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Estimates of patent rents from firm market value

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ABSTRACT

The value of patent rents is an important quantity for policy analysis. However, estimates in the literature based on patent renewals might be understated. Market value regressions could provide validation, but they have not had clear theoretical foundations for estimating patent rents. I develop a simple model to make upper-bound estimates of patent rents using regressions on Tobin's *Q*. I test this on a sample of US firms and find it robust to a variety of considerations. Estimates from market value regressions correspond well with estimates based on patentee behavior generally, but renewal estimates might be understated for pharmaceuticals.

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1. Introduction

Patents are intended to provide an economic incentive for invention by granting the patent holder an exclusive right for a limited period. This right to exclude allows a patent-holding firm to become a monopolist or, perhaps more often, to achieve some lesser degree of market power, either in product markets or in the market for technology licenses. This market power, in turn, is supposed to permit the firm to earn supra-normal profits, "rents," that are an economic incentive to invent.

The value of patent rents is thus an important quantity for evaluating the performance of the patent system and also for understanding firm value. Some researchers have used the observed behavior of patent owners to estimate the private value of patents, which should equal the discounted value of patent rents.[1] Beginning with Pakes and Schankerman (1984), these studies have imputed patent value from observed decisions to pay maintenance fees (see Bessen, 2008 for estimates using this method for the US),[2] decisions to file patents in multiple countries (Putnam, 1996), and decisions to sell (re-assign) patents (Serrano, 2005).

But these approaches share an important limitation: they do not directly reflect the value of the most valuable patents and, given the skewed distribution of patent values, most of the aggregate value of patents is determined by the relatively small number of highly valuable patents. These studies typically assume a distributional form, such as a log-normal distribution. They then fit that distribution to the observed data and extrapolate to the upper tail. However, if the upper tail diverges significantly from the assumed distribution, then estimates of mean patent value might be too large or too small (although estimates of median patent value obtained from these methods are accurate). In the worst case, the upper tail might be so "heavy" that the actual distribution has an infinite mean as with the Pareto distribution (Scherer and Harhoff, 2000). Then estimates of the mean would be unstable and would not converge even at asymptotically large sample sizes.

An alternative might be to use firm market value to estimate patent value, that is, to decompose firm value into its component parts including that part attributed to patents. This way, investor behavior, rather than the behavior of patent owners, might reveal

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[1] Other researchers have used surveys to assess inventors' view of patent values (Harhoff et al., 2003a; Gambardella et al., 2008). However, these studies obtain a measure of patent value that is equivalent to the value of patent rents plus the value of the invention realized by other means (see Harhoff et al., 2003a). See Section 4.4 below.

[2] See Lanjouw et al. (1998) for a review of this literature. Recent studies also include Baudry and Dumont (2006) and Gustafsson (2005).

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patent value. At the very least, estimates based on firm market value might serve as an important check on the values obtained from data on the behavior of patent owners.

A large number of researchers have run regressions that use firm market value (or Tobin's *Q*, which is firm market value divided by the replacement value of firm assets) as the dependent variable and some measure of patents as an independent variable.[3] Surprisingly, however, the inclusion of patent measures in these studies has been *ad hoc*. None of these papers has sought to formally model the role of patent rents in determining firm value. And, for this reason, none have reported any rigorous estimates of patent rents (or patent value), aside from a few casual observations.[4]

The main contribution of this paper is that I provide a simple model that relates patent rents to firm value, allowing me to make rigorous inferences about these rents from my own estimates and also to re-interpret previous regressions to obtain estimates of patent rents.

One major difficulty, which has been noted in the literature, is that patent rents cannot be fully identified. This is because patents proxy for other unmeasured variables that are plausibly correlated with firm value. For example, firms might obtain more patents if their research investments turn out to be successful. In this case, the quality of R&D (R&D "success") would be an omitted variable that might bias estimates of patent rents upwards. However, although a coefficient corresponding to patent rents cannot be fully identified, my model shows that an approximate *upper bound* on mean rents per patent *can* be estimated.

I also show that estimates based on this model are robust to a variety of considerations including firm-specific differences in appropriability conditions, other firm characteristics, different specifications and stability over time. I further test whether these estimates appear to be stable in light of the skewed distribution of invention values (Scherer, 1965; Scherer and Harhoff, 2000, Harhoff et al., 2003b; Silverberg and Verspagen, 2004). I find that my estimates of mean patent value show definite evidence of convergence to the mean, suggesting that the distribution of patent values does not have an infinite mean (n.b., *invention* values might be different).

I compare upper-bound estimates of patent value to estimates obtained from a variety of other sources and using a variety of different methods. These include estimates based on the renewal behavior of US and European patentees and estimates based on the choices of US patentees regarding re-assignment and international filing. I also compare my estimates of annual patent rents to several rough benchmarks including the net income of large pharmaceutical companies and patent licensing revenues of IBM and US universities.

This exercise demonstrates that although only limited inferences can be drawn from market value regressions, by providing upper-bound estimates, they can play a role in evaluating estimates obtained by other methods, possibly confirming those estimates or possibly calling them into question. In a sister paper (Bessen, 2008), I use the renewal method to estimate patent value for US patents. In Section 4 of the current paper, I compare those estimates (and other estimates based on patentee behavior) to estimates obtained from market value regressions. In Bessen and Meurer (2008), we use all of these estimates of patent rents and patent value, along with some other considerations, to evaluate patent policy.

2. A market value model of patent rents

2.1. Market value regressions using patent data

In theory, the value of patents derives from the rents they generate. Patents provide their owners a degree of market power—either in product markets or in markets for technology—that affects the demand for the owner's products, allowing them to charge prices that exceed those they could charge in a perfectly competitive market. These supra-normal prices generate supra-normal profits, or rents, and these should contribute to the value of the firm that owns the patents.

I wish to explore the extent to which market value regressions can be used to measure the magnitude of the mean rents earned per patent. There is a significant literature that performs market value regressions, however, that research line began with a different objective: it sought to measure the "knowledge stock" of firms and patent terms have been included in these regressions as *ad hoc* proxies of R&D quality. Because of this different objective, the models used in this literature do not explicitly include patent rents, making any inferences about rents difficult.

These studies mostly build on Griliches's (1981) "hedonic" model of the firm, where investors are assumed to value a firm based on a combination of its characteristics, including the firm's "knowledge stock."[5] Researchers have included a variety of knowledge stock quality characteristics on the right hand side of market value regressions, including R&D spending and stocks, patent counts, patent stocks, citation counts, and citations stocks, as well as counts of trademark and design applications. Hall (1993, 2007), using a model of Hayashi and Inoue (1991), provides a rigorous treatment of the R&D coefficient in these regressions. Hall et al. (2005) add patent terms to Hall's model in order to capture some measure of "R&D success."

However, the models used in these regressions do not lend themselves to inferences regarding patent rents and, for the most part, researchers have not tried to draw such inferences. For one thing, it is well known that the coefficients of hedonic regressions are difficult to interpret unless one makes some strong assumptions (Rosen, 1974). Second, although Hall et al. (2005) provide a rigorous interpretation of the R&D coefficient, their model, based on Hayashi and Inoue (1991), assumes competitive markets. It is therefore *inconsistent* with the occurrence of patent rents.

My approach is not only to explicitly consider the contribution of rents to firm market value but also to incorporate the insights of Hall, Jaffe and Trajtenberg regarding R&D and the possible effect of R&D success on patenting.

2.2. Patent rents

Hayashi (1982) developed a formal model for firms with market power that relates Tobin's *Q* to the value of rents. Under assumptions of constant returns to scale and profits as a function of an aggregate capital stock in nominal dollars, *K*, for the *j*th firm at time *t*,

$$V_{jt} = q_t(K_{jt} + W_{jt}) \quad (1)$$

where *V* is firm market value, *W* is the present discounted value of firm rents (Hayashi derives this as a function of the product

[3] See Hall (2000) for a review of this literature. Some recent additions to this literature include Bosworth and Rogers (2001), Toivanen et al. (2002), Hall (2007), Hall et al. (2005) and Griffiths et al. (2005).

[4] Griliches's initial paper (1981) noted that "a successful patent is worth about $200,000," but this was more of an informal observation than a rigorous inference. Cockburn and Griliches (1988) mention tentative values implied by their coefficient estimates. Hall (2005) and Hall and MacGarvie (2006) compare coefficients for different sub-samples and infer that higher values imply more valuable patents on average.

[5] This follows the literature on hedonic product pricing (Court, 1939; Griliches, 1961) where, for example, the value of an automobile is modeled as a combination of its characteristics, each independently valued.

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