State of the Art Review

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Value of patents for the innovating firm

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Patents are the first choice innovation protection instrument. This SOTA Review outlines the evidence on the value of patents, the factors influencing patent value and highlights the gaps in our understanding of patent value in the UK. The focus of the review is on the value of patents to the innovating firm. It is worth noting that patents also have broader implications for societal welfare. The private value of patents is influenced by many factors (most notably by the degree of innovativeness or quality of innovation) and so these estimates also represent more than the value of the protection instrument itself.

Background

Trading in inventions, technological knowledge and information poses specific transactional hurdles which might make markets for technology inefficient. Arrow (1962) showed that a fundamental paradox in technology transactions is that the potential purchaser of the information describing a technology (or other information having some value, such as facts), wants to know the technology and what it does in sufficient detail as to understand its capabilities or have information about the facts or products to decide whether or not to buy it.

Once the customer has this detailed knowledge, however, the seller has in effect transferred the technology to the customer without any compensation. Patent protection solves this problem because by vesting an ownership right with the inventor, the patent prevents others (except the owner of the patent) from profiting from new knowledge, while disclosure of the invention entailed in patent grants ensures that there is enough knowledge about the invention to draw in consumers.

Evidence on value of patents for innovating firms[1]

The literature on returns to patenting is vast and many reviews exist (see Nagaoka 2010 and Allison 2017 for recent reviews). State of the Art Studies studies adopt one of three approaches to estimate the value of patents for the innovating firms. These are the market value approach, the patent renewal approach and the inventor survey approach. Though the estimates of patent value obtained through the three methods are comparable in principle, they vary greatly in magnitude.

The market value approach uses stock market values and implicitly the evaluation of the investor about the value of firms' tangible and intangible capital stock (which include patent stocks). Although not all market value studies report the monetary value of a patent, the maximal estimate of an additional patent is $13,244,914 (Connolly and Hirschey, 1988) and the minimal is $382,960 (Griliches, 1981) - all $ figures at 2005 values. These figures vary greatly between technological sectors.

The patent renewal approach analyses patent renewal records and the associated costs of patenting and renewing in order to assess the distribution of earnings from patents from the perspective of the patent holder. A valuable patent enhances a firm's profitability and is likley to be renewed. The maximal estimate of the mean value of a patent in this approach is $116,527 (Barney, 2002) and the minimal estimate is $2,390 (Baudry and Dumont, 2006). Furthermore, there are differences in the returns to patenting across broad technology sectors with pharmaceuticals earning the highest returns.

Inventor surveys identify the market value of patents on the inventor's subjective estimate of patent value on the date of invention. As an example, in the PatVal-EU survey on European Patent Office (EPO) patent inventors in France, Germany, Italy, Netherlands, Spain and the UK (Giuri et al. 2007), the inventors were asked to produce their best estimate of the minimum price at which the owner of the patent, whether the firm, other organizations, or the inventor themselves, would have sold the patent rights on the day on which the patent was granted. The estimated mean of the resulting patent value distribution is greater than 3 million Euros ($3,831,611) and the median is about thirteen percent of the mean ($510,882) (Gambardella et al., 2008).

Thus the largest values are reported by the inventor survey approach and the smallest values by the patent renewals method. Bessen (2009) offers some explanations of the discrepancies (in the range of hundreds of thousands of dollars) between estimates based on the market value approach and the higher estimates in the Inventor survey approaches, particularly the PatVal surveys. EPO patents are likely to be several times more valuable than their corresponding US patents because EPO implements stricter standards and inventors obtained fewer EPO patent per invention. Further, the survey estimate by inventors is likley to be about the value of invention, rather than of the value of patent rents, which are estimated by the market value approach. Value of invention, according to Bessen, includes value of patent rents plus rents that the firm earns by lead time advantage, learning-by-doing which is likely to be greater than the value of patent rents. Survey responses might be inflated in those cases where there are multiple patents on an

[1] This section draws upon an earlier unpublished literature review by Arora, Athreye and Huang (2010).

invention. Selling just one of these patents to a competitor may prevent the firm in focus from practising the invention at all, so the reservation value might reflect the value of all the patents covering the invention.

Much less attention has focussed on why patent renewal estimates are so small. Arora, Athreye and Huang (2010) suggest that this may depend upon the value of patent returns—both whena few highly valuable patents can bring a firm a substantial amount of profit to cover the cost of its applications of a large number of other patents and when there is a the skewed distribution of patent returns over time (for example most of the returns to a patent may be appropriated shortly after the patent is granted and the patent may not need to be renewed).

Table 1 presents studies on patent value for the UK and the estimates they obtain using different methods. A striking feature of the UK data on patent value is ts skewness with a very small number of firms accounting for a large proportion of valuable patents.

Table 1: Value of patents for innovating firms in the UK

Study	Data	Method used	Findings and/or value of estimates
Schankerman and Pakes (1986)	Patents filed between 1950-79	Renewal method	Median estimate of UK patent value (in US$2005) was $3,897 per patent and mean value was $14,580 per patent.
Bloom and Van Reenan (2000)	USPTO patents by UK-based firms	Tobins Q (market value)	Doubling the citation-weighted patent stock increased the value of firms per unit capital by 43%.12 firms accounted for 72% of the UK patent count held at the USPTO.
Toivanen et al. (2002)	Panel data on 1519 UK public firms from 1988–1995	Stock market value; Fixed effects	The coefficient of patent applications divided by physical assets was negative and significant in explaining stock market value.
Greenhalgh and Longland (2005)	843 UK companies in 1988–1994	Market value	Raising all firms' patent stocks by one standard deviation would raise real value added by 6.4 percent for EPO patents and by 4.4 percent for UK patents
PatVal Survey Giuri et al (2007)	1542 patent applications by UK inventors to the EPO across 29 technology classes.	Inventor suvey method	Over 40% of all patents reported a value of between 100 and1000 million Euros. that 12 patent applications together accounted for roughly 36-42% of all value.

Evidence on other factors influencing patent value

The availability of new datasets on innovating firms and data on the trade in patent backed licenses have allowed scholars to search for determinants of the patent value using methodologies more suited to the analysis of these new datasets.

Arora et al. (2008) used the Carnegie Mellon Survey, a dataset which is similar to the EU's Community Innovation Survey, to construct a structural model of R&D investment and innovation outcomes that consists of three simultaneous equations. They find that firms expect to earn almost 50 percent more on average from patented inventions than if they had not patented the inventions. This suggests that the opportunity cost of patenting, including the cost of information disclosure, the likelihood of inventing around, and the cost of enforcement are substantial. The structural model estimated by Arora et al (2008) also estimates the elasticity of R&D investment with respect to the existence of patent protection. They estimate the R&D elasticity to patent protection to be about 0.61, which is consistent with other studies of the relationship between patents and R&D (e.g., Pakes and Griliches,1984; Hall et al., 1986; Cincera, 1997).

Using a modified model more suited to the structure of the CIS3, 4 and 5 data collected in the UK, and based upon assumptions about patent propensity of R&D, Arora and Athreye (2012) report that a unit increase in perceived patent effectiveness is estimated to result in additional revenue from new products of about 160% to 200% and incremental profits of just over 32%. In addition, such an increase in patent effectiveness would bring forth an increase of between 11 - 27% in R&D. The suggestion is that patent incentives for large firms work as well in the UK as they do in the US (estimated revenue premiums for large firms average 66%), but may not be as strong for smaller firms (where estimated premiums are lower at 46%). Similarly, sectors such as biotechnology and pharmaceuticals, computer and electronic equipment, instruments, machinery and medical instruments showed higher than average patent premiums suggesting that these sectors benefit more from patenting.

Another line of studies obtains patent value from licence contracts, auction or inventor surveys and focuses on investigating the *determinants of observed patent values.* Sakakibara (2010) analyzed 661 patent licensing contracts in Japan to estimate elasticity of price of patent with respect to licensor/licensee type. She found that the price of a patent whose licensor is a large company is 69 percent of the price of a patent licensed by a small company, individual or cooperative, which indicates large licensor's adverse selection to license only small and unprofitable inventions; the price of a patent whose licensee is a large company is worth 85–90 percent of the price of a patent licensed to a small company, individual or cooperative, suggesting large company's great bargaining power.

Sneed and Johnson (2009) used patent auction data to estimate the elasticity of patent sold value with respect to patent characteristics. They found that belonging to one additional (technology) class adds roughly $250,000 to the patent value if the lot is sold; each additional forward citation received per patent adds roughly $10,600 to the patent value; patent lots owned by private corporations were sold for $200,000 less than comparable lots owned by individuals or public entities. Odasso, Scellato and Ughetto, (2013) use a data set covering all patent auctions held until the end of 2008 by intellectual property merchant bank Ocean Tomo, and regress the offer price (ex ante value set by the seller) and the closing price (the market value

determined by the buyers) of patent lots on a number of patent characteristics and buyer types. They found positive correlations between the economic value of patents (in terms of both the lot offer price and the lot closing price), forward citations and the number of countries in which a patent was granted, while the number of prior art references had a significant positive impact only on the lot offer price. Some patent characteristics positively affected price only in the case of buyers who were nonpracticing entities (NPEs), including the number of claims and relatively young patent age.

The availability of litigation data has led research in economics and law to associate litigation propensity with private patent value, under the view that the extremely high costs of patent enforcement would generally lead patent owners to sue for infringement only in the case of patents they deem to be important (Lanjouw and Schankerman, 1999). Allison, Lemley, Moore and Trunkey (2004) found that when compared with other patents issued at the same time but unlitigated, litigated patents have significantly more prior patent and nonpatent prior art references, claims (including, a larger number of independent claims), more technology areas per patent, and were found to be cited more by later patents. Reitzig (2004) and Helmers and McDonagh (2012) find similar results suggesting that litigated patents were also of higher quality. Harhoff and Hoisl (2007) used an ordered probit model to investigate elasticity of patent value/inventor compensation with respect to characteristics of inventors and companies. They found that citations, legal challenges (opposition) and size of patent family were positively associated with patent value. Patented inventions that are planned products of R&D projects are more valuable than unplanned results or by-products of R&D. Inventions made during the inventor's leisure time are more valuable than the ones made from the inventors' normal work but not from R&D projects.

Summary and evidence gaps

Based on diverse methodologies the common conclusion of studies on patent value is the high private value of patents for innovating firms. Patent value studies have estimated the average value of a patent and also highlighted that that higher value patents are correlated with invention (patent) quality, which in turn may have implications for the societal value of patents. But we know much less about the social value of patents -- an area that should be a concern for public policy which aims to trade-off the monopoly inherent in a patent with the social diffusion of technological knowledge.

In particular studies based on inventor survey data have drawn attention to the strategic use of patents to block the inventions by competitors suggesting that the link between contestable markets and patenting may deserve closer attention. This is closely related to the social value of patenting. Theoretical work by Scotchmer (2004) and others has shown that in areas of new and cumulative technologies, long term patents could be socially harmful. Building on this insight, Barry and Delcamp (2012) use the discrete versus cumulative nature of patents to discern the difference between private and social value of patents. Such analysis is lacking but could be informative in the UK context as policy ponders the right balance in the context of new technologies (Artificial Intelligence, 3D printing) and new global challenges.

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