Collaboration and Knowledge Production in the Context of Cumulative Innovation

Research Proposal for the NBER Innovation Policy Research Grant Program

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I am a Ph.D. candidate in Strategic Management at the Rotman School of Management, University of Toronto under the supervision of Ajay Agrawal (chair), Joshua Gans, Avi Goldfarb and Brian Silverman. I expect to complete my dissertation in the spring of 2014.

At a broad level my research focuses on questions related to the drivers and consequences of technological innovation and entrepreneurship and the organization of creative activity. In my dissertation I leverage two natural experiments to explore the impact of cumulative innovation on the creative process with a focus on the rate and composition of collaboration, measured by co-authorship on academic publications. I find evidence of fundamental changes in the organization of creative activity relative to collaboration patterns that influence the evolution of innovation trajectories. These findings open a series of follow-on questions that constitute the subject of this proposal. I provide a brief description of my current research to motivate the proposed follow-on research questions.

First, in collaborative work with Ajay Agrawal and Avi Goldfarb, I investigate the effect of knowledge accumulation on changes in the intensity of collaborative activity and provide empirical support[1] for the knowledge burden hypothesis which states that reaching the knowledge frontier is progressively costlier due to knowledge accumulation over time and results in increasing specialization and collaboration. This is important because several plausible explanations may explain the documented rise in collaboration (Adams et al, 2005; Wuchy et al, 2007; Jones, 2009), yet the knowledge accumulation hypothesis yields distinct policy implications such as subsidies and rewards to incentivize entry into research careers, team-based evaluation of grant applications, and national or regional subsidies and specialization to prevent poverty traps due to underinvestment in human capital from coordination failures arising from thin markets for complementary skills (Jones, 2009, 2010, 2011). Although our study offers no means by which to comment on the suitability of these particular interventions, the evidence we present in this paper does suggest the possibility that the knowledge frontier effect on the organization of knowledge creation, and on collaboration in particular, is indeed non-trivial and thus worthy of further research.

Related, in another paper I explore changes in the composition of collaboration in the context of increased complexity of knowledge production due to the forward movement of the frontier while taking into account another aspect of the cumulative nature of innovation. The salient role of cumulativeness[2] for knowledge production implies that the ability to build on the existing stock of knowledge also depends on the cost of access to knowledge (Mokyr, 2002). While scholars have documented a positive impact of low-cost conditions on the rate of inventive activity (e.g., Murray and Stern, 2007; Furman and Stern, 2011; Williams, 2012) with implications for the type of follow-on research (e.g., Murray et al., 2009), less is understood regarding the organization of knowledge creation under such conditions as a factor influencing the direction of inventive activity and thus the evolution of innovation trajectories.

[1] Identification is difficult since many unobservables may be (and likely are) correlated with both collaborative behavior and time. To provide more compelling evidence we leverage a natural experiment, the collapse of the Soviet Union that triggered a sudden access to state of the art developments in mathematics, correlated with the knowledge frontier but not with academic collaboration except indirectly through its effect on the frontier.

[2] In order to avoid diminishing returns to investments in knowledge production, research "stands on the shoulders" of prior knowledge (Jones, 1995, Furman and Stern, 2011).

Leveraging a natural experiment, the launch of Microsoft Kinect which triggered an unanticipated reduction in the cost of motion-sensing research technology, I analyze the impact of researchers' breadth of expertise on innovation when opportunities for knowledge creation arise due to a reduction in cost of access to knowledge. Despite growing emphasis on the importance of specialists for knowledge creation, I identify generalists (researchers with broader exposure to knowledge) as playing a particularly important role in connecting specialists to the opportunities opened by the reduction in cost of access to knowledge thus influencing the direction of inventive activity. Collaboration emerges as the salient mechanism.

Taken together, the results suggest fundamental changes in the organization of creative activity with the role of generalists potentially growing in significance as knowledge accumulation leads to specialization in progressively narrower niches and an increased need for collaboration (Jones, 2009). To get closer to informing policy, I propose to extend this research to consider two additional questions.

First, I would like to consider implications for productivity, an issue at the heart of efforts to explain heterogeneity in performance across research institutions, firms and regions. Specifically, I propose to investigate factors affecting the optimal balance between generalists and specialists for efficient knowledge production as well as factors influencing researchers' behavior as specialists or generalists. For instance, the optimal balance of generalists and specialists might be contingent on the frequency of technological advancements that result in reductions in the cost of access to knowledge. Also, age or career level might play an influential role in researchers' innovation behavior as specialists or generalists.

Second, I would like to explore to what extent researchers' behavior following reductions in cost of access to knowledge impact the direction of inventive activity through an increase in the breadth of research trajectories or a displacement of existing research trajectories. In particular, it is unclear if the process of idea recombination triggered by opportunities opened by the reduction in cost of access to knowledge contributes to an increase in the diversity of research trajectories or it channels research towards an immediately identifiable opportunity or research path. The latter behavior is aligned with Merton's assertion that "sometimes the discoveries are simultaneous or almost so" (Merton, 1973). The former encourages diversity of research trajectories and thus seems more desirable for economic growth (Acemoglu, 2012). This analysis would also inform the extent to which changes in the cost of access to knowledge influence entry and exit into research domains or scientific careers altogether.

While important, the proposed research questions are empirically challenging since the knowledge creation process endogenously affects the cost of access to knowledge and with it the forward movement of the knowledge frontier. To address this concern I propose to leverage the two natural experiments mentioned above. The launch of Microsoft Kinect represents an unanticipated reduction in the cost of access to motion-sensing knowledge and the collapse of the Soviet Union provides an exogenous shock to the knowledge frontier in mathematics. Both these events are uncorrelated with researchers' ex-ante behavior or research trajectory, thus making it possible to study the proposed research questions from a more causal perspective.

However, additional data is required to augment my current datasets.[3] Specifically the funds will be used to acquire most recent publication data, especially related to the Kinect event, thus allowing for a better estimation of changes in innovation trajectories. Additionally I will collect individual level attributes, such as first year of publication as a proxy for age, academic affiliation and mobility data. I also plan on conducting interviews to better understand these knowledge creation dynamics and uncover other variables of interest.

[3] The datasets include 40 years of academic publications in mathematics, 20 years before and 20 years after the collapse of the Soviet Union, and 8 years of publications, early-access publications and conference proceedings in electrical engineering, computer science and electronics (6 years before the launch of Kinect, and 2 years after the launch of Kinect in Nov 2010).

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