Understanding the Link between Patent Value and Citations: Creative Destruction or Defensive Disruption?

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Abstract

The patent system is the leading legal mechanism for protecting new inventions and as such, patents are used in a host of research to proxy for innovative activity. Understanding how new products and processes are created and how to value them is critical to fields as diverse as industrial organization, endogenous growth theory, and intellectual property law. In this paper we provide the first evidence that much of the work in these literatures is based on an erroneous assumption: that the value of innovation is proportional to citation-weighted patent counts. Using a proprietary dataset with patent-specific revenues, we find that there is an inverted-U relationship between patent value and citations. We attempt to explain this relationship using a simple model of firms, allowing for both productive and defensive patents. Simulations from the model match the empirical regularity that some very high-value patents receive substantially fewer citations than less valuable patents. Further, we find evidence of greater use of defensive patenting along the dimensions where it is predicted. These findings have important implications for our basic understanding of growth, innovation, and intellectual property policy.

JEL Codes: O3, L2, K1.

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1 Introduction

One of the core questions of economics, both at the micro and macro level, is what leads to productivity gains. In order to understand what policies impact innovative activity and ultimately productivity, it is crucial to start with a good metric to value innovation. While the importance of such a metric has long been recognized (Scherer 1956; Grilliches 1990) so too have the inadequacies of the proxies for value that are in widespread use (Schankerman and Pakes 1986; Hall and Harhoff 2012).

Over the last 30 years, two primary metrics have been used to proxy for the value of innovation, patent counts and citation-weighted patent counts. The intuition is simple: fields with greater innovative activity will have more value to protect and will do so by applying for more patents. Weighting patent counts by forward citations[1] is a natural augmentation to simple patent counts, given the well-known fact that patents vary tremendously in value[2]. This metric, however, is based on the assumption that a larger number of citations corresponds to higher value.

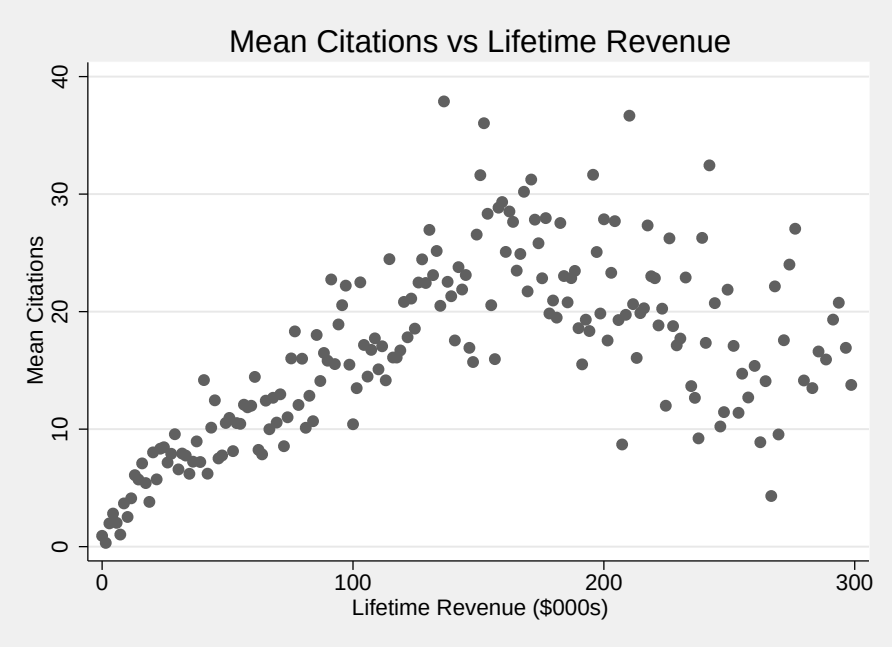

Figure 1: LIFETIME FORWARD CITATIONS VS. REVENUE
Notes: Data is normalized so that the mean annual revenue is $10,000.

Yet, the history of science and economics is replete with theories that did not bear up

[1]Forward citations is the number of citations received by a particular patent by subsequent patents.

[2]Fewer than 10 percent of patents are worth the money spent to secure them (Allison, Lemley, Moore, Trunkey 2009), but the most valuable ones are thought to be worth hundreds of millions of dollars (Hall, Jaffe, and Trajtenberg 2005).

under empirical scrutiny and until now there has been no good way to test this assumption. In order to say anything convincing about innovation we need a credible measure of its value. In Figure 1 we present strong evidence that the main approach to valuing innovation is fatally flawed. The relationship between citations and patents is not only non-linear, it is not even monotonic. This striking finding calls for a deeper understanding of the process of innovation, patenting, and citations, which we explore empirically and theoretically in this paper.

The citation-value relationship revealed in Figure 1 is extremely surprising relative to what has previously been assumed. Prior empirical study of the relationship was quite limited due to several problems: companies are reluctant to share proprietary patent data, single firm portfolios tend to have limited technological breadth and small sample size, and almost no companies allocate revenues to specific patents. This paper is only possible by virtue of access to a very large, diversified patent portfolio owned by non-practicing entities (NPEs) that calculate patent-specific revenues. We discuss details of the data set and its advantages for academic inquiry further in Section II.

We introduce a theoretical model that suggests that the inverted-U shape is the result of two types of innovative effort, which we characterize as productive and defensive. Productive innovative effort leads to the traditional increasing relationship between patent value and citations; defensive innovative effort, however, leads to a negative relationship between patent value and citations. In an economy that exhibits both of these types of innovative effort, the link between patent value and citations will be the inverted-U that we observe empirically.

We test several predictions of the model, besides the overall inverted-U shape. Defensive patenting should be more prevalent among larger entities, for divisional and continuation patents, for newer patents, and in technology classes with rapid growth. Each of these predictions is borne out in the data and we find evidence that defensive patenting is more prominent in these categories.

This is certainly not the first paper that has attempted to examine the relationship between patent value and citations, but it is the first not severely constrained, for the reasons mentioned above. Trajtenberg (1990) is perhaps the leading prior work on the subject, but he had access to a data set several orders of magnitude smaller than in this paper. In addition, all patents were in a single narrow field (computed tomography or CT) and values were imputed from a structural model of the CT device. Harhoff, Scherer, and Vopel (2003), obtain categorical measures of value on 772 patents from a survey of German patents with 1977 priority that were renewed to full term. Several excellent studies examine the patent value distribution using the renewal decision to infer value (Pakes 1986; Schankerman and Pakes 1986; Bessen 2008). These papers make use of the contingent claim valuation method pioneered by Pakes and Schankerman. Since a renewal decision can only convey an upper or lower bound on value, this approach is not useful for learning more about the citation-value relationship.

In the legal literature, defensive patenting has received a great deal of attention in re-

cent years as allowable subject matter has widened to include software and business methods patents. As the number of patents granted has increased, technological progress has led to devices that implicate thousands of separate patents. Some have argued that we have arrived at a point where the patent system is actually detrimental to innovation (Bessen and Meurer 2008; Boldrin and Levine 2012). We capture these observations and intuitions by modeling defensive patents as ones which do not lead to substantial further work in a field and in fact may stifle it (blocking patents). Thus, there may be extremely valuable defensive patents that receive very few citations, leading to a null or negative relationship between forward citations and revenue.

A single figure is not enough to convince one of the correctness of a theory, or even of the robustness of the empirical findings. We aim to tackle both of these tasks in the balance of the paper, but we take the unusual step of including this striking figure in the beginning because it immediately conveys our central contribution. In Section II we provide substantial detail about incentives to patent and cite, the business models of NPEs and further description of the data. Section III introduces our model which we believe captures some of the key elements of the patenting and citing processes. In Section IV we present the main empirical results and a discussion of them. Section V concludes and makes the point that the goal of this work is not to undermine the large body of work on innovation that has relied on widely-held assumptions about the patent value-citations relationship. Rather, we hope that this will help build a more robust literature that informs some of the central economic issues of our time.

2 Background

Since the major limitation of previous studies of patent value is due to the lack of available data on individual patent revenues, it is worth discussing the data source and characteristics in some detail. The data in this paper was provided by large non-practicing entities (NPEs), with focuses in the technology sectors. NPEs are firms whose revenue primarily derives not from producing products based on patented technology, but from licensing patents. These companies employ a range of different business models ranging from aggressive litigators to passive licensors, and the number of patents held by NPEs continues to grow rapidly.

This is fortunate for those interested in learning about innovation as NPEs function as an excellent data source in many ways, and when compared to traditional patent holding firms, NPEs have several advantages as an object of study. Their portfolios can be substantially larger than practicing firms, since their capital is almost exclusively employed in assembly and licensing, rather than production. NPEs are more diversified than practicing firms as well, since it is often easier to acquire the breadth of expertise necessary to acquire and license patents in a large array of fields, rather than to practice them. The data available from NPEs is also likely to be substantially more useful for researchers, as they tend to determine patent-

specific revenues. This is something that almost no practicing firms do, unless licensing is a major part of their business. This should not be surprising since ultimately most firms care about overall profit from innovation, not specifically from which patent the profit derives.

Table I reports variables definitions and summary statistics for the primary patent and assignee characteristics analyzed in this paper. After dropping design and plant patents, we observe 46,891 regular, utility patents. The average lifetime patent value is $204,212, but the standard deviation is $1.9 million. The mean number of forward citations is 13, but the median is 0. This degree of skewness in the distributions of patent value and forward citations is similar to that reported by Trajtenberg (1990); Harhoff, Scherer, and Vopel (2003); and Bessen (2008).

The heterogeneity in the underlying patent characteristics and assignees is extensive. The patents are licensed to and acquired from a broad range of intellectual property sources including individual inventors, small firms, large firms, universities, hospitals, and government agencies. The dataset represent patents originated in 89 different countries, and patents granted in the United States represent just less than the majority at 46 percent. Individual inventors account for 58% of the patents, and the average patent has 2 inventors that make 20 claims, of which 16 are dependent claims. On average, backward citations are not concentrated in very recent patents with only 20% in the three years prior to application.

Table II describes the diverse range of technologies that are patented. Our sample covers 267 unique primary technology classifications, which we have grouped into 10 broad technology categories. The technology categories include: internet and software, wireless communications, circuits, network communications, computer architecture, peripheral devices, semiconductors, electromechanical, optical networking, and nanotechnology.

In our subsequent theoretical and empirical analyses, where we attempt to provide a theoretical foundation for the inverted U-shape in the data, we focus on a few variables characterized by productive and defensive innovations. While building our theoretical model, we rely on the *Schumpeterian theory of creative destruction* (see the recent survey by Aghion, Akcigit and Howitt (2013) for more on this topic), where each new innovation builds on previous technologies, but also makes them obsolete by introducing a better one. This tension between the incumbent technology owner's wish to defend its monopoly power and the future innovator's wish to utilize the spillovers generated by the current incumbent help us rationalize the non-monotonic relationship between patent value and subsequent entry, identified by forward citations. Moreover, models presented by Farrell and Shapiro (2008) emphasize the ability of patent holders, even of weak or less productive patents, to hold up firms through the threat of infringement. Similarly, our model emphasizes the decision to innovate productively or defensively. Intuitively, this suggests that non-original and less productive patent applications with a higher concentration of backward citations in recent years are more likely to be strategic or

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