Market value and patent citations

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Abstract

This paper explores the usefulness of patent citations as a measure of the "importance" of a firm's patents, as indicated by the stock market valuation of the firm's intangible stock of knowledge. Using patents and citations for 1963-1999, we estimate Tobin's q equations on the ratios of R&D to assets stocks, patents to R&D, and citations to patents. We find that each ratio significantly impacts market value, with an extra citation per patent boosting market value by 3%. Further findings indicate that "unpredictable" citations have a stronger effect than the predictable portion, and that self-citations are more valuable than external citations.

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1. Introduction

It is widely understood that the R&D conducted by private firms is an investment activity, the output of which is an intangible asset that can be labeled as the firm's "knowledge stock." If this asset is known to contribute positively to the firm's future net cash flows, then the size of a firm's knowledge stock should be reflected in the observed market value of the firm. This implies that a firm's R&D investments should be capitalized in the firm's market value. Further, since the output of the R&D investment process is stochastic, some of the R&D will result in the creation of more valuable knowledge capital; if this success is observable, then it should be reflected in greater market value bang for the R&D buck.

Empirical testing of this formulation requires an observable proxy for R&D "success." There is a considerable literature using counts of firms' successful patent applications for this purpose. But the value of patent counts as a proxy for R&D success is severely limited by the very large variance in the significance or value of individual patents, rendering patent counts an extremely noisy indicator of R&D success. In this paper we utilize information on the number of subsequent citations received by a firm's patents to get a better measure of R&D success. Further, because citations arrive over time, and can be distinguished by the identity of the citing organization, we can distinguish the impact of a firm's patents on its market value according to the time path and source of subsequent citations.

This project was made possible by the recently completed creation of a comprehensive data file on patents and citations, comprising all US patents granted during the period 1963-1999 (three million patents), and all patent citations made during 1975-1999 (about 16 million citations), as described in Hall, Jaffe, and Trajtenberg (2001).[1] We construct on the basis of these data three measures of "knowledge stocks": the

[1] The complete data are available in the NBER site at http://www.nber.org/patents/, and also in a CD included with Jaffe and Trajtenberg (2002). For purposes of this paper, we actually used a previous version of the data that extends only until 1996.

traditional R&D and patent count stocks, and a citations stock. The last poses serious truncation problems, since citations to a given patent typically keep coming over long periods of time, but we only observe them until the last date of the available data; we apply correction methods developed elsewhere to deal with this and related problems. It is important to note that in this paper we look only at a simple "hedonic" (and hence snapshot-like) market value equation, and do not address the deeper dynamic forces at work, as discussed by Pakes (1985) – these will have to wait for future research.

We estimate Tobin's q "hedonic" equations on three complementary aspects of knowledge stocks: R&D "intensity" (the ratio of R&D stocks to the book value of assets), the patent yield of R&D (i.e., the ratio of patent count stocks to R&D stocks), and the average citations received by these patents (i.e., the ratio of citations to patent stocks). We find that each of these ratios has a statistically and economically significant impact on Tobin's q. This confirms that the market values R&D inputs, values R&D output as measured by patents, and further values "high-quality" R&D output as measured by citation intensity.

When we look in more detail at the aspects of citation patterns that are associated with higher market value, we find: (i) The value of high citation intensity is disproportionately concentrated in highly cited patents: firms having two to three times the median number of citations per patent display a 35% value premium, and those with 20 citations and more command a staggering 54% market value premium. (ii) There are wide differences across sectors in the impact of each knowledge stock ratio on market value. (iii) Market value premia associated with patent citations confirm the forward-looking nature of equity markets: at a given point in time, market value premia are associated with future citations rather than those that have been received in the past, and the portion of total lifetime citations that is unpredictable based on the citation history at a given moment has the largest impact. (iv) Self-citations (i.e., those coming from down-the-line patents owned by the same firm) are more valuable than citations coming from external patents, but this effect decreases with the size of patent portfolio held by the firm, as might be expected.

The paper is organized as follows: section 2 discusses the rationale for the use of patent and citations data in this sort of research, and reviews previous literature. The data are described in section 3, along with a discussion of truncation and its remedies. Section 4 deals with the specification of the market value equation, and the construction of citation stocks, including the partition into past-future and predictable-residual citation stocks. The empirical findings are presented in section 5: starting with a "horse race" between R&D, patents, and citations, we proceed to estimate the preferred specification that includes the three ratios, add industry effects, experiment with the various partitions of the citations stock, and finally look at the differential impact of self-citations. Section 6 concludes with ideas for further research.

2. Patents, citations, and market value: where do we stand?

Patents have long been recognized as a very rich data source for the study of innovation and technical change. Indeed, there are numerous advantages to the use of patent data: each patent contains highly detailed information on the innovation; patents display extremely wide coverage in terms of technologies, assignees, and geography; there are already millions of them (the flow being of over 150,000 US Patent and Trademark Office [USPTO] patent grants per year); the data contained in patents are supplied entirely on a voluntarily basis, etc. There are serious limitations as well, the most glaring being that not all innovations are patented, simply because not all inventions meet the patentability criteria, and because the inventor has to make a strategic decision to patent, as opposed to relying on secrecy or other means of appropriability.[2]

[2] Unfortunately, we have very little idea of the extent to which patents are representative of the wider universe of inventions, since there is no systematic data about inventions that are not patented (see, however, Crepon, Duguet, and Mairesse, 1998). This is an important, wide-open area for future research.

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