sensitive to competitor failure news coming from within the same market and technology area—more than doubling their propensity to terminate projects in the wake of this type of competitor news. Second, I investigate and find evidence supporting the hypothesis that firms overreact to failure news from closely related competitor projects. Finally, I evaluate and uncover project- and firm-level characteristics that drive persistent differences in decision-making performance.

2. Financing Novel Drugs (with Danielle Li and Dimitris Papanikolaou)

The process of drug discovery is expensive and highly uncertain. In this setting, risk-averse firms facing financial constraints may be more likely to invest in less novel ``me-too'' drugs than may be socially optimal. We examine this hypothesis by studying how resource constraints impact firms' decisions to invest in novel drug compounds. This paper has two contributions. First, we develop a new molecule-based measure of the chemical novelty of new drug candidates. Second, we use variation in the expansion of Medicare prescription drug coverage in the United States (which differentially benefited firms with more drugs targeted toward elderly patients, as well as firms with more remaining patent life on those drugs) to isolate exogenous variation in firm cash flow. We find that firms which benefit more from the expansion of drug coverage develop more drug candidates as a result and, moreover, this increase in drug development is driven by an increase in the development of more chemically novel drug compounds.

3. The Career Effects of Scandal: Evidence from Scientific Retractions. National Bureau of Economic Research Working Paper #21146 (with Pierre Azoulay and Alessandro Bonatti). *Under review*

Scandals permeate social and economic life, but their consequences have received scant attention in the economics literature. To shed empirical light on this phenomenon, we investigate how the scientific community's perception of a scientist's prior work changes when one of his articles is retracted. Relative to non-retracted control authors, faculty members who experience a retraction see the citation rate to their earlier, non-retracted articles drop by 10% on average, consistent with the Bayesian intuition that the market inferred their work was mediocre all along. We then investigate whether the eminence of the retracted author and the publicity surrounding the retraction shape the magnitude of the penalty. We find that eminent scientists are more harshly penalized than their less distinguished peers in the wake of a retraction, but only in cases involving fraud or misconduct. When the retraction event had its source in "honest mistakes," we find no evidence of differential stigma between high- and low-status faculty members.

4. **Mergers and the Direction of Pharmaceutical R&D (with Ramana Nanda and Jennifer Kao).** *Data construction.*

In this project, we analyze how mergers and acquisitions impact the direction of research and development in the pharmaceutical industry. We are using data on mergers and failed mergers in the biopharmaceutical industry, combined with detailed information about drug development pipelines to evaluate how mergers change the overall mix of development projects.

5. The Impact of Technological Failure on Rivals' Stock Market Valuation (with Lindsey Raymond). *Data construction and analysis.*

How do investors interpret technological failures and their ripple effects within an industry? The market's response to product development news plays an important role in financing and setting incentives for innovative industries. However, parsing failure information is a difficult task, requiring both technical expertise and deep knowledge of how a project failure alters competitive dynamics. The drug development industry provides an ideal setting for studying these questions, because product development failures are frequent and can have massive impact on the market valuation of the failed project's sponsor, as well as its

competitors. In this paper, we use fine-grained information about drug development events and the relationship between projects in order to measure the impact of failure news the stock market valuations for competition firms. Furthermore, we are linking sentiment analysis of press releases to failure events in order to evaluate how investors react to failure news with different levels of severity.

Future Research

In my dissertation and related research, I have explored how information events such as retracted publications and failed clinical trials impact the direction of innovative effort. In my future work, I am interested in studying other settings in which competitor news influences project selection, and investigating how organizations can improve their resource allocation decisions in the face of changing information and competitive landscapes.

For example, I am interested in applying analyses similar to those in my job market paper to the context of venture capital investing. Similar to drug development decisions, venture capital investments involve judgments about technology, market competition, and portfolio risk. "Herding" into particular technologies or business models is a common narrative in media reports and casual analysis of the venture capital industry. Therefore, both success and failure news may change investors beliefs about attractiveness of a given set of investments. Investors may also have access to different levels of information about the reason for a given startup's success or failure, depending on the investor's expertise, and relationship to the startup. I hope to exploit features of venture capital project selection (e.g. multiple firms investing in single startup, variation in portfolio strategies, partner voting, etc.) to test hypotheses about belief updating and investment herding in new technologies and business models.

I am also interested in studying how different disclosure regimes impact entry and productivity in research and development. Policymakers and firms both have to make decisions about how much disclosure is appropriate, given the implications for consumers and firms. However, we have very little empirical evidence about who benefits from increased disclosure, and when partial disclosure provides value. In the past 20 years, changes around clinical trial reporting have made the drug development process more transparent, and reduced the challenges in tracking competitors. Some of these changes have been mandated by congress, others by regulatory agencies (e.g. FDA), organizations' internal policies, and others through non-governmental organizations (International Committee of Medical Journal Editors). I aim to study how these disclosure changes influence the timing of R&D entry and productivity of projects that are most effected by the disclosure changes. In doing so, I hope to illuminate scenarios in which both policymakers and firms may wish to alter disclosure rules.

I am confident that my research experience during my PhD has provided me with the theoretical and empirical tools to make progress on these research streams and others in entrepreneurship an innovation. I hope that you will find that my background and interests are a great fit for the NBER post-doctoral fellowship.

Sincerely,



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September 8, 2016

Dear Members of the Recruiting Committee:

I wish to recommend Joshua Krieger for an Assistant Professor position in your department. I have been serving as Joshua's principal adviser since he joined our PhD program 5 years ago. The experience has been extremely rewarding. We have worked very closely together on projects that deal with the phenomenon of scientific retractions, with one paper published last year in the *Review of Economics and Statistics*, and another under review at the *American Economic Journal: Applied Economics*.

Joshua's dissertation project, however, was conceived entirely independently. He defined the topic early on, zeroed in on a setting that held promise as a laboratory to test theoretically-motivated hypotheses, relentlessly assembled the required data, and conducted the econometric analyses.

Joshua's job market paper examines how firms learn through the failure of their competitor's R&D investments. The real options framework has been a useful lens to think about how firms invest, or ought to invest in very uncertain R&D projects. To date, however, the assumption has been that it is the firm's own actions that help resolve uncertainty at various stages. Joshua incorporates the additional insight that in many settings, the outcomes of one's competitors' experiments also help resolve uncertainty. Potentially, this means that the impact of an increase in competition is not unalloyed bad news for a particular firm. Increased product-market competition is to be weighed against the potential for learning from these additional competitors. In his job market paper, Josh proposes a simple theoretical framework that crystalizes this trade-off. A model in this spirit, however, is not that interesting without actual evidence that these competitive learning opportunities matter empirically.

Fortunately, Joshua also delivers on the empirical front. He found the perfect petri dish to pin down these effects econometrically: that of drug development, and particularly Phase II and III of the clinical trials process. The biggest empirical hurdle to overcome is a sensible way to identify which competitors' experiments are actually likely to influence a particular firm's own thinking about the value of its project portfolio. How can one ascertain whether two projects are related such that one is actually at risk of being influenced by the other? Without a tractable,

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scalable, and judgement-free way of identifying these project pairs, one is unlikely to make progress in answering the question (however interesting the question may be in the abstract!)

Joshua shows that it is possible to identify related projects. His clever initial observation is that drug projects can be usefully characterized in two distinct dimensions. The first dimension is one already familiar to applied economists: the therapeutic market, such as "Non-small cell lung cancer." The second one is much more technological in nature: the biological target, e.g., "Programmed Death Ligand-1 checkpoint." Two drug projects that share the same market and the same technology are obviously very related, but this can be contrasted with situations where two drug projects share the same technology, but deploy these technologies in different markets, or when two drug projects target the same narrow market, but using two different technologies. Joshua's dataset creates project pairs that vary in their degree of relatedness along these two dimensions, which he combines with precise information on the timing of starts and discontinuation from Thomson-Reuters *Cortellis* database.

Using these data, Joshua delivers three results. First, using a diff-in-diff specification, he shows the firms are sensitive to the news arising from the failures of competitors (in that they become more prone to discontinue their own projects), but this sensitivity is very selective: mostly for projects related in both the technological and market dimension, and moderated by the number of future opportunities to learn and the degree of extant product-market competition.

Second, Joshua lays out a statistical framework to gauge the extent to which discontinuation decisions correspond to under-reactions or over-reactions. Intuitively, controlling for project quality (a tall order!), a panicked flight away from the space has a specific signature: the probability of eventual success is higher for the projects that continued despite a high number of competitor failures. Joshua's results imply that there is in fact a fair bit of overreaction to "same technology, same market"-type news.

Finally, Joshua provides a way to grade the quality of decision-making of the firms involved, using information about the fate of other projects in the same narrow space. For example, if company A stops a project in the wake of company B's disappointing results in the same class and indication, but company C and D persist and successfully introduce a new drug on the market, then company A's decision can be considered a "bad call" ex post. Conversely, there are example of good calls when company A discontinues, and Firms C and D persist, only to fail later in the process. Leveraging this insight in project-level regressions, Joshua can compute firm fixed effects whose dispersion testify to the existence of persistent differences in decision quality across otherwise very similar firms.

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To summarize: not only are firm sensitive to the news arising from the failures of competitors, but significant differences across firms in how and when they respond to competitor failures might itself serve as a source of innovation-driven competitive advantage. To my knowledge, this is a novel insight in the strategy field, and one I would expect to reverberate widely.

Joshua and I (together with Jeff Furman and Fiona Murray) have published an article in the *Review of Economics and Statistics* entitled "Retractions" in 2015. Separately, Joshua, Alessandro Bonatti and I have a manuscript entitled "The Career Effects of Scandal" under review at the *American Economic Journal: Applied Economics.* Joshua was a collaborator in the fullest sense of the term in both of these projects. I believe Alessandro Bonatti will provide more details on the second project in his letter, but for my part I very much doubt this line of research would have been as successful without Joshua's conceptual and empirical contributions.

I expect Joshua to excel in the MBA classroom. He proved invaluable as a TA in the core Strategy class in our Exec MBA program; I believe my colleague Scott Stern had an equally wonderful experience in his MBA elective, Entrepreneurial Strategy. But beyond his performance as a TA, he is a very polished presenter, and a cogent explainer of his ideas (and sometimes that of others, including mine!).

As is clear from the above, I am now at a stage where I have stopped relating to Joshua as simply an excellent graduate student. I regard Joshua as a peer and a collaborator. He is very likely to become an impactful researcher in our field. Compared to the recent graduates of our PhD program, I would say that Josh is on par with Abhishek Nagaraj who graduated last year and went to UC Berkeley. Apart from Abhishek, one would have to reach back to 2006/2007, when Ramana Nanda and Karim Lakhani graduated from MIT, to find PhD students of comparable promise at this career stage.

In short, I strongly recommend Joshua for a faculty position in your department, without any reservations.

Sincerely,

