Massachusetts Institute of Technology



David Colino
PhD Candidate

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Subject: NBER Post-Doctoral Fellowship on Innovation Policy

I would like to be considered for the NBER Post-Doctoral Fellowship on Innovation Policy. I am a PhD candidate in the Department of Economics at the Massachusetts Institute of Technology, and expect to complete my doctoral studies in June 2017.

Overview of Research

My research focuses on investigating the mechanisms of innovation production and its associated spillovers. Its goal is to shed light on the economics of innovation in a context that has large implications both for the competitive advantage of businesses, and for long-term economic growth at a more macro level. In my dissertation, I quantify the gap between the social and the private returns to corporate R&D by estimating knowledge spillovers accruing dynamically both within and between organizations through cumulative channels. As my research on durable crises can testify, I am also more broadly interested in applying economic tools to questions of central importance for organizations, particularly if these entail macroeconomic consequences.

Dissertation Research: Dynamic R&D Spillovers

My dissertation aims to measure the gap between the social and private returns to corporate R&D. In particular, and on top of traditional static spillovers, my job market paper estimates knowledge spillovers that accrue dynamically through cumulative innovation channels. R&D effort produces innovations that are used as foundations upon which to build future subsequent innovations, and this mechanism results in dynamic or inter-temporal spillovers across firms and years. Despite much theoretical attention on the importance of dynamic spillovers for economic growth, such spillovers have been difficult to empirically measure. Using a panel of US firms and a network of corporate patent citations, I estimate the dynamic spillovers of corporate R&D on firm productivity, market value, and innovative activity. In order to address the identification challenge caused by firms endogenously selecting their R&D levels and their citation network position, I use an instrumental variable approach that exploits the observed persistence in the citation network between firms across time, together with variations in the state and federal tax incentives to corporate R&D expenses.

I measure causal impacts of dynamic R&D spillovers and find that they are economically significant, as the effect of past foundational R&D on firm productivity is at least as large as that of own current R&D investments. Dynamic spillovers accrue mainly in complex technologies, where final products or processes build cumulatively on multiple separately patentable components. Moreover, they exhibit little depreciation over time, continue accruing through indirect connections, are larger for established firms than for VC-backed startups, and do not decrease in magnitude with geographic distance. Because a share of these spillovers are subsequently reabsorbed by the original innovator, previous estimates of spillovers that did not account for this dynamism were underestimating the extent of both private and social returns to R&D. Taking into account dynamic spillovers as well as traditional static spillover measures results in social returns to R&D about three times as large as private returns.

Durable crises

My second research stream studies how the conditions faced by firms in durable manufacturing sectors can amplify economic recessions. Demand for durable goods is known to be highly pro-cyclical, because people consume a flow value out of their stock of durable goods, and so a decline in the demand for goods and services causes a disproportionate fall in the demand for durable goods. In joint work with Nicolas Caramp and Pascual Restrepo, we show that this amplification aggregates, and commuting zones that were historically specialized in the production of durable goods experienced a larger decline in employment during the recent Great Recession compared to areas with less employment in durable goods industrial sectors. This study shows that business conditions that affect even a reduced subset of firms can have strong local implications on the economic activity, through aggregate demand externalities and stickiness in factor reallocation.

Moreover, the role of durable manufacturing firms as business cycle amplificators seems stronger in zones that experienced larger booms from 2000 to 2007. This finding is consistent with the view that consumers and firms overbuilt their stock of durable goods before the recession, which forced firms providing durables to scale down production during the recession and the recovery. Overall, the findings call to the importance of considering local productive structure for risk management, as well as maintaining a long-term view of inventory and production management.

Future Research

In future work, I am interested in studying inter-temporal knowledge flows and the patent citation network further. Among others, I have found suggestive evidence that, conditional on a citation being observed, the intensity of knowledge flows does not vary with geographic distance. Due to the dependence of citation patterns on distance found previously in the literature, and the implications for firms' co-agglomeration strategies, this is a challenging result that deserves further attention. Moreover, I will delve deeper into how the citation network structure affects mechanisms of spillover transmission between firms: Which firms are the key players? Is there scope for policy intervention in order to facilitate the flow of knowledge?

Finally, and in order to conduct valid empirical inference using the patent citation network, in joint work with Lucciano Villacorta I am interested in examining the structure of standard error dependence in the context of an interaction network that transcends the spatial and time component. In a setting such as the citation network, where panel observations are interconnected, the error dependence must take into account non-contemporaneous spatial network dependence, as well as traditional spatial and time dependence. We therefore aim to present a class of covariance matrix estimators that allow for time and individual clusters within a larger network structure.

I am hopeful that my research on dynamic R&D spillovers will have a broad impact on overall research in innovation, and I am excited at the possibility to continue working on these topics as a post-doctoral fellow at the NBER. I thank you for your attentive consideration and look forward to hearing from you

Sincerely,

David Colino

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DOCTORAL STUDIES

Massachusetts Institute of Technology (MIT)
PhD, Economics, Expected completion June 2017
DISSERTATION: "Essays on innovation and productivity"

DISSERTATION COMMITTEE AND REFERENCES

Professor Glenn Ellison
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Professor Thomas Stoker
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PRIOR EDUCATION

CEMFI, Madrid. 2011
Master in Economics and Finance

Ecole Polytechnique, Paris. 2009
M.Sc. in Mechanical Engineering

CITIZENSHIP Spain, Luxembourg **GENDER:** Male

LANGUAGES English (proficient)

Spanish, French (native)
German (advanced), Luxembourgish (intermediate)

RESEARCH INTERESTS

Primary: Economics of Innovation & Entrepreneurship, Industrial Organization
Secondary: Corporate Finance, Productivity

TEACHING EXPERIENCE

14.30 Introduction to Statistical Methods in Economics (Undergraduate), Course Instructor.	Fall 2014
14.20 Indust. Org. & Competitive Strategy (UG), TA to Gastón Illanes, MIT.	Spring 2016
14.003 Microecon. Theory & Public Policy (UG), TA to Prof. Nikhil Agarwal, MIT.	Spring 2016
15.024 Applied Economics for Managers (Sloan Fellows), Teaching Assistant (TA) to Prof. Tom Stoker, MIT.	Summers 2013, 2014, 2015
14.271 Industrial Organization I (Graduate), TA to Prof. Glenn Ellison, MIT.	Fall 2013
14.01 Principles of Microeconomics (UG), TA to Prof. Jon Gruber, MIT.	Fall 2013

RESEARCH POSITIONS

Research Assistant for Pr. Antoinette Schoar, MIT-Sloan.	2013-2014
Research Assistant for Prs. JJ Dolado (EUI) and Pierre Cahuc (CREST-INSEE).	2009
Internship in LECG, Madrid, 2months. Work on competition, regulation and merger issues.	2010

FELLOWSHIPS, HONORS, AND AWARDS

Rafael del Pino Fellowship	2013-2015
James Berkovec Memorial Fund Scholarship, MIT	2012
MIT Fellowship	2011
Luis Angel Rojo Prize for best student, CEMFI	2011
CEMFI Fellowship	2009-2011
Honorable mention, International Mathematics Olympiad	2004

RESEARCH PAPERS

"Cumulative Innovation and Dynamic R&D Spillovers" (Job Market Paper)

While much theoretical attention has focused on the important role of dynamic knowledge spillovers for economic growth, such spillovers have been difficult to empirically measure. Using a panel of US firms and a network of corporate patent citations, this paper estimates the dynamic spillovers of corporate R&D on firm productivity, value, and innovation activity. Causal effects are estimated with an instrumental variables strategy that exploits the persistence of the network as well as variation in tax incentives. The positive effect of dynamic spillovers on firm productivity is economically important, and at least as large as that of own R&D investments. Dynamic spillovers accrue mainly for so-called "complex" technologies that build cumulatively on multiple components, they exhibit little depreciation over time, are larger for established firms than for VC-backed startups, and do not decrease in magnitude with geographic distance. Around 40% of dynamic spillovers are

re-absorbed by the original innovator, and –accounting for other spillovers– these estimates suggest that the social returns to R&D are about three times as large as the private returns.

RESEARCH IN PROGRESS

"Durable Crises" (joint with Nicolas Caramp and Pascual Restrepo)
This paper studies the role that durable goods play in amplifying recessions. People consume a flow value out of their stock of durable goods, and so a decline in the demand for goods and services causes a disproportionate fall in the demand for durable goods. We show that commuting zones that were historically specialized in the production of durable goods experienced a larger decline in employment during the recent Great Recession than areas with less employment in durables. The reduction in the demand for durable goods spills over upstream. Because industries locate close to their suppliers, input-output linkages amplify the negative effects of employment at the local labor market level. The effects are particularly large in commuting zones specialized in the production of durable inputs utilized in the production of other durable goods. Finally, we show that the role of durables is stronger in commuting zones that experienced a boom from 2000 to 2007. This finding is consistent with the view that consumers and firms overbuilt their stock of durable goods before the recession, which forced firms providing durables to scale down production during the recession and the recovery.

"Knowledge Diffusion and the Patent Citation Network"
Innovation activities form networks through which information flows and diffuses across researchers, inventors, and firms. This paper studies knowledge diffusion patterns across the patent citation network. Efficient algorithms are applied to compute centrality measures on a large, yet sparse, network. The betweenness and eigenvector centrality measures paint a more complete picture of knowledge diffusion than the more commonly used degree centrality, or simple forward-citation count. Using a subset of corporate patents held by publicly listed firms, this paper identifies *key players* in the innovation network.

"Error Dependence Beyond Two-Way Cluster: A Panel Spatial Autoregressive model for Non-Contemporaneous Spatial Dependence" (joint with Lucciano Villacorta)
Considering error dependence when computing standard errors is crucial for conducting valid inference in applied work. One-way cluster and two-way cluster estimators are used for robust standard errors to time and (contemporaneous) spatial dependence in panel data. However, more complicated structures of dependence across time and space are not usually taken into account. This paper proposes a panel version of the spatial autoregressive model to consider non-contemporaneous spatial dependence. The covariance estimator consists of a non-parametric two-way cluster, and a parametric part with a known NTxNT weighting matrix for the non-contemporaneous spatial dependence. The model is suitable for settings where the researcher has a prior knowledge about the dependence structure. We apply this estimator to Colino (2016), in which non-contemporaneous spatial dependence arises because of dynamic spillovers of R&D accruing between firms and across time.

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Dear Sir or Madam:

I am writing on behalf of **David Colino**, a PhD student in economics at **MIT** who is on the academic job market this year. David is an applied economist working in the field of industrial organization, with a strong focus in the economics of innovation. I am very pleased to have the opportunity to recommend David as a bright and hard-working student who is doing novel research on important questions in the innovation policy space. As background, I joined David's committee later than his main adviser (Glenn Ellison), but have had the opportunity to get to know David and his work in detail in the last year or so.

David's job market paper is tackling a central innovation policy question: how large are the spillovers from private research investments? That is, what is the gap between the private and social returns to private research investments? Dating back at least to the seminal work of Zvi Griliches, economists have made a number of attempts to measure spillovers in a variety of ways. One excellent recent contribution on this topic – which I know well as I teach the paper in detail in my PhD public finance course at MIT – is a 2013 *Econometrica* paper by Nick Bloom, Mark Schankerman, and John Van Reenen. Their paper proposes estimating spillovers by estimating the magnitude of two off-setting effects: on one hand, a firm's research may positively affect other firms through *knowledge spillovers* if the knowledge produced through the process of research and development is not fully appropriated by the original innovator; on the other hand, a firm's research may negatively affect other firms through *business stealing* if those firms compete in the same product market. Bloom-Schankerman-Van Reenen develop two different structures to represent the networks that might mediate each of these two types of spillovers. For knowledge spillovers, they assume that spillovers will be mediated through a network of those firms that patent in the same area; for business stealing spillovers, they assume that spillovers will be mediated through a network of those firms that compete in the same product market. Somewhat surprisingly, those two networks are not that highly correlated. They discuss as an example that IBM over their time period is close in "knowledge" space to Intel, Motorola, and Apple as the technologies IBM uses for computer hardware are closely related to the technologies used by those other companies. However, IBM and Apple are close in product space (personal computers) whereas IBM is not close in product space to either Intel or Motorola (as they produce semiconductor chips, where IBM had little focus, at least over their time period of study).

David's job market paper takes an ambitious stab at building on and extending this important work. David's key insight is that a central characteristic of knowledge spillovers that has been emphasized in the theoretical literature is their cumulative, dynamic nature. That is, a discovery today may enable many future innovations, and if the initial inventor is not fully compensated for those follow-on innovations, that will be an important source of spillovers. Suzanne Scotchmer's work is always what I return to re-read when I think about the topic of cumulative innovation, but the cumulative nature of knowledge spillovers has of course also been a central focus of the endogenous growth literature. David argues that prior papers attempting to quantify spillovers – such as the Bloom-Schankerman-Van Reenen paper – have not been designed with the goal in mind of measuring and quantifying these dynamic spillovers. He sets out to do so in his paper. To me, this is a first order question to be working on: there are two separate literatures (one quantifying spillovers, one analyzing cumulative innovation), and David's paper is an attempt to build a bridge between those two areas.

Using the linked Compustat-NBER patent database, David constructs a network of patent citations. Patent citations are an often-used measure of follow-on innovation, and it turns out empirically that this patent citation network is not that highly correlated with the type of static knowledge spillover network used in the Bloom-Schankerman-Van Reenen paper. What that means substantively is that firms tend to build on (translation: cite patents in) a variety of technological areas other than the specific technological area of the patent. He uses this patent citation network (in practice, a lagged network as a way to try to address network endogeneity) as an assumed structure for what network will mediate cumulative innovation spillovers, and adds that term to the Bloom-Schankerman-Van Reenen model.

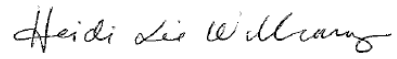
David's results are quite interesting. His estimates suggest that these dynamic spillovers are as important as a firm's own current R&D in terms of their effect on firm output and market value. Substantively, these dynamic spillovers suggest that the spillovers estimated in past work like the Bloom-Schankerman-Van Reenen paper have understated the magnitude of the spillovers from private research investments. Perhaps most interesting is a heterogeneity cut that David does which distinguishes between so-called "simple" and "complex" technologies. This distinction, made by Cohen-Nelson-Walsh (2000) among others, depends on whether products are comprised of numerous separately patentable elements ("complex") or relatively few patentable elements ("simple"). Complex technologies are a priori more likely to be affected by spillovers, and David documents empirical evidence exactly matching that prediction: dynamic spillovers are important for complex technologies, but not for simple technologies which are less likely to build on past inventions. In some other results, David documents using self-citation data that at least one third of follow-on innovation directly benefits the original innovator and hence does not constitute a spillover (this is a lower bound because follow-on innovation by other firms could still benefit the original innovator through licensing payments, which are unobserved). He uses these estimates to calculate that after incorporating dynamic spillovers, the social returns to private research investments seem to be about four times as large as the private returns.

When David presents, it is clear that he has put together an extremely thoughtful analysis that builds in a meaningful way on the past literature, creating bridges between topics that had been previously missing. I think there are a number of innovative ideas in the paper, all of which David came up with quite independently. David is also a good communicator: his paper is quite well-written, and he is a good presenter. This skill set is also evidenced by his very positive teaching ratings as a TA during his time at MIT.

On a personal level, David is quite pleasant and will I expect be a valuable colleague in terms of providing constructive feedback to his colleagues on their own work.

Please do not hesitate to contact me if I can be of further assistance.

Sincerely,



Heidi Williams