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Boundary spanning innovation and the patent system: Interdisciplinary challenges for a specialized examination system☆

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ABSTRACT

This article discusses the importance of boundary spanning innovation, demonstrates the drawbacks of popular metadata based boundary spanning measures, and proposes a new full text semantic similarity measure of boundary spanning. It subsequently uses the semantic distance boundary spanning measure to demonstrate that boundary spanning innovation has become more common in recent decades, and show that these boundary spanning inventions pose challenges for the traditional specialized-examiner patent examination model. Examining the applications for inventions that span technical boundaries takes longer and requires more back-and-forth with the patent office than their comparatively simple peers. Finally, this article discusses potential reforms to the patent examination system to help address these challenges.

1. Introduction

In recent decades, science and technology policymakers have promoted interdisciplinary research that spans the traditional boundaries between research communities (Cummings and Kiesler, 2005). Crossing disciplinary and technical boundaries has resulted in a variety of new areas of scientific development and new consumer goods. For instance, the increasingly important biotechnology sector draws on the traditionally distinct fields of biology and engineering. Likewise, consumer goods in recent years have integrated technologies from what were once distinct technical domains. While our in home temperature control was once accomplished with relatively simple mechanical switches, we now have thermostats that feature wireless connectivity, machine-learning capabilities, and remote control user interfaces.

Because of the potential that crossing disciplinary boundaries has for generating new high-impact ideas, policymakers remain interested in promoting research that brings together diverse sets of researchers. However, despite this increased focus on encouraging porousness in disciplinary boundaries, we have an incomplete understanding of the extent to which there has been more boundary spanning scientific output, and what effects this may have on innovation policy players such as patent offices. There is some evidence to suggest that boundary spanning has increased in recent years (Porter and Rafols, 2009), and that research spanning across disciplinary boundaries has outsized impact (Shi et al., 2009). However, there has been little thought given to how this trend towards increasing boundary spanning and interdisciplinarity might affect how we incentivize and reward research behavior. Research suggests that interdisciplinary proposals have lower success in attaining funding support (Bromham et al., 2016). This may occur at least partially as a result of it being more difficult to assess interdisciplinary proposals given that they do not fit neatly within expected knowledge frameworks. If a similar process holds in the assessment of technical information—that is, if it is more difficult for patent examiners to assess boundary spanning inventions—an increase in boundary spanning inventions may pose challenges for effective patent application assessment.

Effective patent examination is central to the modern innovation incentive system. Intellectual property law provides for limited monopolies on inventions, provided those inventions meet the patentability threshold. There is evidence to suggest that patent offices are already straining under the application workload, which has increased dramatically in recent years. Frakes and Wasserman (2015) show that as patent examiner workload increases, so too does their propensity to grant bad patents. This research focuses on the increasing number of patent applications, and the effect this can have on 21st century patent offices. However, it provides little insight into whether patent applications have changed qualitatively as well as quantitatively, and if so, what effects this might have on our ability to effectively examine 21st

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century patent applications.

Due to the increasing popularity of interdisciplinary research, one primary way that inventions may have qualitatively changed in recent decades, is in an increasing tendency to span disciplinary boundaries. This could arise as the product of positive campaigns to encourage interdisciplinarity (Haythornthwaite, 2006), or due to fortuitous boundary spanning discoveries, as a response to market demand for more boundary spanning products, or as a result of information technology that facilitates the discovery of ideas that researchers might not otherwise encounter (Whalen, 2015). To determine whether inventions have changed qualitatively in recent decades, and what if any implications this has on the patent system, we first need to discuss the relationship between boundary spanning and innovation more generally.

2. Boundary spanning & innovation

Spanning boundaries has long been associated with good ideas (Burt, 2004), and high impact scientific and technical developments (Leahey et al., 2015; Shi et al., 2009; Tushman and Scanlan, 1981). Boundary spanning occurs when researchers draw on expertise from distinct and disparate fields. This enables them to engage in a sort of knowledge arbitrage as they broker information across boundaries (Tushman, 1977; Tushman and Scanlan, 1981). By doing so, researchers are more likely to discover novel connections, and generate ideas or inventions offering unique solutions or capabilities.

Making these combinations across rarely combined fields leads to a higher probability of a scientific article or patent becoming high impact (Uzzi et al., 2013). Similarly, using a diverse interdisciplinary mixture of knowledge inputs is also associated with higher impact (Chen et al., 2015). However, spanning technological boundaries is not without cost. Doing so increases success variance, leading both to more low and high impact outcomes (Fleming, 2001; Yegros-Yegros et al., 2015).

At least in the context of academic science, spanning disciplinary boundaries has increased in recent decades (Porter and Rafols, 2009). Much of this has occurred as our collective knowledge has become so vast that it has become increasingly important for researchers to team together with one another in order to assemble sufficient knowledge mastery (Jones, 2009). Meanwhile, developments in information and communication technologies have enabled both increased teamwork and eased research, facilitating innovation (Whalen, 2015). As this has occurred, both the frequency and the impact of team research have increased (Wuchty et al., 2007), and those teams are now more likely than ever to cross disciplinary boundaries (Porter and Rafols, 2009).

As research that spans across disciplines has increased, there has been a wide variety of discussions about the implications this has on various facets of science and research. Scholars have explored the implications on universities (e.g. Lattuca, 2001), academic publishing (e.g. Rafols et al., 2012), and applied research (e.g. Etzkowitz, 1998). There has been comparatively little attention paid to patent offices, and whether an increase in boundary spanning inventions has occurred and if so, what implications, if any, that may have for the way we incentivize inventions and assess patent eligibility. This leads me to pose the following research question:

RQ1. Has there been a change in the tendency for patents to span boundaries, bringing together distant knowledge?

2.1. Boundary spanning and the patent system

Patent examination is the primary task of patent offices. It is a labor-intensive task, requiring patent offices to hire large corps of examiners, train them extensively, and provide them with advanced information resources. It is ultimately a costly endeavor, with the USPTO requiring an annual budget of approximately $3.3 billion, while the EPO has a budget of approximately €2 billion. Increasing boundary spanning innovation has the potential to complicate the traditional specialized examiner model used by most patent offices, and thereby potentially upset the existing examination regime.

2.1.1. Patent examination specialization

In many jurisdictions, the patent application examination process has long been, and largely remains, an individual one. Examiners are assigned applications, and depending on their seniority and the rules of their patent office, often do the majority of their patentability assessment with little input. Their work is at times reviewed by a supervising examiner, but for the most part the process proceeds individually. In the United States, this has largely been the case since the Patent Office was founded in 1836. Early examiners were generalists, and expected to be able to assess applications in any technological area (Post, 1976). Over time, as technology grew more intricate and complex, Patent Offices encouraged specialization, establishing technology centers and art units with expertise in specific technical areas.

We see this increasing specialization empirically when we look to the examination loads of particular patent examiners. The USPTO Patent Application Information Retrieval (PAIR) data includes unique examiner IDs and records of the technological classification of the applications they have assessed. Using this, we can associate each examiner with their assigned workload and subsequently calculate the average breadth of an examiner's work over time. By breadth, I refer to the number of distinct USPC subclasses that each individual examines at least one application within. Calculating this for every active examiner on a yearly basis, shows us how many subclasses the average patent examiner worked within each year (see Fig. 1).

We see in Fig. 1 that in recent decades there has been a steady decrease in the number of patent classes that each examiner works within. This suggests that examiners are becoming more narrowly-focused on specific areas of technical expertise. For the most part, this increase in specialization has been a good thing, allowing for efficient examination of highly-specialized technologies. Specialization allows for more familiarity with the relevant prior art and fluency with the associated technical language. However, specialization's strengths can become a weakness if inventions do not fit clearly within a pre-defined technological area, but instead draw on inspiration from diverse fields.

Boundary spanning inventions by definition do not fit neatly within disciplinary boundaries. Instead, they draw on diverse sets of information and span multiple technical areas. We see in scientific research funding applications that interdisciplinary research proposals are less-likely to receive funding than proposals that fit more neatly within traditional disciplinary boundaries (Bromham et al., 2016). Although this could arise if interdisciplinary research is of consistently lower quality, it could also be the product of inherent challenges that interdisciplinary research poses for traditional methods of assessing research merit (Feller, 2006). In the case of boundary spanning research, the specialized backgrounds and training of those who assess the research may become a liability rather than an advantage. It is reasonable to expect that this same principle may be at play in the patent examination context. Given that examiners are increasingly domain experts with specialized knowledge, they may be at a disadvantage when assessing inventions that span technical boundaries.

Both interviews with patent examiners and quantitative assessment of pendency times suggest that particularly complex inventions generally require more time to assess (Popp et al., 2004). These "complexity problems are particularly acute in cross-disciplinary fields" because of the demands that cross-disciplinary inventions pose for patent examiners as they attempt to search the prior art and assess patentability (Popp et al., 2004, p. 9). Although it is probably true that not all boundary spanning inventions will pose complexity challenges for patent examiners, because of the way they re-combine information from diverse sources they are more likely to do so. By bringing together distantly-related information inputs, boundary spanning inventions require examiners to search more areas of prior art, and compare the